



# **Intel® E8501 Chipset North Bridge (NB)**

**Datasheet**

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**May 2006**



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## Revision History

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| Revision Number | Description  | Date       |
|-----------------|--|------------|
| -001            | <ul style="list-style-type: none"> <li>Initial public release</li> </ul> | April 2006 |

§

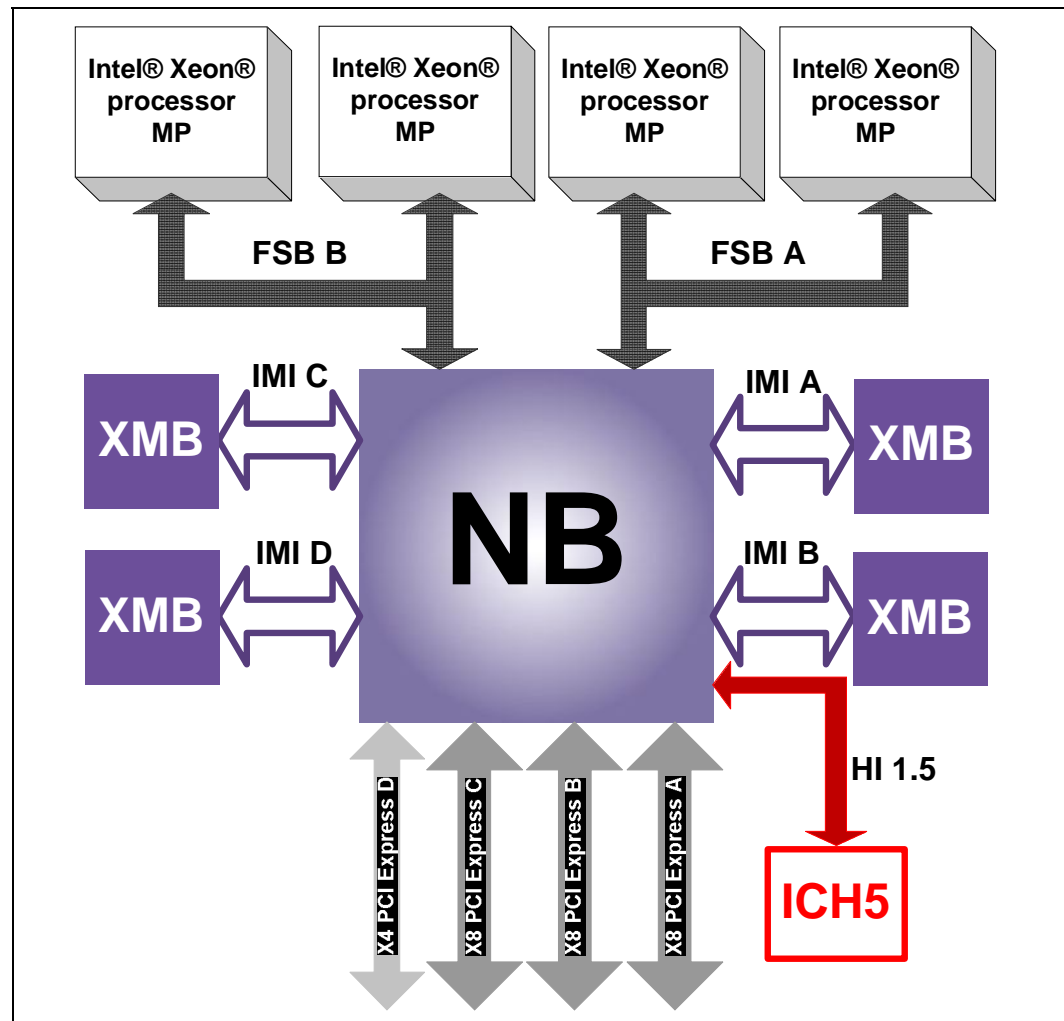


# 1 Introduction

The Intel® E8501 chipset is a 4-way server chipset offering world class performance. The chipset is built architecturally around the Intel® E8501 chipset north bridge (NB) and the Intel® E8501 chipset external memory bridge (XMB).

This document, the *Intel® E8501 Chipset North Bridge (NB) Datasheet*, describes the features, modes and registers supported by the Intel® E8501 chipset north bridge (NB) component only. Additional details on the Intel® E8501 chipset external memory bridge (XMB) are described in a separate document, the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*. For details on any other platform component, please refer to the component's respective documentation. This chapter is an introduction to the entire platform.

**Figure 1-1. Intel® E8501 Chipset System Block Diagram**



## 1.1 Intel® E8501 Chipset North Bridge (NB) Feature List

The NB is the center of the Intel® E8501 Chipset architecture (refer to [Figure 1-1](#)). The NB provides the interconnect to:

- 64-bit Intel® Xeon® processor MP or Dual-Core Intel® Xeon® processor 7000 sequence via two 667 MHz or 800 MHz front side buses optimized for server applications
- XMBs via four Independent Memory Interfaces (IMI)
- I/O components via one x4 & three x8 PCI Express\* links and Intel® 82801EB I/O Controller Hub 5 (ICH5) via the HI 1.5

### 1.1.1 Processor Front Side Bus Support

- Supports up to 4 64-bit Intel® Xeon® processor MP or Dual-Core Intel® Xeon® processor 7000 sequence
- 667 MHz or 800 MHz operation
- Maintains coherency across both buses
- Double-pumped 40-bit address buses with ADS every other clock which provides a total address bandwidth of 167 million addresses/second
- Quad-pumped, 64-bit data bus providing a bandwidth of 5.3 GB/s per bus at 667 MHz or 6.4 GB/s per bus at 800 MHz
- In-Order-Queue depth of 12
- Maintains coherency across both buses
- Return data by Enhanced Defer to allow out-of-order completion
- ECC protection on data signals and parity protection on address signals

### 1.1.2 Independent Memory Interface

- 4 Independent Memory Interface (IMI) ports, each with up to 5.33 GB/s inbound (read) bandwidth and 2.67 GB/s outbound (write) bandwidth simultaneously
- 40-bit addressing support provides one terabyte ( $2^{40}$  bytes) addressing capability (this is in excess of maximum physical memory supported by the Intel® E8501 chipset platform)
- Memory technology independent
- Hot-plug support on each IMI

### 1.1.3 I/O Interfaces

The Intel® E8501 chipset relies primarily on PCI Express to provide the interconnect between the NB and the I/O subsystem. The I/O subsystem is based on one x4 PCI Express link, three x8 PCI Express links (each of which can be split into two x4 links), and one HI1.5 link.

### PCI Express\*

- One x4 and three x8 links. Each x8 link can be configured as two x4 links, making a total of seven x4 links
- 1 GB/s bandwidth in each direction for x4 links and 2 GB/s for x8 links
- All ports support Hot-Plug

### HI 1.5

- 8-bit wide, 4x data transfer, 66 MHz base clock
- 266 MB/s bandwidth
- Legacy I/O interconnection to the ICH5

## 1.1.4 Transaction Processing Capabilities

- 64 transactions processed concurrently
- 128-entry Common Data Cache (CDC) for write combining and write buffering

## 1.1.5 RASUM

- ECC on all internal data paths
- Error Detection and Logging Registers on all interfaces
- CRC32 and CRC16 on PCI Express links
- Packet level CRC on IMI's
- IMI error recovery support via read or write retry
  - Transient DRAM read error recovery
  - Transient single IMI wire failure recovery
- Memory mirroring support
- Parity protection on Hub Interface 1.5 (address, control & data)
- Hot-Plug support on PCI Express and IMI ports
- SMBus and JTAG interfaces for system management
- Support for Mirroring of memory
- Parity protected Hub Interface (Address, Control & Data)

## 1.1.6 Package

- 1432 pin FC-BGA3 (42.5 x 42.5 mm) with a pin-pitch of 1.09 mm.

## 1.2 Intel® E8501 Chipset eXternal Memory Bridge (XMB) Feature List

The Intel® E8501 chipset external memory bridge (XMB) is an intelligent memory controller that bridges the IMI and DDR interfaces. Each XMB connects to one of the NB's four IMI interfaces. The Intel® E8501 chipset may operate with 1 to 4 XMBs.

### 1.2.1 DDR Memory Support

- Dual DDR memory channels operating in lockstep with four DIMM slots per channel
- DIMMS must be populated in pairs, and DIMMS within a pair must be identical
- Supports either DDR at 266 MHz or 333 MHz or DDR2 at 400 MHz
- Supports 256-Mb, 512-Mb, and 1-Gb technologies
- Registered ECC DIMMS required
- Integrated I<sup>2</sup>C\* controller for reading DIMM SPD data

### 1.2.2 IMI Support

- High speed, point-to-point, differential, recovered clock interconnect
- 2.67 GB/s outbound (to the XMB) and 5.33 GB/s inbound (from the XMB) simultaneous bandwidth
- Hot-Plug support

### 1.2.3 RASUM Features

- ECC on all internal data paths
- Error detection and logging registers on all interfaces
- Packet level CRC protection on IMI
- IMI error recovery support via read or write retry
  - Transient single IMI wire failure recovery
- Intel® x8 Single Device Data Correction (x8 SDDC) technology
- DIMM demand and patrol scrubbing
- DIMM sparing
- Hardware memory initialization
- Performance counters
- SMBus and JTAG interfaces for system management
- Hot-plug capable IMI

## 1.2.4 Intel® E8501 Chipset eXternal Memory Bridge (XMB) Package

- 829-pin FC-BGA3 (37.5 x 37.5 mm) with a pin-pitch of 1.27 mm

## 1.3 Terminology

| Term                                  | Description  |
|---------------------------------------|--|
| Agent                                 | A logical device connected to a bus or shared interconnect that can either initiate accesses or be the target of accesses.   |
| Asserted                              | Signal is set to a level that represents logical true.   |
| Asynchronous                          | 1. An event that causes a change in state with no relationship to a clock signal.<br>2. When applied to transactions or a stream of transactions, a classification for those that do not require service within a fixed time interval.                                   |
| Atomic operation                      | A series of two or more transactions to a device by the same initiator which are guaranteed to complete without intervening accesses by a different master. Most commonly required for a read-modify-write (RMW) operation.  |
| Bit Interleave, Address Bit Permuting | The way the bits in a cache line are mapped to DIMM rows, banks, and columns (DDR SDRAM) of memory.  |
| Buffer                                | 1. A random access memory structure.<br>2. The term I/O buffer is also used to describe a low level input receiver and output driver combination.  |
| Cache Line                            | The unit of memory that is copied to and individually tracked in a cache. Specifically, 64 bytes of data or instructions aligned on a 64-byte physical address boundary.   |
| Cache Line Interleave                 | The way a series of cache lines are mapped to DRAM devices.  |
| Cfg                                   | Used as a qualifier for transactions that target PCI configuration address space.  |
| Character                             | The raw data Byte in an encoded system (e.g. the 8b value in a 8b/10b encoding scheme). This is the meaningful quantum of information to be transmitted or that is received across an encoded transmission path.   |
| Coherent                              | Transactions that ensure that the processor's view of memory through the cache is consistent with that obtained through the I/O subsystem.   |
| Command                               | The distinct phases, cycles, or packets that make up a transaction. Requests and Completions are referred to generically as Commands.  |
| Completion                            | A packet, phase, or cycle used to terminate a Transaction on a interface, or within a component. A Completion will always refer to a preceding Request and may or may not include data and/or other information.   |
| Core                                  | The internal base logic in the NB.   |
| CRC                                   | Cyclic Redundancy Check; A number derived from, and stored or transmitted with, a block of data in order to detect corruption. By recalculating the CRC and comparing it to the value originally transmitted, the receiver can detect some types of transmission errors. |

| Term                 | Description  |
|----------------------|--|
| Critical Word First  | The Independent Memory Interface specification constrains the XMB to deliver the words of a cache line in a particular order such that the word addressed in the request appears in the first data transfer.   |
| DDR                  | Double Data-Rate memory.   |
| DDR Channel          | One electrical interface to one or more DIMMs, supporting 8 bytes of data and 1 byte of ECC.   |
| Deasserted           | Signal is set to a level that represents logical false.  |
| DED                  | Double-bit Error Detect.   |
| Deferred Transaction | A front side bus Split Transaction. The requesting agent receives a Deferred Response which allows other transactions to occur on the bus. Later, the response agent completes the original request with a separate Deferred Reply transaction.  |
| Delayed Transaction  | A transaction where the target retries an initial request, but unknown to the initiator, forwards or services the request on behalf of the initiator and stores the completion or the result of the request. The original initiator subsequently re-issues the request and receives the stored completion.               |
| DFM                  | Design for Manufacturability.  |
| DFT                  | Design for Testability.  |
| DIMM                 | Dual-in-Line Memory Module. A packaging arrangement of memory devices on a socketable substrate.   |
| DIMM Rank            | That set of SDRAMs on one DDR branch which provides the data packet.   |
| DIMM Slot            | Receptacle (socket) for a DIMM. Also, the relative physical location of a specific DIMM on a DDR channel.  |
| DIMM Stack           | A set of DIMMs that share data lines.  |
| Direct Memory Access | Method of accessing memory on a system without interrupting the processors on that system.   |
| DMA                  | See Direct Memory Access.  |
| Downstream           | Describes commands or data flowing away from the processor-memory complex and toward I/O. The terms Upstream and Downstream are never used to describe transactions as a whole. (e.g. Downstream data may be the result of an Outbound Write, or an Inbound Read. The Completion to an Inbound Read travels Downstream). |
| DRAM Page (Row)      | The DRAM cells selected by the Row Address.  |
| DW                   | A reference to 32 bits of data on a naturally aligned four-byte boundary (i.e. the least significant two bits of the address are 00b).   |
| ECC                  | Error Correcting Code.   |
| Front Side Bus       | Processor-to-NB interface. The front side bus in this document refers to operation at 166/333/667 MHz (Bus Clock/Address/Data) or 200/400/800 MHz (Bus Clock/Address/Data) . The front side bus is not compatible with the P6 front side bus.  |
| Full Duplex          | A connection or channel that allows data or messages to be transmitted in opposite directions simultaneously.  |

| Term  | Description  |
|---|--|
| GB/s  | Gigabytes per second (10 <sup>9</sup> bytes per second).   |
| Gb/s  | Gigabits per second (10 <sup>9</sup> bits per second).   |
| Half Duplex   | A connection or channel that allows data or messages to be transmitted in either direction, but not simultaneously.  |
| HI1.5   | The Intel proprietary hub interface that connects the NB to the ICH5   |
| Host  | This term is used synonymously with Processor.   |
| I/O   | 1. Input/Output.<br>2. When used as a qualifier to a transaction type, specifies that transaction targets Intel architecture-specific I/O space. (e.g., I/O read).   |
| Intel® ICH5   | The I/O Controller Hub component that contains the legacy I/O functions. It communicates with the NB over a proprietary interconnect called Hub Interface.   |
| Implicit Writeback  | A snoop initiated data transfer from the bus agent with the modified Cache Line to the memory controller due to an access to that line.  |
| Inbound   | A transaction where the request destination is the processor-memory complex and is sourced from I/O. The terms Inbound and Outbound refer to transactions as a whole and never to Requests or Completions in isolation. (e.g. An Inbound Read generates Downstream data, whereas an Inbound Write has Upstream data. Even more confusing, the Completion to an Inbound Read travels Downstream.) |
| Inbound (IB)/Outbound (OB)<br>AKA Upstream/<br>DownStream,<br>Northbound/Southbound,<br>Upbound/Downbound | Up, North, or Inbound is in the direction of the Independent Memory Interface, Down, South, or Outbound is in the direction of other IO (SDRAM, SMBus).<br>or<br>Inbound is towards the NB, Outbound is away from it.  |
| Initiator   | The source of requests. (IBA) An agent sending a request packet on PCI Express is referred to as the Initiator for that Transaction. The Initiator may receive a completion for the Request. [PCI Express]   |
| Isochronous   | A classification of transactions or a stream of transactions that require service within a fixed time interval.  |
| Layer   | A level of abstraction commonly used in interface specifications as a tool to group elements related to a basic function of the interface within a layer and to identify key interactions between layers.  |
| Legacy  | Functional requirements handed down from previous chipsets or PC compatibility requirements from the past.   |
| Line  | Cache line   |
| Line-Atomically   | Atomic operation on one cache lines. Operations on other lines proceed normally during the line-atomic operation. Other operations to the same cache line are suspended until the line-atomic operation is complete.   |
| Link  | A full duplex transmission path between any two PCI Express devices.   |
| LSb   | Least Significant Bit  |
| LSB   | Least Significant Byte   |

| Term   | Description   |
|--|---|
| Master   | A device or logical entity that is capable of initiating transactions. A Master is any potential Initiator.   |
| Master Abort                                   | A response to an illegal request. Reads receive all 1s data. Writes have no effect.   |
| MB/s   | Megabytes per second ( $10^6$ bytes per second)   |
| Mem  | Used as a qualifier for transactions that target memory space. (e.g. A Mem read to I/O)   |
| Memory Issue                                   | Committing a request to DDR or, in the case of a read, returning the read header.   |
| Mesochronous                                   | Distributed or common referenced clock  |
| Metastability                                  | A characteristic of flip flops that describes the state where the output becomes non-deterministic. Most commonly caused by a setup or hold time violation.   |
| MSb  | Most Significant Bit  |
| MSB  | Most Significant Byte   |
| MTBF   | Mean Time Between Failure   |
| NB   | Intel® E8501 Chipset North Bridge (NB)  |
| Non-Coherent                                   | Transactions that may cause the processor's view of memory through the cache to be different with that obtained through the I/O subsystem.  |
| Outbound                                       | A transaction where the request destination is I/O and is sourced from the processor-memory complex. The terms Inbound and Outbound refer to transactions as a whole and never to Requests or Completions in isolation. (e.g. An Outbound Read generates Upstream data, whereas an Outbound Write has Downstream data. Even more confusing, the Completion to an Outbound Read travels Upstream.) |
| PCI-PCI (P-P)                                  | Peer-to-Peer Transactions that occur between two devices independent of memory or the processor.  |
| Packet   | The indivisible unit of data transfer and routing, consisting of a header, data, and CRC.   |
| Page Hit                                       | An access to an open page, or DRAM row. The data can be supplied from the sense amps at low latency. The two halves of the cache line are always placed on the same page, so that only one row command is used. Outside of a cache line the XMB maps address bits to optimize random accesses, at the expense of page hits. Thus page hits outside a cache line are rare.                         |
| Page Miss (Empty Page)                         | An access to a page that is not buffered in sense amps and must be fetched from DRAM array. Address Bit Permuting Address bits are distributed among channel selects, DRAM selects, bank selects so that a linear address stream accesses these resources in a certain sequence.  |
| Page Replace Aka Page Miss, Row Hit/Page Miss. | An access to a row that has another page open. The page must be transferred back from the sense amps to the array, and the bank must be precharged.   |
| PCI Bus  | Peripheral Component Interconnect Local Bus. A 32-bit or 64-bit bus with multiplexed address and data lines that is primarily intended for use as an interconnect mechanism within a system between processor/memory and peripheral components or add-in cards.   |
| PCI 2.3 compliant                              | Refers to compliance to the <i>PCI Local Bus Specification, Revision 2.3</i>  |



| Term  | Description  |
|---|--|
| Plesiochronous  | Each end of a link uses an independent clock reference. Support of this operational mode places restrictions on the absolute frequency difference, as specified by PCI Express, which can be tolerated between the two independent clock references.   |
| Posted  | A Transaction that is considered complete by the initiating agent or source before it actually completes at the Target of the Request or destination. All agents or devices handling the Request on behalf of the original Initiator must then treat the Transaction as being system visible from the initiating interface all the way to the final destination. Commonly refers to memory writes. |
| Push Model  | Method of messaging or data transfer that predominately uses writes instead of reads.  |
| Queue   | A first-in first-out structure (FIFO).   |
| RASUM   | Reliability, Availability, Serviceability, Usability, and Manageability.   |
| Receiver  | <ol style="list-style-type: none"> <li>1. The Agent that receives a Packet across an interface regardless of whether it is the ultimate destination of the packet.</li> <li>2. More narrowly, the circuitry required to convert incoming signals from the physical medium to more perceptible forms.</li> </ol>  |
| Request   | A packet, phase, or cycle used to initiate a Transaction on a interface, or within a component.  |
| Reserved  | The contents or undefined states or information are not defined at this time. Using any reserved area is not permitted. Reserved register bits must have their values preserved.   |
| RMW   | Read-Modify-Write operation  |
| SDRAM   | Synchronous Dynamic Random Access Memory   |
| SEC   | Single-bit Error Correct   |
| Serial Presence Detect (aka I <sup>2</sup> C* protocol) | A 2-signal serial bus used to read and write control registers in the SDRAMs.  |
| Simplex   | A connection or channel that allows data or messages to be transmitted in one direction only.  |
| SMBus   | System Management Bus. Mastered by a system management controller to read and write configuration registers. Signaling and protocol are loosely based on I <sup>2</sup> C, limited to 100 KHz.   |
| Snooping  | A means of ensuring cache coherency by monitoring all memory accesses on a common multi-drop bus to determine if an access is to information resident within a cache.  |
| Split Lock Sequence                                     | A sequence of transactions that occurs when the target of a lock operation is split across a front side bus data alignment or Cache Line boundary, resulting in two read transactions and two write transactions to accomplish a read-modify-write operation.  |
| Split Transaction                                       | A transaction that consists of distinct Request and Completion phases or packets that allow use of bus, or interconnect, by other transactions while the Target is servicing the Request.  |
| SSTL  | Stub-Series Terminated Logic   |

| Term                | Description   |
|---------------------|---|
| Symbol              | An expanded and encoded representation of a data Byte in an encoded system (e.g. the 10-bit value in a 8-bit/10-bit encoding scheme). This is the value that is transmitted over the physical medium.   |
| Symbol Time         | The amount of time required to transmit a symbol.   |
| Target              | A device that responds to bus Transactions. (PCI-X*) The agent receiving a request packet is referred to as the Target for that Transaction. [PCI Express].   |
| Tenured Transaction | A transaction that holds the bus, or interconnect, until complete, effectively blocking all other transactions while the Target is servicing the Request.   |
| TID                 | Transaction Identifier; A multi-bit field used to uniquely identify a transaction. Commonly used to relate a Completion with its originating Request in a Split Transaction system.   |
| Transaction         | An overloaded term that represents an operation between two or more agents that can be comprised of multiple phases, cycles, or packets.  |
| Transmitter         | <ol style="list-style-type: none"> <li>1. The Agent that sends a Packet across an interface regardless of whether it was the original generator of the packet.</li> <li>2. More narrowly, the circuitry required to drive signals onto the physical medium.</li> </ol>  |
| Upstream            | Describes commands or data flowing toward the processor-memory complex and away from I/O. The terms Upstream and Downstream are never used to describe transactions as a whole. (e.g. Upstream data may be the result of an Inbound Write, or an Outbound Read. The Completion to an Outbound Read travels Upstream.) |
| XMB                 | Intel® E8501 Chipset eXternal Memory Bridge (XMB)   |

## 1.4 References

This revision of the *Intel® E8501 Chipset North Bridge (NB) Datasheet* is consistent with the following documentations:

- *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*
- PCI Express Specification
- PCI Local Bus Specification
- *Intel® 6700PXH 64-bit PCI Hub and Intel® 6702PXH 64-bit PCI Datasheet*
- *Intel® 82801EB I/O Controller Hub5 (ICH5) and Intel® 82801ER I/O Controller Hub5 R (ICH5R) Datasheet*
- *64-bit Intel® Xeon® Processor MP with 1MB L2 cache Datasheet*
- *64-bit Intel® Xeon® Processor MP with up to 8MB L3 cache Datasheet*
- *Dual-Core Intel® Xeon® Processor 7000 Sequence Datasheet*

§

## 2 Overview

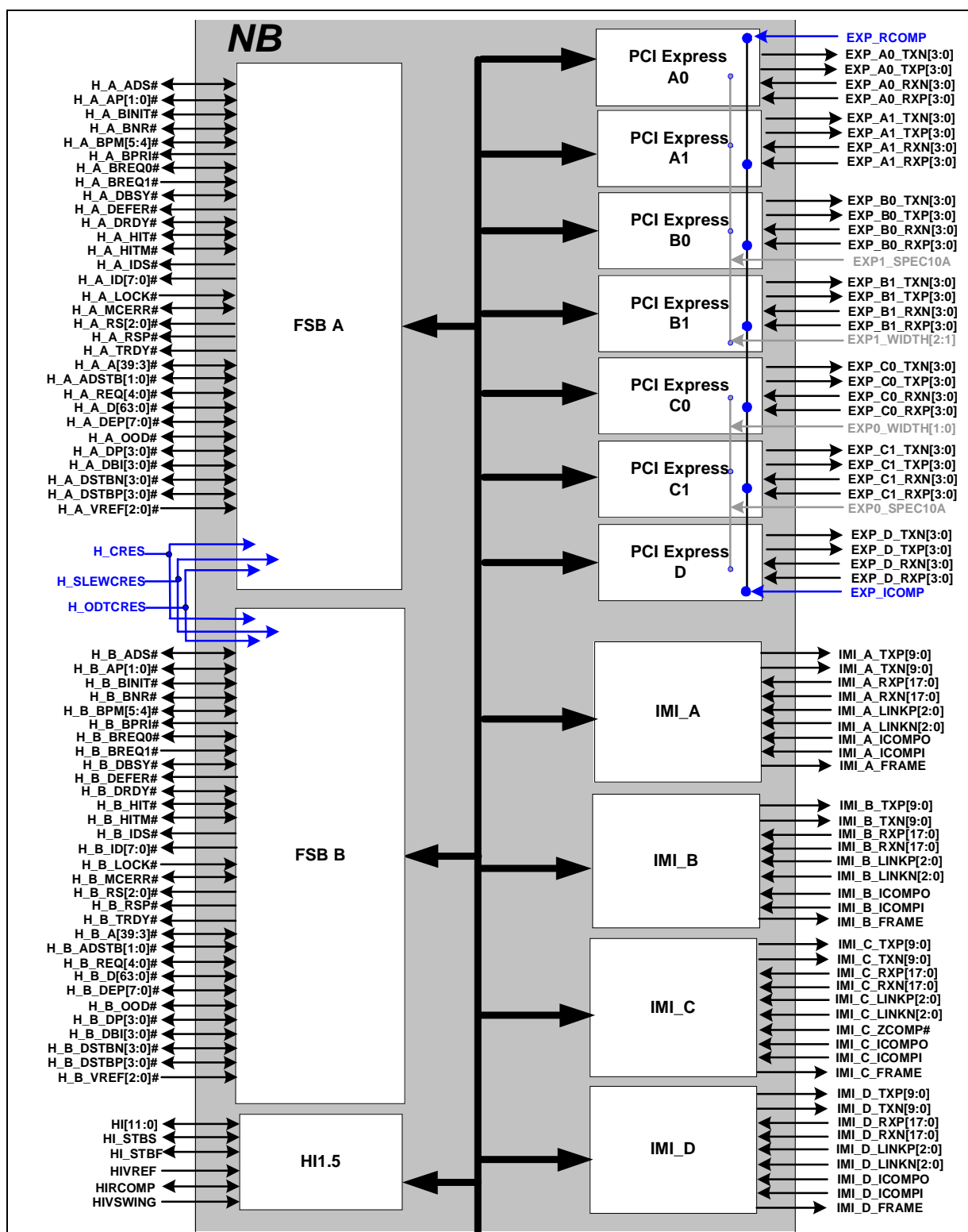
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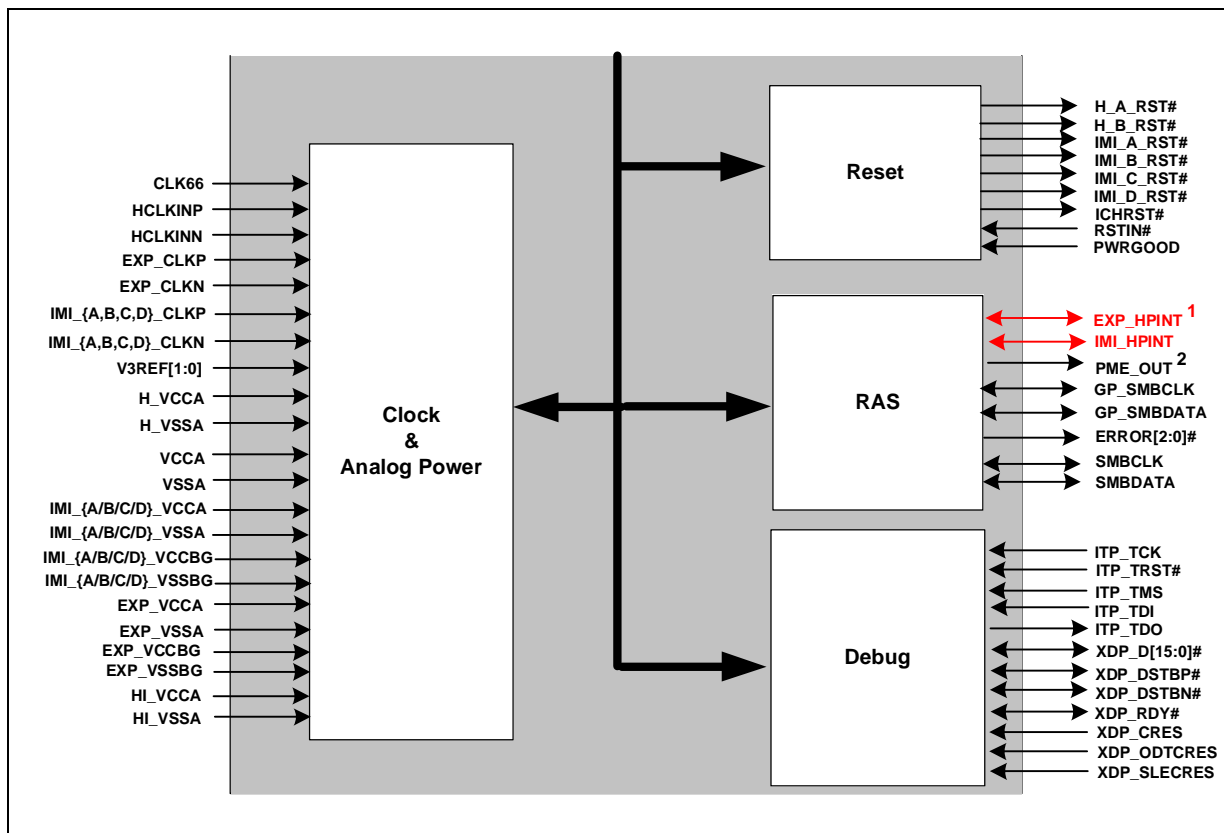
This chapter provides a general overview of the Intel® E8501 chipset North Bridge (NB) and its properties. For functionality details on each interface, please refer to [Section 6](#).

### 2.1 Logical Pin Grouping

[Figure 2-1](#) provides a complete list of the NB signals. The signals are arranged in functional groups according to their associated logical interfaces: FSB{A,B}, IMI{A/B/C/D}, PCI Express{A0/A1/B0/B1/C0/C1/D}, HI1.5, Clock, RAS and Debug. For the complete description of each signal, please refer to [Section 3](#).

Figure 2-1. Intel® E8501 Chipset North Bridge (NB) Interface Signals




**NOTES:**

1. EXP\_HPINT and EXP1\_WIDTHH1 are muxed names
2. PME\_OUT and EXP1\_WIDTHH2 are muxed names

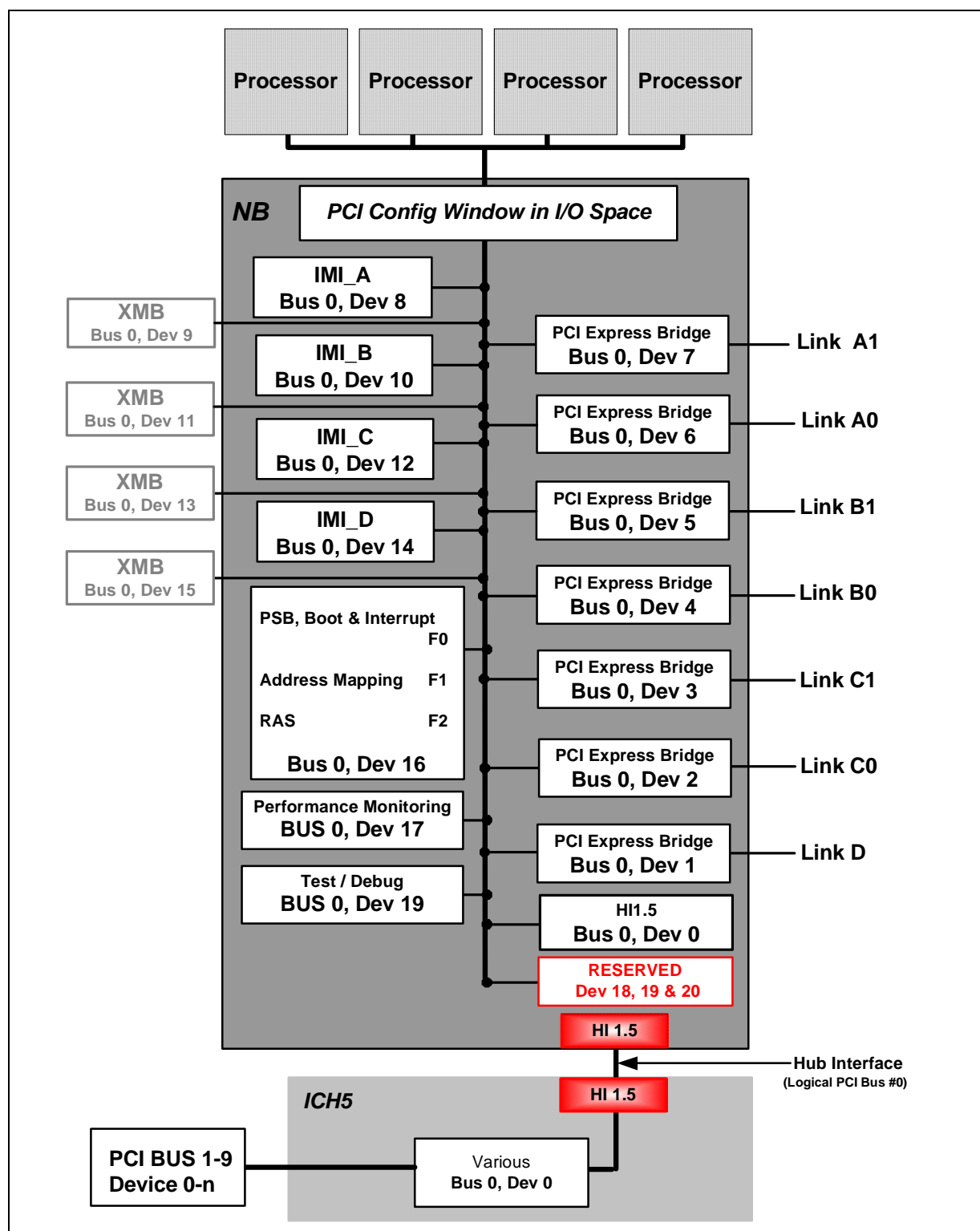
## 2.2 Quadrant Placement

For the quadrant and ball placement, refer to [Figure 7-1](#).

## 2.3 Register Devices

Intel® E8501 chipset configuration registers reside in the NB and the XMB. The registers are grouped into buses, devices, and functions. [Figure 2-2](#) shows the hard-coded bus and function numbers for the NB. All configuration devices in this figure are hard-coded to Bus #0. For detailed information on the register configuration, please refer to [Section 4](#). For hard-coded XMB devices, please refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

Figure 2-2. PCI Device Map



## 2.4 Intel® E8501 Chipset North Bridge (NB) Clocking

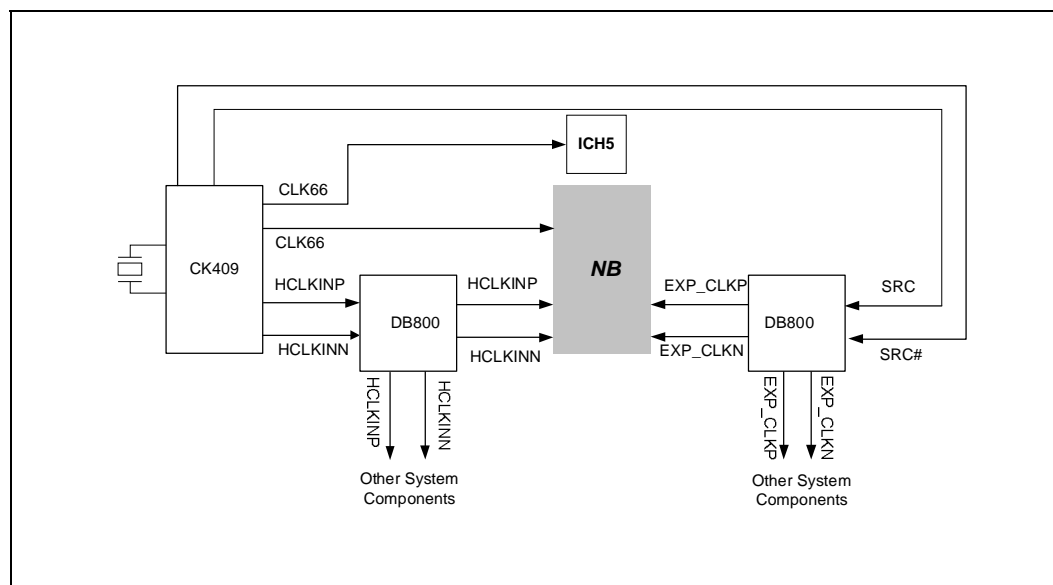
The CK409 is the only clock generator required in a Intel® E8501 chipset platform. Paired with DB800 and DB400 fan-out buffers, this clock solution supplies the reference clocks to all processor and chipset agents. The NB derives the front side bus request and data strobes, XDP debugger data strobes, General Purpose I/O (GPIO) I<sup>2</sup>C clock, and the SMBus clock from its reference clock.

The reference clock supplying the processors and NB is called “HCLKIN”. The processors and NB populate a low-skew, highly phase-coherent “Common Clock” HCLKIN domain.

Another clock supplied the NB and ICH5 is the Hub Interface Clock, or “CLK66”. The NB and ICH5 populate a low-skew, highly phase-coherent “Common Clock” CLK66 domain. CLK66 can be asynchronous to any other clock on the platform. There is no phase coherence required between HCLKIN and CLK66.

The CK409 also supplies the NB with the PCI Express Clock, or “EXP\_CLK”. The PCI Express connections between the NB and PCI Express may be driven from different DB800/DB400 buffers due to their tight part-per-million (ppm) frequency tolerance. Clock skew control between these agents is not required.

**Figure 2-3. Intel® E8501 Chipset North Bridge (NB) Reference Clocks**



## 2.5 Interrupt Delivery

The Intel® E8501 chipset supports both the xAPIC and traditional 8259 methods of interrupt delivery. I/O interrupts, and Inter-Processor Interrupts (IPIs) appear as write or interrupt transactions in the system and are delivered to the target processor via the front side bus. This chipset does not support the three-wire sideband bus (the APIC bus). xAPIC interrupts that are generated from I/O devices will need to go through an I/O(x)APIC device unless the device

supports Message Signalled Interrupts (MSI). In this document, I/O(x)APIC is an interrupt controller. This functionality will be embedded into the Intel 6700PXH 64-bit PCI Hub and ICH5 components of the chipset.

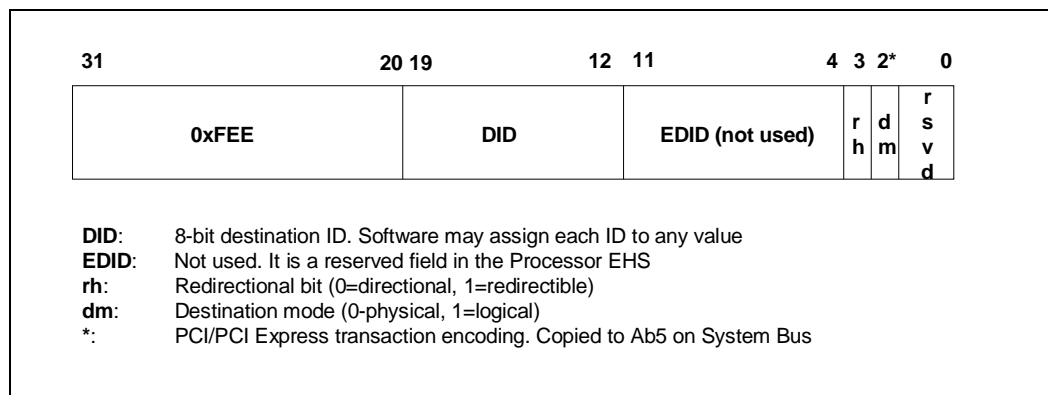
The legacy 8259 functionality is embedded in the ICH5 component. The Intel® E8501 chipset will support inband 8259 interrupt messages from PCI Express devices for boot. The chipset also supports the processor-generated “interrupt acknowledge” (for legacy 8259 interrupts), and “end-of-interrupt” transactions (xAPIC).

## 2.5.1 xAPIC Interrupt Message Delivery

The xAPIC interrupt architectures deliver interrupts to the target processor core via interrupt messages presented on the front side bus. Interrupts can originate from I/O(x)APIC devices or processors in the system. Interrupts generated by I/O(x)APIC are in the form of writes with a specific address encoding. Interrupts generated by the processor appear on the front side bus as transactions with a similar address encoding, and a specific encoding on the REQa/REQb signals (REQa=01001, REQb=11100).

The xAPIC architecture provides for lowest priority delivery through interrupt redirection by the chipset. If the redirectable “hint bit” is set in the xAPIC message, the chipset may redirect the interrupt to another processor. Note that redirection of interrupts can be to any processor on either Front Side Bus ID and can be applied to both I/O interrupts and IPIs. The redirection can be performed in logical (flat or clustered) and physical destination modes (these modes are explained in section 6.8.2.2). [Figure 2-4](#) shows the address definition in an IA-32 system (xAPIC). For more information on xAPIC refer to [Section 6.8.1, “xAPIC Interrupt Message Delivery” on page 333](#).

**Figure 2-4. xAPIC Address Encoding**



The data field of an interrupt transaction is included in [Table 2-1](#) for reference.

**Table 2-1. XAPIC Data Encoding**

| D[63:16] | D[15]        | D[14]           | D[13:11] | D[10:8]       | D[7:0] |
|----------|--------------|-----------------|----------|---------------|--------|
| X        | Trigger Mode | Delivery Status | X        | delivery Mode | Vector |



## 2.6 Intel® E8501 Chipset North Bridge (NB) RAS Features

The NB provides a rich set of RAS (Reliability, Availability and Serviceability) features at all its logical interfaces to assure high data integrity, system availability and manageability of the system.

### 2.6.1 Data Integrity (Error Detection)

The NB provides data integrity throughout the component by employing ECC (Error Correcting Codes), CRC (Cyclic Redundancy Checks) and parity on its logical interfaces (Front Side Bus, IMI, PCI Express and HII.5) as well as ECC on its own internal data paths and buffers (Refer to Figure 2-5).

#### 2.6.1.1 Front Side Bus Interface

- Parity protection on the address lines.
- ECC protection on the data bus.

#### 2.6.1.2 Independent Memory Interface (IMI)

- CRC on outbound control packets.
- CRC and x8 SDDC on inbound data packets.
- Re-issue capability on detected packets that contain a packet CRC errors (errors bad packet will be discarded).
- Transaction ID contained in each packet.
- Transaction retry on time-out or uncorrectable errors.
- 3 virtual signals for errors: FATAL, Uncorrectable and Correctable.
- Hot-Pluggable

#### 2.6.1.3 PCI Express Interface

- 8B/10B encoding at the physical layer.
- CRC on all packets for further data protection (The illegal codes can be detected since not all 8B/10B encoding is used).
- Additional link level mechanisms:

##### **PCI Express Training**

Synchronizes the two end of the interface without software intervention to ensure a robust connection.

##### **PCI Express Retry**

If packets contain errors, the packet will be discarded and the sending end of the interface gets signaled. The sending hardware will re-transmit the particular packet in question and all following packets. Although this will cause a temporary interruption in the delivery of packets, it does so in order to maintain the link integrity.

##### **PCI Express Recovery**

When enough errors occur, the PCI Express link may enter into a quick training sequence,

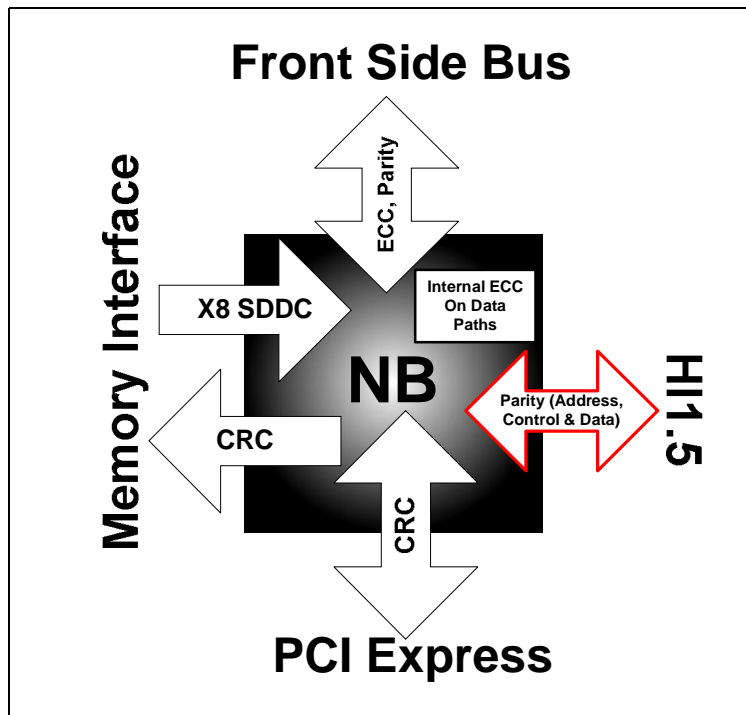
referred to as recovery sequence. At this time, the connections will not be renegotiated, but the adjustment of skew between lanes of the link may occur.

### 2.6.1.4 Legacy Hub Interface (HI1.5)

- Even parity protection scheme over the data signals.

Figure 2-5 summarizes the error detection method at each logical interface of the NB.

**Figure 2-5. Intel® E8501 Chipset North Bridge (NB) Data Integrity Map**



## 2.6.2 Error Reporting

The NB is the collection point for a variety of errors that are either detected internally or signaled from the external interfaces (Front Side Bus, PCI Express and IMI). All detected errors are logged in the two provided registers, FERRST (first error status register), and NERRST (next error status register). First fatal and/or first non-fatal errors are flagged in the FERRST register and subsequent errors are indicated in the NERRST. There are some errors that trigger multiple errors within a component. In that case, these errors will be logged in both FERRST and NERRST. There are control and data logs associated with some of the errors flagged in the FERRST. In some cases, the logs are duplicated for the same error (for example, the four PCI Express interfaces on the NB will have identical error log registers). When error logs are duplicated, a pointer to the interface that reported the first error is provided.

The contents of FERRST and NERRST are “sticky” across a reset (while PWRGOOD remains asserted). This provides the ability for firmware to perform diagnostics across reboots. For more information on the error registers refer to [Section 4](#).

### 2.6.3 Memory Mirroring

The Memory Mirroring enables redundancy by always keeping an exact duplicate of memory accessible. The Memory Mirroring logic is located in the NB and is a user selectable feature. At configuration time, the user can enable mirroring and select which IMI Ports are mirrored. The IMI port mirroring options are as follows:

- IMI Port A and B are mirrored, IMI Port C and D are mirrored.
- IMI Port A and C are mirrored, IMI Port B and D are mirrored.

Mirroring control registers include REDUN ([Section 4.19.9](#)), IMIST ([Section 4.13.9](#)) and IMIHPC ([Section 4.13.10](#)) registers.

For a detailed description of mirroring, including the Hot-Plug and re-silvering in mirroring mode, refer to [Section 6.3](#).

### 2.6.4 Memory RAID

The Memory RAID enables the data to be reconstructed upon failure behind the IMI ports. The Memory RAID logic is located in the NB and is a user selectable feature. At configuration time, the user can enable memory RAID.

**Note:** The NB cannot be configured to be in Memory Mirroring Mode and RAID mode at the same time, as these features are mutually exclusive. Also, in order to enable the Memory RAID, the platform must be configured with four XMBs with matching memory configurations.

Raid control registers include REDUN ([Section 4.19.9](#)), IMIST ([Section 4.13.9](#)) and IMIHPC registers ([Section 4.13.10](#)).

For a detailed description of RAID, including the Hot-Plug and re-silvering in RAID mode, refer to [Section 6.3](#).

### 2.6.5 Hot-Plug

**PCI Express** – All the PCI Express ports are Hot-Pluggable. For more information refer to [Section 6.4.8, “Hot-Plug” on page 314](#).

**IMI** – The NB provides the ability to add or remove each XMB and the memory behind it to or from any IMI port interface from a running OS instance. The details of the support will be provided in the future revision of this document. For more information refer to [Section 6.3.8, “IMI Hot-Plug” on page 287](#).

**Note:** In addition to the above Hot-Plug support on the NB, the Intel® E8501 chipset offers Hot-Plug support at the Intel® 6700PXH 64-bit PCI Hub (PCI-X\*) interface as well. For detail on application and implication of this component, please refer to *Intel® 6700PXH 64-bit PCI Hub and Intel® 6702PXH 64-bit PCI Hub Datasheet*.

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## 3 Signal Description

This section provides a detailed description of the Intel® E8501 chipset north bridge (NB) signals. The signals are arranged in functional groups according to their associated interface. The summary of all signals are also captured on [Figure 2-1 “Intel® E8501 Chipset North Bridge \(NB\) Interface Signals” on page 28](#).

### 3.1 Conventions

The terms *assertion* and *de-assertion* are used extensively when describing signals, to avoid confusion when working with a mix of active-high and active-low signals. The term *assert*, or *assertion*, indicates that the signal is active, independent of whether the active level is represented by a high or low voltage. The term *de-assert*, or *de-assertion*, indicates that the signal is inactive.

Signal names may or may not have a “#” appended to them. The “#” symbol at the end of a signal name indicates that the active, or asserted state occurs when the signal is at a low voltage level. When “#” is not present after the signal name the signal is asserted when at the high voltage level.

Differential signal pairs adopt a “{P/N}” suffix to indicate the “positive” (P) or “negative” (N) signal in the pair. If a “#” is appended, it will be appended to both.

When discussing data values used inside the component, the logical value is used (i.e. a data value described as “1101b” would appear as “1101b” on an active-high bus, and as “0010b” on an active-low bus). When discussing the assertion of a value on the actual signal, the physical value is used (i.e. asserting an active-low signal produces a “0” value on the signal).

Some signals or groups of signals have multiple versions. These signal groups may represent distinct but similar ports or interfaces, or may represent identical copies of the signal used to reduce loading effects. [Table 3-1](#) shows the conventions used in this document.

Curly-bracketed, non-trailing numerical indices (e.g. “{X/Y}”) represent replications of major buses. Square-bracketed numerical indices (e.g. “[n:m]”) represent functionally similar but logically distinct bus signals; each signal provides an independent control, and may or may not be asserted at the same time as the other signals in the grouping). In contrast, trailing curly-bracketed numerical indices, e.g., “{x/y}” typically represent identical duplicates of a signal that are provided for electrical reasons.

**Table 3-1. Signal Naming Conventions**

| Convention      | Expands to  |
|-----------------|---|
| RR{A/B/C}XX     | <b>Expands to:</b> RRAXX, RRBXX, and RRCXX. This denotes similar signals on replicated buses. |
| RR[2:0]         | <b>Expands to:</b> RR[2], RR[1], and RR[0]. This denotes a bus.                               |
| RR{A/B/C}       | <b>Expands to:</b> RRA, RRB, and RRC. This denotes electrical duplicates.                     |
| RR# or RR[2:0]# | Denotes an active low signal or bus.  |

Table 3-2 lists the reference terminology used for signal types.

**Table 3-2. Buffer Signal Directions**

| Buffer Direction | Description                         |
|------------------|-------------------------------------|
| I                | Input Signal                        |
| O                | Output Signal                       |
| A                | Analog                              |
| I/O              | Bidirectional (Input/Output) Signal |

## 3.2 FSB Signals

**Table 3-3. Intel® E8501 Chipset North Bridge (NB) Signals (FSB) (Sheet 1 of 3)**

| Signal              | Type | Description  |
|---------------------|------|--|
| H_{A/B}_A[39:3]#    | I/O  | <b>Address Signals:</b> Processor Address Bus. During processor cycles these are inputs. The NB drives A[39:3]# for transactions originating from PCI Express, other FSB, and for deferred reply transactions.   |
| H_{A/B}_ADS#        | I/O  | <b>Address/Data Strobe:</b> Indicates the first cycle of any request phase. This signal is driven and sampled by the NB.   |
| H_{A/B}_ADSTB[1:0]# | I/O  | <b>Address Strobes:</b> Used to transfer requests at the x2 rate. The falling edge of the strobe transfers the 1st subphase. The rising edge of the strobe transfers the 2nd subphase.   |
| H_{A/B}_AP[1:0]#    | I/O  | <b>Address Parity:</b> Parity protection on the address and request bus. The NB will generate AP[1:0]# for its own transactions. The NB will also monitor AP[1:0]# for all transactions and check parity on the address bus.   |
| H_{A/B}_BINIT#      | I/O  | <b>Bus Initialization:</b> Processor assertions are logged as “F2” errors. The NB does not assert this signal.   |
| H_{A/B}_BNR#        | I/O  | <b>Block Next Request:</b> The NB monitors processor assertions of this signal to block any of the NB's transactions from being issued on the bus.   |
| H_{A/B}_BPM[5:4]#   | I/O  | <b>Breakpoint / Debug Bus:</b> This group of signals is used by the system debug logic and by the NB for communicating debug information. BPM[5:4] are used as breakpoint triggers.  |
| H_{A/B}_BPRI#       | O    | <b>Priority Agent Bus Request:</b> The NB asserts this signal to drive requests originating from the PCI Express and HI ports, snoops from the other FSB, and to issue a deferred reply transaction in some special cases. The NB will also assert this signal to block the processors from issuing transactions. Symmetric agents do not assert this signal. The NB does not observe this signal. |
| H_{A/B}_BREQ[0]#    | I/O  | <b>Physical Bus Request:</b> The NB drives BREQ[0]# during POC and de-asserts it one clock after the NB samples reset de-asserted.   |
| H_{A/B}_BREQ[1]#    | I    | <b>Physical Bus Request:</b> The NB does not drive BREQ[1]#, but rather observes active BREQ[1:0] from processors to determine de-assertion of BPRI# to transfer bus ownership to the processor.   |

**Table 3-3. Intel® E8501 Chipset North Bridge (NB) Signals (FSB) (Sheet 2 of 3)**

| Signal            | Type | Description  |
|-------------------|------|--|
| H_{A/B}_D[63:0]#  | I/O  | <b>Data Bus:</b> 64 bits of data driven by the agent responsible for driving data during the Data phase.   |
| H_{A/B}_DBI[3:0]# | I/O  | <b>Data Bus Inversion:</b> Each bit corresponds to one of the FSB data signal group and 8 bits of ECC.   |
| H_{A/B}_DBSY#     | I/O  | <b>Data Bus Busy:</b> Indicates that the data bus is owned by the agent responsible for driving the data during the Data phase. DBSY# assertion does not imply that data is being transferred during that cycle.   |
| H_{A/B}_DEFER#    | O    | <b>Defer:</b> The NB asserts DEFER# for all processor-initiated transactions with DEN# asserted. The NB will also generate deferred responses for these transactions except for the case when an in-order retry is forced.   |
| H_{A/B}_DEP[7:0]# | I/O  | <b>Data Bus Extended Parity:</b> ECC coverage for 64 bits of data (D). The NB generates this ECC when it drives data during the Data phase. The NB also checks the ECC accompanying incoming data.   |
| H_{A/B}_DP[3:0]#  | I/O  | <b>Data Bus Parity</b>   |
| H_{A/B}_DRDY#     | I/O  | <b>Data Ready:</b> Indicates that data is valid on the data bus during any cycle DRDY# is asserted. The NB asserts DRDY# for each valid data transfer.   |
| H_{A/B}_HIT#      | I/O  | <b>Snoop Hit:</b> The NB captures the value of HIT# for transactions that are deferred and returns it using DHIT# during the Deferred Phase.<br>The NB asserts HIT# to initiate a snoop stall (HIT# and HITM# asserted together).  |
| H_{A/B}_HITM#     | I/O  | <b>Snoop Hit with Modified:</b> The NB observes HITM# and when asserted drives TRDY# for implicit writeback.<br>The NB asserts HITM# to initiate a snoop stall (HIT# and HITM# asserted together).   |
| H_{A/B}_ID[7:0]#  | O    | <b>Transaction Identifier:</b> These are driven during the Deferred Phase and indicate the transaction ID of the deferred transaction. On the second clock of the deferred phase (IDS# +1), IDb[1:0]# carries the parity for the ID signals. IDb[2]# renamed as DHIT# is asserted by NB if the snoop phase of the original transaction resulted in HIT#. |
| H_{A/B}_IDS#      | O    | <b>Transaction Identifier Strobe:</b> IDS# is asserted by the NB to indicate the first cycle of the deferred phase.  |
| H_{A/B}_LOCK#     | I    | <b>Bus Lock:</b> Indicates atomicity of transactions.  |
| H_{A/B}_MCERR#    | I/O  | <b>Machine Check Error:</b> MCERR# indicates non-recoverable bus protocol violation.   |
| H_{A/B}_REQ[4:0]# | I/O  | <b>Request Command:</b> The NB issues requests by driving REQ[4:0]# while asserting ADS#. The NB tracks processor requests on REQ[4:0]# upon observing assertions on ADS#.   |
| H_{A/B}_OOD#      | O    | <b>Out Of Order Data:</b> OOD# delivers the data for the deferred phase.   |
| H_{A/B}_RS[2:0]#  | O    | <b>Response Status:</b> Indicates the type of response generated by the NB. Valid responses are Hard Fail, Implicit Writeback, Normal Data, No Data, Deferred, and Retry.  |
| H_{A/B}_RSP#      | O    | <b>Response Status Parity:</b> Parity protection on RS[2:0]#.  |

Table 3-3. Intel® E8501 Chipset North Bridge (NB) Signals (FSB) (Sheet 3 of 3)

| Signal              | Type | Description  |
|---------------------|------|--|
| H_{A/B}_DSTBN[3:0]# | I/O  | <b>Negative Data Strobes:</b> Used to transfer data at the x4 rate. DSTBN[3:0]# is the negative phase data strobe. Data transfer for subphases 2 and 4 occur on the falling edges of STBN#. The NB drives and samples DSTBN[3:0]#. |
| H_{A/B}_DSTBP[3:0]# | I/O  | <b>Positive Data Strobes:</b> Used to transfer data at the x4 rate. DSTBP[3:0]# is the positive phase data strobe. Data transfer for subphases 1 and 3 occur on the falling edges of STBP#. The NB drives and samples DSTBP[3:0]#. |
| H_{A/B}_TRDY#       | O    | <b>Target Ready:</b> The NB asserts TRDY# when it is ready to accept data from the processor.  |
| H_{A/B}_VREF[2:0]   | A    | <b>FSB AGTL+ Receiver Voltage References</b> (0.733 V)   |
| H_CRES              | A    | <b>FSB Compensation Resistor Common:</b> Common (ground) pin for connection to the H_ODTCRES and H_SLWCRES compensation resistors.   |
| H_ODTCRES           | A    | <b>FSB On-Die Termination Compensation Resistors:</b> Compensation resistor that determines the FSB on-die termination.  |
| H_SLWCRES           | A    | <b>FSB Slew Rate Compensation Resistor:</b> Compensation resistor that determines the FSB driver slew rate.  |

### 3.3 Independent Memory Interface (IMI) Signals

Table 3-4. Intel® E8501 Chipset North Bridge (NB) Signals (IMI)

|                          |   |   |
|--------------------------|---|---|
| IMI_{A/B/C/D}_TXP[9:0]   | O | <b>Memory Port Outbound:</b> Signals used for command and write operations.   |
| IMI_{A/B/C/D}_TXN[9:0]   | O | <b>Memory Port Outbound Complement:</b> The complement of the signals used for command and write operations.            |
| IMI_{A/B/C/D}_RXP[17:0]  | I | <b>Memory Port Inbound Data:</b> Signals used for returning data from read operations.                                  |
| IMI_{A/B/C/D}_RXN[17:0]  | I | <b>Memory Port Inbound Data Complement:</b> The complement of the signals used for returning data from read operations. |
| IMI_{A/B/C/D}_LINKP[2:0] | I | <b>Memory Port Inbound Link:</b> Link signals used for command completions.   |
| IMI_{A/B/C/D}_LINKN[2:0] | I | <b>Memory Port Inbound Link Complement:</b> The complement of the link signals used for command completions.            |
| IMI_{A/B/C/D}_ICOMPI     | A | <b>Memory Port Impedance Compensation</b>   |
| IMI_{A/B/C/D}_ICOMPO     | A | <b>Memory Port Impedance Compensation</b>   |
| IMI_{A/B/C/D}_FRAME      | O | <b>IMI Frame</b>  |



## 3.4 PCI Express Ports Signals

Table 3-5. Intel® E8501 Chipset North Bridge (NB) Signals (PCI Express) (Sheet 1 of 2)

| Signal Name                        | Type                    | Description  |       |          |   |                       |   |                         |
|------------------------------------|-------------------------|--|-------|----------|---|-----------------------|---|-------------------------|
| EXP_{A0/A1/B0/B1/C0/C1/D}_TXP[3:0] | O                       | PCI Express Transmit Data (Outbound)   |       |          |   |                       |   |                         |
| EXP_{A0/A1/B0/B1/C0/C1/D}_TXN[3:0] | O                       | PCI Express Outbound Complement  |       |          |   |                       |   |                         |
| EXP_{A0/A1/B0/B1/C0/C1/D}_RXP[3:0] | I                       | PCI Express Receive Data (Inbound)   |       |          |   |                       |   |                         |
| EXP_{A0/A1/B0/B1/C0/C1/D}_RXN[3:0] | I                       | PCI Express Inbound Complement   |       |          |   |                       |   |                         |
| EXP_ICOMP                          | A                       | PCI Express Impedance Compensation   |       |          |   |                       |   |                         |
| EXP_RCOMP                          | A                       | PCI Express Impedance Compensation   |       |          |   |                       |   |                         |
| EXP0_SPEC10A                       | I                       | <b>PCI Express Training State Machine Mode for EXP_{D/C0/C1}</b> : This signal is sampled at the assertion of PWRGOOD. <table><tr><th>Value</th><th>Function</th></tr><tr><td>0</td><td>Use 1.0 Specification</td></tr><tr><td>1</td><td>use 1.0 A Specification</td></tr></table>     | Value | Function | 0 | Use 1.0 Specification | 1 | use 1.0 A Specification |
| Value                              | Function                |  |       |          |   |                       |   |                         |
| 0                                  | Use 1.0 Specification   |  |       |          |   |                       |   |                         |
| 1                                  | use 1.0 A Specification |  |       |          |   |                       |   |                         |
| EXP1_SPEC10A                       | I                       | <b>PCI Express Training State Machine Mode for EXP_{B0/B1/A0/A1}</b> : This signal is sampled at the assertion of PWRGOOD. <table><tr><th>Value</th><th>Function</th></tr><tr><td>0</td><td>Use 1.0 Specification</td></tr><tr><td>1</td><td>use 1.0 A Specification</td></tr></table> | Value | Function | 0 | Use 1.0 Specification | 1 | use 1.0 A Specification |
| Value                              | Function                |  |       |          |   |                       |   |                         |
| 0                                  | Use 1.0 Specification   |  |       |          |   |                       |   |                         |
| 1                                  | use 1.0 A Specification |  |       |          |   |                       |   |                         |
| EXP0_WIDTH[1:0]                    | I                       | <b>PCI Express Link Width Force for EXP_{D/C0/C1}</b> : These signals are sampled at the assertion of PWRGOOD.   |       |          |   |                       |   |                         |
| EXP1_WIDTH0                        | I                       | <b>PCI Express Link Width Force for EXP_{B0/B1/A0/A1}</b> : This signal is sampled at the assertion of PWRGOOD.  |       |          |   |                       |   |                         |
| EXP1_WIDTH1 / EXP_HPINT            | I/O                     | <b>PCI Express Link Width Force for EXP_{B0/B1/A0/A1}</b> : This signal is sampled at the assertion of PWRGOOD.<br><b>PCI Express Hot-Plug Interrupt</b> : The NB asserts this signal to signal a PCI Express hot-plug event.  |       |          |   |                       |   |                         |

Table 3-5. Intel® E8501 Chipset North Bridge (NB) Signals (PCI Express) (Sheet 2 of 2)

| Signal Name            | Type | Description  |
|------------------------|------|--|
| EXP1_WIDTHH2 / PME_OUT | I/O  | <p><b>PCI Express Link Width Force for EXP_{B0/B1/A0/A1}:</b> This signal is sampled at the assertion of PWRGOOD.</p> <p><b>Power Management Event Output:</b> Each PCI (and PCI Express) slot supports a signal called Power Management Event (PME). This signal is used by an I/O device (e.g. a LAN adapter) to wake up a system that is in a sleep state. Traditionally, these pins are routed directly to the ICH. However, with PCI Express, these messages will arrive inband through an ON/OFF pair of messages.</p> <p>To manage this transition (since ICH5 is not on PCI Express), the NB implements the PME Status bit in <a href="#">Section 4.11.49, "EXP_RTSTS[7:1]: PCI Express Root Status Register (D1-7, F0)" on page 4-129</a> for each of the PCI Express ports. There is one bit per port. The NB OR's all the bits together and asserts the PME_OUT signal to the ICH5. When all the bits are clear, the signal is de-asserted.</p> |

### 3.4.1 Industry Standard Naming Convention

The PCI Express signal naming convention used by the NB is different from the standard naming convention specified by PCISIG because the NB naming occurred before the PCISIG convention was ratified.

[Table 3-6](#) correlates the NB signal names to the ratified PCISIG naming convention. Consult this table for help in attaching PCI Express devices to the NB using the standard PCISIG naming convention.

**Table 3-6. Intel® E8501 Chipset North Bridge (NB) Signals (PCI Express)  
Correlated to Industry-Standard Naming Convention (Sheet 1 of 2)**

| Existing Signal Names | PCISIG Naming Equivalent | Existing Signal Names | PCISIG Naming Equivalent |
|-----------------------|--------------------------|-----------------------|--------------------------|
| EXP_A0_RXN0           | PE6Rn0                   | EXP_B0_RXN3           | PE4Rn3                   |
| EXP_A0_RXN1           | PE6Rn1                   | EXP_B0_RXP0           | PE4Rp0                   |
| EXP_A0_RXN2           | PE6Rn2                   | EXP_B0_RXP1           | PE4Rp1                   |
| EXP_A0_RXN3           | PE6Rn3                   | EXP_B0_RXP2           | PE4Rp2                   |
| EXP_A0_RXP0           | PE6Rp0                   | EXP_B0_RXP3           | PE4Rp3                   |
| EXP_A0_RXP1           | PE6Rp1                   | EXP_B0_TXN0           | PE4Tn0                   |
| EXP_A0_RXP2           | PE6Rp2                   | EXP_B0_TXN1           | PE4Tn1                   |
| EXP_A0_RXP3           | PE6Rp3                   | EXP_B0_TXN2           | PE4Tn2                   |
| EXP_A0_TXN0           | PE6Tn0                   | EXP_B0_TXN3           | PE4Tn3                   |
| EXP_A0_TXN1           | PE6Tn1                   | EXP_B0_TXP0           | PE4Tp0                   |
| EXP_A0_TXN2           | PE6Tn2                   | EXP_B0_TXP1           | PE4Tp1                   |
| EXP_A0_TXN3           | PE6Tn3                   | EXP_B0_TXP2           | PE4Tp2                   |
| EXP_A0_TXP0           | PE6Tp0                   | EXP_B0_TXP3           | PE4Tp3                   |
| EXP_A0_TXP1           | PE6Tp1                   | EXP_B1_RXN0           | PE5Rn0                   |
| EXP_A0_TXP2           | PE6Tp2                   | EXP_B1_RXN1           | PE5Rn1                   |
| EXP_A0_TXP3           | PE6Tp3                   | EXP_B1_RXN2           | PE5Rn2                   |
| EXP_A1_RXN0           | PE7Rn0                   | EXP_B1_RXN3           | PE5Rn3                   |
| EXP_A1_RXN1           | PE7Rn1                   | EXP_B1_RXP0           | PE5Rp0                   |
| EXP_A1_RXN2           | PE7Rn2                   | EXP_B1_RXP1           | PE5Rp1                   |
| EXP_A1_RXN3           | PE7Rn3                   | EXP_B1_RXP2           | PE5Rp2                   |
| EXP_A1_RXP0           | PE7Rp0                   | EXP_B1_RXP3           | PE5Rp3                   |
| EXP_A1_RXP1           | PE7Rp1                   | EXP_B1_TXN0           | PE5Tn0                   |
| EXP_A1_RXP2           | PE7Rp2                   | EXP_B1_TXN1           | PE5Tn1                   |
| EXP_A1_RXP3           | PE7Rp3                   | EXP_B1_TXN2           | PE5Tn2                   |
| EXP_A1_TXN0           | PE7Tn0                   | EXP_B1_TXN3           | PE5Tn3                   |
| EXP_A1_TXN1           | PE7Tn1                   | EXP_B1_TXP0           | PE5Tp0                   |
| EXP_A1_TXN2           | PE7Tn2                   | EXP_B1_TXP1           | PE5Tp1                   |
| EXP_A1_TXN3           | PE7Tn3                   | EXP_B1_TXP2           | PE5Tp2                   |
| EXP_A1_TXP0           | PE7Tp0                   | EXP_B1_TXP3           | PE5Tp3                   |
| EXP_A1_TXP1           | PE7Tp1                   | EXP_C0_RXN0           | PE2Rn0                   |
| EXP_A1_TXP2           | PE7Tp2                   | EXP_C0_RXN1           | PE2Rn1                   |
| EXP_A1_TXP3           | PE7Tp3                   | EXP_C0_RXN2           | PE2Rn2                   |
| EXP_B0_RXN0           | PE4Rn0                   | EXP_C0_RXN3           | PE2Rn3                   |

**Table 3-6. Intel® E8501 Chipset North Bridge (NB) Signals (PCI Express)  
Correlated to Industry-Standard Naming Convention (Sheet 2 of 2)**

| Existing Signal Names | PCISIG Naming Equivalent | Existing Signal Names | PCISIG Naming Equivalent |
|-----------------------|--------------------------|-----------------------|--------------------------|
| EXP_B0_RXN1           | PE4Rn1                   | EXP_C0_RXP0           | PE2Rp0                   |
| EXP_B0_RXN2           | PE4Rn2                   | EXP_C0_RXP1           | PE2Rp1                   |
| EXP_C0_RXP2           | PE2Rp2                   | EXP_D_RXN2            | PE1Rn2                   |
| EXP_C0_RXP3           | PE2Rp3                   | EXP_D_RXN3            | PE1Rn3                   |
| EXP_C0_TXN0           | PE2Tn0                   | EXP_D_RXP0            | PE1Rp0                   |
| EXP_C0_TXN1           | PE2Tn1                   | EXP_D_RXP1            | PE1Rp1                   |
| EXP_C0_TXN2           | PE2Tn2                   | EXP_D_RXP2            | PE1Rp2                   |
| EXP_C0_TXN3           | PE2Tn3                   | EXP_D_RXP3            | PE1Rp3                   |
| EXP_C0_TXP0           | PE2Tp0                   | EXP_D_TXN0            | PE1Tn0                   |
| EXP_C0_TXP1           | PE2Tp1                   | EXP_D_TXN1            | PE1Tn1                   |
| EXP_C0_TXP2           | PE2Tp2                   | EXP_D_TXN2            | PE1Tn2                   |
| EXP_C0_TXP3           | PE2Tp3                   | EXP_D_TXN3            | PE1Tn3                   |
| EXP_C1_RXN0           | PE3Rn0                   | EXP_D_TXP0            | PE1Tp0                   |
| EXP_C1_RXN1           | PE3Rn1                   | EXP_D_TXP1            | PE1Tp1                   |
| EXP_C1_RXN2           | PE3Rn2                   | EXP_D_TXP2            | PE1Tp2                   |
| EXP_C1_RXN3           | PE3Rn3                   | EXP_D_TXP3            | PE1Tp3                   |
| EXP_C1_RXP0           | PE3Rp0                   | EXP_CLKN              | PECLKN                   |
| EXP_C1_RXP1           | PE3Rp1                   | EXP_CLKP              | PECLKP                   |
| EXP_C1_RXP2           | PE3Rp2                   | EXP_HPINT/EXP1_WIDTH1 | PE1WIDTH[1]              |
| EXP_C1_RXP3           | PE3Rp3                   | EXP_ICOMPI            | PEICOMPI                 |
| EXP_C1_TXN0           | PE3Tn0                   | EXP_RCOMP             | PERCOMP                  |
| EXP_C1_TXN1           | PE3Tn1                   | EXP_VCCA              | VCCAPE                   |
| EXP_C1_TXN2           | PE3Tn2                   | EXP_VCCBG             | VCCABGPE                 |
| EXP_C1_TXN3           | PE3Tn3                   | EXP_VSSA              | VSSAPE                   |
| EXP_C1_TXP0           | PE3Tp0                   | EXP_VSSBG             | VSSBGPE                  |
| EXP_C1_TXP1           | PE3Tp1                   | EXP0_Spec10A          | PE0Spec10a               |
| EXP_C1_TXP2           | PE3Tp2                   | EXP0_WIDTH0           | PE0WIDTH[0]              |
| EXP_C1_TXP3           | PE3Tp3                   | EXP0_WIDTH1           | PE0WIDTH[1]              |
| EXP_D_RXN0            | PE1Rn0                   | EXP1_Spec10A          | PE1Spec10a               |
| EXP_D_RXN1            | PE1Rn1                   | EXP1_WIDTH0           | PE1WIDTH[0]              |

## 3.5 Hub Interface 1.5 (HI1.5) Signals

**Table 3-7. Intel® E8501 Chipset North Bridge (NB) Signals (Hub Interface)**

| Signal Name | Type | Description  |
|-------------|------|--|
| HI[11:0]    | I/O  | <b>Data pins:</b> The data interface.  |
| HI_STBF     | I/O  | <b>First Packet Data Interface Strobe:</b> (idle & default voltage level = H_VCCA) together provide timing for 4X and 1X data transfer on the data interface. The agent that is providing data drives this signal. HI_STBF and HI_STBS should be sensed pseudo-differentially at the receiver. |
| HI_STBS     | I/O  | <b>Second Packet Data Interface Strobe:</b> See HI_STBF description above.   |
| HIRCOMP     | A    | <b>HI RCompensation:</b> Connects to the external RCOMP resistor and used for impedance matching.  |
| HIVREF      | A    | <b>HI Voltage Reference:</b> Receiver threshold (0.35 V reference voltage).  |
| HIVSWING    | A    | <b>HI Voltage Swing:</b> A voltage reference (0.8 v to 0.7 v) used by the RCOMP circuits to adjust the I/O drivers' strength and maximum signal voltage to be driven onto the board.   |

## 3.6 Clocking and Analog Power Signals

**Table 3-8. Intel® E8501 Chipset North Bridge (NB) Signals (Clocking and Analog Power) (Sheet 1 of 2)**

| Signal Name | Type | Description  |
|-------------|------|--|
| CLK66       | I    | <b>Clock 66:</b> 66 MHz clock for HI1.5. Synchronization to EXP_CLK or HCLKIN not required. Bypass clock in bypass mode.   |
| EXP_CLKN    | I    | <b>PCI EXPRESS Clock Complement:</b> This is the other differential reference clock input to the PCI Express Phase Locked Loops. Synchronization to H_CLK or CLK66 not required. |
| EXP_CLKP    | I    | <b>PCI EXPRESS Clock:</b> This is one of the two differential reference clock inputs to the PCI Express Phase Locked Loops. Synchronization to H_CLK or CLK66 not required.      |
| EXP_VCCA    | A    | <b>VCC:</b> Analog Voltage for the PCI Express PLL's.  |
| EXP_VCCBG   | A    | <b>VCC:</b> Bandgap Voltage for the PCI Express.   |
| EXP_VSSA    | A    | <b>VSS:</b> Analog Voltage for the PCI Express PLL's.  |
| EXP_VSSBG   | A    | <b>VSS:</b> Bandgap Voltage for the PCI Express.   |
| H_VCCA      | A    | <b>VCC:</b> Analog Voltage for the FSB PLL.  |
| H_VSSA      | A    | <b>VSS:</b> Analog Voltage for the FSB PLL.  |

**Table 3-8. Intel® E8501 Chipset North Bridge (NB) Signals  
(Clocking and Analog Power) (Sheet 2 of 2)**

| Signal Name         | Type | Description  |
|---------------------|------|--|
| HCLKINN             | I    | <b>FSB Clock Complement:</b> This is the other differential reference clock input to the Phase Locked Loop in the NB core. Phase Locked Loops in the NB will shift this to all frequencies required by the core, FSB, and SMBus ports. |
| HCLKINP             | I    | <b>FSB Clock:</b> This is one of the two differential reference clock inputs to the Phase Locked Loop in the NB core. Phase Locked Loops in the NB will shift this to all frequencies required by the core, FSB, and SMBus ports.      |
| HI_VCCA             | A    | <b>VCC:</b> Analog Voltage for the Hub Interface PLL.  |
| HI_VSSA             | A    | <b>VSS:</b> Analog Voltage for the Hub Interface PLL.  |
| IMI_{A/B/C/D}_CLKN  | I    | <b>Independent Memory Interface Clock Complement:</b> This is the other differential reference clock input to the Phase Locked Loop in the NB IMI.   |
| IMI_{A/B/C/D}_CLKP  | I    | <b>Independent Memory Interface Clock:</b> This is one of the two differential reference clock inputs to the Phase Locked Loop in the NB IMI.  |
| IMI_{A/B/C/D}_VCCA  | A    | <b>VCC:</b> Analog Voltage for the Independent Memory Interface PLL's. One for each IMI.   |
| IMI_{A/B/C/D}_VCCBG | A    | <b>VCC:</b> Bandgap Voltage for the Independent Memory Interfaces. One for each IMI.   |
| IMI_{A/B/C/D}_VSSA  | A    | <b>VSS:</b> Analog Voltage for the Independent Memory Interface PLL's. One for each IMI.   |
| IMI_{A/B/C/D}_VSSBG | A    | <b>VSS:</b> Bandgap Voltage for the Independent Memory Interfaces. One for each XMI.   |
| VCCA                | A    | <b>VCC:</b> Analog Voltage for the core PLL.   |
| VSSA                | A    | <b>VSS:</b> Analog Voltage for the core PLL.   |
| V3REF[1:0]          | A    | <b>Voltage Reference:</b> Reference Voltage for 3.3 V signal tolerance.  |

## 3.7 Reset Signals

Table 3-9. Intel® E8501 Chipset North Bridge (NB) Signals (Reset)

| Signal Name        | Type | Description   |
|--------------------|------|---|
| H_{A/B}_RST#       | O    | <b>Host Reset:</b> This signal is the FSB reset. Asserted due to RSTIN# or writes to the SYRE register. Reset on an unpopulated FSB will remain asserted.                     |
| ICHRST#            | O    | <b>ICH5 Reset:</b> 66 MHz synchronized version of the reset input signal to the ICH5.   |
| IMI_{A/B/C/D}_RST# | O    | <b>IMI Port Reset:</b> Assertion resets the XMB.  |
| PWRGOOD            | I    | <b>Power Good:</b> Clears the NB. This signal is held low until all power supplies are in specification. This signal may be pulsed after power-up to completely reset the NB. |
| RSTIN#             | I    | <b>Reset Input:</b> This is the hard reset input to the NB.   |

## 3.8 Debug Signals

Table 3-10. Intel® E8501 Chipset North Bridge (NB) Signals (Test and Debug) (Sheet 1 of 2)

| Signal Name  | Type | Description  |
|--------------|------|--|
| ITP_TCK      | I    | <b>Test Clock:</b> Clock input used to drive Test Access Port (TAP) state machine during test and debugging. This input may change asynchronous to HCLK.   |
| ITP_TDI      | I    | <b>Test Data In:</b> Data input for test mode. Used to serially shift data and instructions into TAP.  |
| ITP_TDO      | O    | <b>Test Data Out:</b> Data output for test mode. Used to serially shift data out of the device.  |
| ITP_TEST     | I    | <b>Test Mode:</b> An assertion of this signal places the component into test mode. A leading-edge transition on this signal will also sample static test mode functions from the “overloaded” signals. |
| ITP_TMS      | I    | <b>Test Mode Select:</b> This signal is used to control the state of the TAP controller.   |
| ITP_TRST#    | I    | <b>Test Reset:</b> This signal resets the TAP controller logic. It should be pulled down unless ITP_TCK is active. This input may change asynchronous to BUSCLK.                                       |
| XDP_CRES     | I    | <b>Debug Bus Compensation Resistor Common:</b> Common (ground) pin for connection to the XDP_ODTCRES and XDP_SLWCRES compensation resistors.   |
| XDP_D[15:0]# | I/O  | <b>Debug Bus Data:</b> XDP debug control/data signals and manufacturing test mode. Includes clock/PLL debug signals.   |

Table 3-10. Intel® E8501 Chipset North Bridge (NB) Signals (Test and Debug) (Sheet 2 of 2)

| Signal Name | Type | Description  |
|-------------|------|--|
| XDP_DSTBN#  | I/O  | <b>Negative Debug Bus Strobe:</b> Used to transfer data at the 4x rate. XDP_DSTBP# is the positive strobe. Transfer occurs on the rising edges of XDP_DSTBN#. The NB drives and samples XDP_DSTBN#.  |
| XDP_DSTBP#  | I/O  | <b>Positive Debug Bus Strobe:</b> Used to transfer data at the 4x rate. XDP_DSTBN# is the negative strobe. Transfer occurs on the falling edges of XDP_DSTBP#. The NB drives and samples XDP_DSTBP#. |
| XDP_ODTCRES | I    | <b>Debug Bus On-Die Termination Compensation Resistors:</b> Compensation resistor that determines the FSB on-die termination.  |
| XDP_RDY#    | I/O  | <b>Debug Bus Ready</b>   |
| XDP_SLWCRES | I    | <b>Debug Bus Slew Rate Compensation Resistor:</b> Compensation resistor that determines the FSB driver slew rate.  |

## 3.9 RAS Signal

Table 3-11. Intel® E8501 Chipset North Bridge (NB) Signals (RAS) (Sheet 1 of 2)

| Signal Name             | Type   | Description   |       |          |   |  |   |  |
|-------------------------|--|---|-------|----------|---|--|---|--|
| PME_OUT / EXP1_WIDTH2   | I/O  | See Table 3-5.  |       |          |   |  |   |  |
| EXP_HPINT / EXP1_WIDTH1 | I/O  | See Table 3-5.  |       |          |   |  |   |  |
| IMI_HPINT               | I/O  | <p><b>IMI Hot-Plug Interrupt:</b> The NB asserts IMI_HPINT to signal an IMI hot-plug event. Also used as Processor Strap.</p> <table><tr><th>Strap</th><th>Function</th></tr><tr><td>0</td><td>64-bit Intel® Xeon® processor MP with 1MB L2 cache or Dual-Core Intel® Xeon® processor 7000 sequence</td></tr><tr><td>1</td><td>64-bit Intel® Xeon® processor MP with up to 8MB L3 cache</td></tr></table> | Strap | Function | 0 | 64-bit Intel® Xeon® processor MP with 1MB L2 cache or Dual-Core Intel® Xeon® processor 7000 sequence | 1 | 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache |
| Strap                   | Function   |   |       |          |   |  |   |  |
| 0                       | 64-bit Intel® Xeon® processor MP with 1MB L2 cache or Dual-Core Intel® Xeon® processor 7000 sequence |   |       |          |   |  |   |  |
| 1                       | 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache   |   |       |          |   |  |   |  |
| GP_SMBCLK               | I/O  | <b>General Purpose I/O Clock:</b> SMBus master clock for a bank of general-purpose I/O which can be connected to the hot-plug controller.   |       |          |   |  |   |  |
| GP_SMBDATA              | I/O  | <b>General Purpose I/O Data:</b> SMBus data for a bank of general-purpose I/O which can be connected to the hot-plug controller.  |       |          |   |  |   |  |



Table 3-11. Intel® E8501 Chipset North Bridge (NB) Signals (RAS) (Sheet 2 of 2)

| Signal Name | Type | Description  |
|-------------|------|--|
| SMBCLK      | I    | <b>System Management Bus Clock:</b> SMBus slave clock for the system management bus. Provides access to configuration registers only. This input may change asynchronously with respect to HCLK. |
| SMBDATA     | I/O  | <b>System Management Bus Address/Data:</b> SMBus data for the system management bus. Provides access to configuration registers only. This input may change asynchronously with respect to HCLK. |
| ERR[2:0]#   | O    | <b>ERROR:</b><br>Assertion time is 18 cycles. Multiple errors on the same signal occurring during an assertion will not be distinguishable as separate events.                                   |

## 3.10 Miscellaneous Signals

Table 3-12. Miscellaneous Signals

| Signal Name | Type | Description   |
|-------------|------|---|
| TESTHI      | N/A  | <b>High Test Pin:</b> Should be pulled high to P1V5 (VCC) on customer platforms. For the locations of these signals on the NB package, refer to <a href="#">Table 7-2 “NB Pin List (by Signal Name)” on page 7-373</a> .  |
| TESTLO      | N/A  | <b>Low Test Pin:</b> Should be pulled low to VSS on customer platforms. For the locations of these signals on the NB package, refer to <a href="#">Table 7-2 “NB Pin List (by Signal Name)” on page 7-373</a> .   |
| RESERVED    | N/A  | <b>Reserved:</b> All reserved pins must be left unconnected. Connection of these pins to VCC, VSS, or to any other signal (including each other) can result in component malfunction.<br><br>For the location of these signals on the NB package, refer to <a href="#">Table 7-2 “NB Pin List (by Signal Name)” on page 7-373</a> . |

§



## 4 Register Description

The Intel® E8501 chipset North Bridge (NB) configuration registers provide functionality, flexibility and settings that can be used to optimize performance of the chipset.

The NB registers can be accessed by a memory mapped register access mechanism, a PCI configuration access mechanism (only PCI space registers), and register access mechanisms through JTAG and SMBus. The memory mapped access mechanism is further broken down into different ranges. The internal registers of this chipset can be accessed in Byte, Word (16-bit), or Dword (32-bit) quantities, with the exception of CFGADR which can only be accessed as a Dword. All multi-byte numeric fields use “little-endian” ordering (i.e., lower addresses contain the least significant parts of the field). The NB can also forward accesses to all IMI and PCI/PCI Express device configuration registers through the same mechanisms.

This chapter describes how the configuration spaces in the NB are organized and accessed. Registers are described in the order of the layout by device and offset. For configuration spaces on the XMB, please refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

### 4.1 Register Terminology

Each of the bits in the configuration registers have specific attributes. The following table defines all the attribute types. With the exception of the Sticky bits, all bits will be set to their default values by a hard reset.

**Table 4-1. Register Attribute Definition (Sheet 1 of 2)**

| Attribute | Definition       | Description   |
|-----------|------------------|---|
| RO        | Read Only        | The bit is set by the hardware only and software can only read the bit. Writes to the register have no effect.  |
| WO        | Write Only       | The bit is not implemented as a bit. The write causes some hardware event to take place.  |
| RW        | Read/Write       | The bit can be both read and/or written by software.  |
| RWC       | Read/Write Clear | The bit can be either read or cleared by software. In order to clear this bit, the software must write a “1” to it. Writing a “0” to this bit will have no effect.  |
| RWS       | Read/Write Set   | The bit can be either read or set by software. In order to set this bit, the software must write a “1” to it. Writing a “0” to this bit will have no effect. Hardware will clear this bit.  |
| RWL       | Read/Write Lock  | The bit can be read and written by software. Hardware or a configuration bit can lock this bit and prevent it from being updated.   |
| RWO       | Read/Write Once  | The bit can be read by software. It can also be written by software, but the hardware prevents writing/setting it more than once without a prior hard reset. This protection applies on a bit-by-bit basis. For example, if the RWO field is two bits and only one bit is written, then the written bit cannot be rewritten (unless reset). However, the unwritten byte can still be written once. This is a special form of RWL. |

Table 4-1. Register Attribute Definition (Sheet 2 of 2)

| Attribute                                      | Definition            | Description  |
|--|-----------------------|--|
| Any of the above with "ST" appended to the end | Sticky                | The bit is "sticky" or unchanged by a hard reset. These bits can only be cleared by a PWRGOOD reset.   |
| RV   | Reserved              | This bit is reserved for future expansion and must not be written. The <i>PCI Local Bus Specification, Revision 2.2</i> requires that reserved bits must be preserved. Any software that modifies a register that contains a reserved bit is responsible for reading the register, modifying the desired bits, and writing back the result. Intel highly recommends not changing the default value of Reserved bits. |
| RRW  | Read Restricted Write | This bit can be read and written by software. However, only supported values will be written. Writes of non-supported values will have no effect.  |

## 4.2 Platform Configuration

Intel® E8501 chipset registers are organized to adhere to the PCI / PCI Express configuration organization. PCI/PCI Express configuration space registers reside on the NB, XMB, ICH5, and on components attached to the PCI Express ports. It can accommodate PCI's 256 distinct buses, 32 devices per bus, 8 functions per device and 64 registers per function. In addition, it can also accommodate the PCI Express enhanced configuration space addressing. The PCI Express enhanced configuration space includes an additional 4-bit extended register address which allows for 16 PCI compatible ranges. The extended region provides addressability of up to 4x16 M configuration registers. Different levels of abstraction are provided by Buses, Devices, Functions, and PCI Express extended register address. The extended PCI Express region can only be accessed through the memory mapped register mechanism.

The Intel® E8501 chipset register set conforms to the minimum necessary subset of PCI to PCI bridge standard registers to aid in software enumeration (required for the PCI Express ports/links).

The NB and ICH5 are physically connected by a legacy Hub Interface port. From a configuration standpoint, the Hub Interface port is the logical PCI/PCI Express bus #0. The NB, XMB, and ICH5 are hard coded to bus #0. The NB/XMB functions and the NB/PCI Express ports on the NB will be different devices on bus #0. The PCI Express devices connected to the NB/PCI Express ports will have programmable bus numbers. The PCI bus connected to the ICH5 will also have a programmable bus number. For a list of all device numbers please refer to [Table 4-8](#).

## 4.3 Conflict Resolution and Usage Model Limitations

The following assumptions are made about the different types of configuration accesses and which ones can be concurrent. These are considered software constraints.

- Only one PCI (legacy PCI Express) configuration access from all processors at a time.

In all cases, the NB can serialize all allowable concurrent configuration accesses.

Table 4-2 summarizes what configuration accesses can be attempted concurrently to the Intel® E8501 chipset registers. This table only applies to the NB and XMB registers. It does not apply to registers that truncates forwards such as a register on a downstream PCI Express device.

**Table 4-2. Intel® E8501 Chipset Concurrent Configuration Accesses**

|                         | Proc MMCFG <sup>1</sup> | Proc CF8/CFC Config | JTAG            | SMBus           |
|-------------------------|-------------------------|---------------------|-----------------|-----------------|
| Proc MMCFG <sup>1</sup> | Yes                     | Yes                 | Yes             | Yes             |
| Proc CF8/CFC Config     | Yes                     | No                  | Yes             | Yes             |
| JTAG                    | Yes                     | Yes                 | No <sup>2</sup> | Yes             |
| SMBus                   | Yes                     | Yes                 | Yes             | No <sup>3</sup> |

**NOTES:**

1. Includes all types of MMCFG accesses: PCI Express, and fixed boot.
2. A JTAG access to the NB can occur concurrently with a JTAG access to XMB if a system has 2 independent JTAG controllers, but accesses to the same component will occur one at a time.
3. An SMBus access to the NB can occur concurrently with an access to XMB if the system has 2 independent SMBus controller.

## 4.4 Device Mapping

Each component in an Intel® E8501 chipset system can be uniquely identified. Based on the PCI configuration convention, each component is assigned a Bus Number and Device Number. All the NB registers will appear on Bus #0.

All the NB configuration resides in the configuration space defined by Bus, Device, Function, and Register. Some registers do not appear in all portions of this space and some mechanisms do not access all portions of this space. The following table defines where the various fields of configuration register addresses appear. Each row defines a different access mechanism, register, interface, or decoder. Each column defines a different field of the configuration address.

**Table 4-3. Configuration Address Bit Mapping (Sheet 1 of 2)**

|   | Source/Destination  | Bus                  | Device      | Function      | Dword Offset[11:8]          | Dword Offset[5:0]              | Byte in Dword               | Type                   |
|---|---|----------------------|-------------|---------------|-----------------------------|--------------------------------|-----------------------------|------------------------|
| HI1.5 Config                                | Both  | A[24:16]<br>always 0 | A[15:11]    | A[10:8]       | <b>Cannot Access</b>        | A[7:2]                         | 1 <sup>st</sup> DW BE       | ct                     |
| PCI Express Config Txns                     | Both  | Bus[7:0]             | Device[4:0] | Function[2:0] | Extended Register Addr[3:0] | Register [5:0]                 | 1 <sup>st</sup> DW BE [3:0] | Fmt, Type <sup>1</sup> |
| PCI Express MMCFG on Front Side Bus         | Source  | A[27:20]             | A[19:15]    | A[14:12]      | A[11:8]                     | A[7:3]<br>BE[7:4] <sup>2</sup> | f(BE[7:0]) <sup>3</sup>     | <b>N/A</b>             |
| PCI Express MMCFG from HI1.5 or PCI Express | <b>Forwarded unmodified to peers and are not permitted to access the NB or XMB regs</b> |                      |             |               |                             |                                |                             |                        |

Table 4-3. Configuration Address Bit Mapping (Sheet 2 of 2)

|   | Source/Destination | Bus                            | Device         | Function              | Dword Offset[11:8]          | Dword Offset[5:0]     | Byte in Dword                           | Type |
|---|--------------------|--------------------------------|----------------|-----------------------|-----------------------------|-----------------------|---|------|
| <b>CFGADR Register</b> <sup>4</sup>             | Source             | Bus Number [7:0]               | DeviceID [4:0] | Function Number [2:0] | Not Present                 | Register Address[5:0] | Not Present                             | N/A  |
| <b>CFC on PSB</b>                               | Source             | CFGADR Register, see row above |                |                       |                             |                       | BE[7:4]                                 | N/A  |
| <b>JTAG Config Access</b>                       | Source             | Bus Number [7:0]               | DeviceID [4:0] | Function Number [2:0] | Extended Register Addr[3:0] | Register Address[7:2] | Register Address[1:0]                   | N/A  |
| <b>SMBus Config Access</b>                      | Source             | Bus Number [7:0]               | Dev[4:0]       | Func[2:0]             | Reg Number [11:8]           | Reg[7:2]              | f(command Register Number) <sup>5</sup> | N/A  |
| <b>Fixed NB Memory Mapped on Front Side Bus</b> | Source             | N/A                            | N/A            | A[18:16] <sup>6</sup> | Cannot Access               | A[15:8]               | All accesses are 4 byte                 | N/A  |
| <b>NB Register Decoding</b>                     | Destination        | 00000000                       | See Table 4-8  | Function [2:0]        | Dword Offset[9:6]           | Dword Offset[5:0]     | Byte[3:0]                               | N/A  |
| <b>IMI Config Cmds</b>                          | Destination        | A[24:16] always 0              | A[15:11]       | A[10:8]               | Cannot Access               | A[7:2]                | M[3:0]                                  | 00   |

**NOTES:**

1. Encoded as CfgWr0, CfgWr1, CfgRd0, CfgRd.
2. If BE[7:4]! = 0, DwordOffset[0] = 1.
3. If (BE[3:0]! = 0000, BE[3:0], else BE[7:4]).
4. The fields of this register are written by D[31:0] of a front side bus CF8 access.
5. If Dword Access, 1111. If Byte Access, function of RegisterNumber as follows: BE[0]=RegisterNumber=00, BE[1]=RegisterNumber=01, BE[2]=RegisterNumber=10, BE[3]=RegisterNumber=11.
6. Hard coded value of 00FE60.

## 4.5 Allowable Configuration Access

Intel® E8501 chipset registers can be accessed by various access mechanisms via different interfaces (JTAG, SMBus, I/O (inbound), processor). Table 4-4 defines which registers are accessible using the various mechanisms. For example, JTAG and SMBus configuration accesses can access all chipset registers. The legends and register definitions are defined directly below the table.

**Table 4-4. Configuration Register Accessibility**

| Initiator             | Access Mechanism  | Type Of Register |                                    |                        |                       |
|-----------------------|-------------------|------------------|------------------------------------|------------------------|-----------------------|
|                       |                   | PCIEXP EXT       | BIOS Fixed                         | SPD & other NB/XMB Cfg | Registers South of NB |
| JTAG/SMBus            |                   | Y                | Y                                  | Y                      | Y                     |
| HI1.5/<br>PCI Express | Cfg <sup>1</sup>  | Y*               | Y*                                 | Y*                     | Y*                    |
|                       | CFC/CF8           | N                | N/A                                | N                      | N                     |
|                       | PCI Express MMCFG | N <sup>2</sup>   | N                                  | N                      | N                     |
|                       | Special Mem Range | N/A              | Y if BIOS Fixed Range <sup>3</sup> | N/A                    | N/A                   |
| Processor             | CFG/CF8           | N                | Y*                                 | Y*                     | Y*                    |
|                       | PCI Express MMCFG | Y                | N/A                                | Y                      | Y                     |
|                       | Special Mem Range | N/A              | Y if BIOS Fixed Range              | N/A                    | N/A                   |

**NOTES:**

1. Enable bit per PCI Express link can disable this access (DIS\_INB\_CFG bit of the EXP\_CTRL register – see Section 4.11.28, “EXP\_CTRL[7:1]: PCI Express Control Register (D1-7, F0)” on page 102).
2. Internal NB mechanism can be that since the inbound memory write doesn't hit any other valid address region, it is sent to the HI1.5 by default.
3. BIOS fixed registers are mapped to special memory ranges.

| Legends for Table 4-2 |                               |
|-----------------------|-------------------------------|
| Y                     | Supported                     |
| Y*                    | Supported but can be disabled |
| N                     | Not Supported                 |
| N/A                   | Not Applicable                |

| Register Definition For Table 4-2 |  |
|-----------------------------------|--|
| PCI Express Ext                   | PCI Express extended configuration space registers (offset >0xFF).   |
| BIOS Fixed                        | Chipset registers fixed in memory space. These are the bOFLA[], SPAD[], and SPADSA[] registers.  |
| Other NB/XMB Cfg                  | NB/XMB registers other than the ones that have already been mentioned above. Also includes DIMM SPD accesses.  |
| Registers South of NB             | Registers residing on ICH5, Intel® 6700PXH 64-bit PCI Hub, and other devices connected to the PCI Express ports, plus all the associated children devices. |

## 4.6 I/O Mapped Registers

The PCI configuration access mechanism enables support of legacy/PCI code that utilizes the PCI mechanism. The mechanism is defined in *PCI Local Bus Specification*, Revision 2.2. Two bus cycles are defined to access PCI configuration space:

- Configuration Read
- Configuration Write

These configurations access the registers through two I/O-space locations: CFGADR and CFGDAT. The Intel® E8501 chipset has reserved two special I/O locations (0xCF8 / 0xCFC) for direct configuration accesses. Accesses to configuration space through these registers are commonly referred as CF8/CFC configuration accesses. The PCI configuration access sequence is described as follows:

1. The processor first performs a Dword I/O write to CONFIG\_ADDRESS to select the bus number, device number, function number and the specific configuration address in the device.
2. A subsequent read or write of the CONFIG\_DATA location causes the data transfer to/from the selected configuration register. Byte enables are valid during accesses to CONFIG\_DATA and are used to select the byte(s) within the configuration register.

If the access is targeted to a chipset register that does not reside in the NB, the NB will forward the access to the appropriate interface. Intel® E8501 chipset supports both Type 0 and Type 1 configuration access mechanism as described in the PCI Local Bus Specification, Revision 2.2 to enable hierarchical PCI buses. Type 0 accesses are used for registers that reside on the secondary bus. Type 1 accesses are used for registers that reside on subordinates buses. For more details, please refer to the PCI Local Bus Specification Revision 2.2. Accesses to the memory port follows the format of Memory Port Specification. Accesses to devices on the PCI Express link follows the format of PCI Express Specification. Both memory port and PCI Express preserves the address mapping of *PCI Local Bus Specification*, Revision 2.2.

### 4.6.1 CFGADR –Configuration Address Register

This 32-bit-wide register is written only when a processor I/O transaction to CF8 is referenced as a Dword, a Byte or Word reference will not access this register, but will generate an I/O space access.

The CFGADR register contains the Bus Number, Device Number, Function Number, and Register Offset for which a subsequent CFGDAT access is intended. The mapping between fields in this register and PCI Express or Hub Interface configuration transactions is defined by [Table 4-3](#).

**Table 4-5. PCI CFGADR Register**

|    |    |          |    |    |            |    |    |               |    |    |                 |   |   |                 |   |   |   |
|----|----|----------|----|----|------------|----|----|---------------|----|----|-----------------|---|---|-----------------|---|---|---|
| 31 | 30 |          | 24 | 23 |            | 16 | 15 |               | 11 | 10 |                 | 8 | 7 |                 | 2 | 1 | 0 |
| En |    | Reserved |    |    | Bus Number |    |    | Device Number |    |    | Function Number |   |   | Register Number |   | 0 | 0 |
| *  |    |          |    |    |            |    |    |               |    |    |                 |   |   |                 |   |   |   |

\* En = Enable Bit  
1 = Enabled  
0 = Disabled



| I/O Address:CF8h |      |         |  |
|------------------|------|---------|--|
| Bit              | Attr | Default | Description  |
| 31               | RW   | 0h      | <b>CFGE: Configuration Enable</b><br>Unless this bit is set, accesses to the <b>CFGDAT</b> register will not produce a configuration access, but will be treated as other I/O accesses. This bit is strictly an enable for the CFC/CF8 access mechanism and is not forwarded to HI or PCI Express. |
| 30:24            | RV   | 00h     | <b>Reserved</b>  |
| 23:16            | RW   | 00h     | <b>Bus Number</b><br>If 0, the NB examines device to determine where to route. If non-zero, route as per PBUSN and SBUSN registers.  |
| 15:11            | RW   | 0h      | <b>Device Number</b>   |
| 10:8             | RW   | 0h      | <b>Function Number</b><br>This field is used to select the function of a locally addressed register.   |
| 7:2              | RW   | 00h     | <b>Register Offset</b><br>If this register specifies an access to the NB registers, this field specifies a group of four bytes to be addressed. The bytes accessed are defined by the Byte enables of the CFGDAT register access.  |
| 1:0              | RW*  | 0h      | Writes to these bits will have no effect, reads return 0.  |

## 4.6.2 CFGDAT –Configuration Data Register

CFGDAT provides data for the 4 bytes of configuration space defined by CFGADR. This register is only accessed if there is an access to I/O address CFCh on the front side bus and CFGADR.CFGE is set. The byte enables with the IO access define how many configuration bytes are accessed.

| I/O Address:CFCh |      |         |  |
|------------------|------|---------|--|
| Bit              | Attr | Default | Description  |
| 31:0             | RW   | 0000h   | <b>Configuration Data Window</b><br>The data written or read to the configuration register (if any) specified by <b>CFGADR</b> . |

## 4.7 Intel® E8501 Chipset North Bridge (NB) Fixed Mapped Registers

These registers are mapped into the fixed chipset-specific range located from FE60\_0000-FE6F\_FFFF. These appear at fixed addresses to support the boot process. These registers also appear in the regular PCI Express configuration space. [Table 4-6](#) defines the memory address of the registers in this region.

Table 4-6. Mapping of Fixed Memory Mapped Registers

| Register | Memory Address |
|----------|----------------|
| BOFL0    | FE60_C000      |
| BOFL1    | FE60_C400      |
| BOFL2    | FE60_C800      |
| BOFL3    | FE60_CC00      |
| SPAD0    | FE60_D000      |
| SPAD1    | FE60_D400      |
| SPAD2    | FE60_D800      |
| SPAD3    | FE60_DC00      |
| SPADS0   | FE60_E000      |
| SPADS1   | FE60_E400      |
| SPADS2   | FE60_E800      |
| SPADS3   | FE60_EC00      |

## 4.8 PCI Express Device Configuration Registers

The PCI Express register structure is exposed to the operating system and requires a separate device per port. Ports A-D will be assigned devices 1 through 7 (refer to [Figure 2-2 on page 2-30.](#)) The PCI Express ports determine at reset the width of the devices to which they are connected. If ports are combined to form x8 ports, configuration accesses to the most significant device numbers will still be completed successfully, but only the least significant device number will control and hold status for the wider port.

Table 4-7. When will a PCI Express Device be Accessible?

| PCI Express Port | Device | x8                   | Registers may be accessed if...   |
|------------------|--------|----------------------|---|
| A1               | 7      | Possible Combination | Port A1 is connected to a x4 device.  |
| A0               | 6      |                      | Port A0 is connected to a x4 or x8 device.  |
| B1               | 5      | Possible Combination | Port B1 is connected to a x4 device.  |
| B0               | 4      |                      | Port B0 is connected to a x4 or x8.   |
| C1               | 3      | Possible Combination | Port C1 is connected to a x4 device.  |
| C0               | 2      |                      | Port C0 is connected to a x4 or x8 device.  |
| D                | 1      | Cannot be a x8       | A 4x device is connected to Port D.<br><b>This port cannot be combined with any other PORT to form an x8.</b> |

Figure 4-1 illustrates how each PCI Express port's configuration space appears to software. Each PCI Express port's configuration space has 4 regions:

- **Standard PCI Header** - This region closely resembles a standard PCI-to-PCI bridge header.
- **PCI Device Dependent Region** - The region is also part of standard PCI configuration space and contains the PCI capability structures. For the NB, the supported capabilities are:
  - Message Signalled Interrupts
  - Hot-Plug
  - PCI Express Capability
- **PCI Express Extended Configuration Space** - This space is an enhancement beyond standard PCI and only accessible with PCI Express aware software. The NB supports the Enhanced Error Signalling capability.
- **Capability Working Register Sets** - These ranges are indirectly accessed through Data and Select registers in the capability structures. For the NB, working register sets exist for the Standard hot-plug Controller and Power Management capabilities.

Figure 4-1. PCI Express Configuration Space

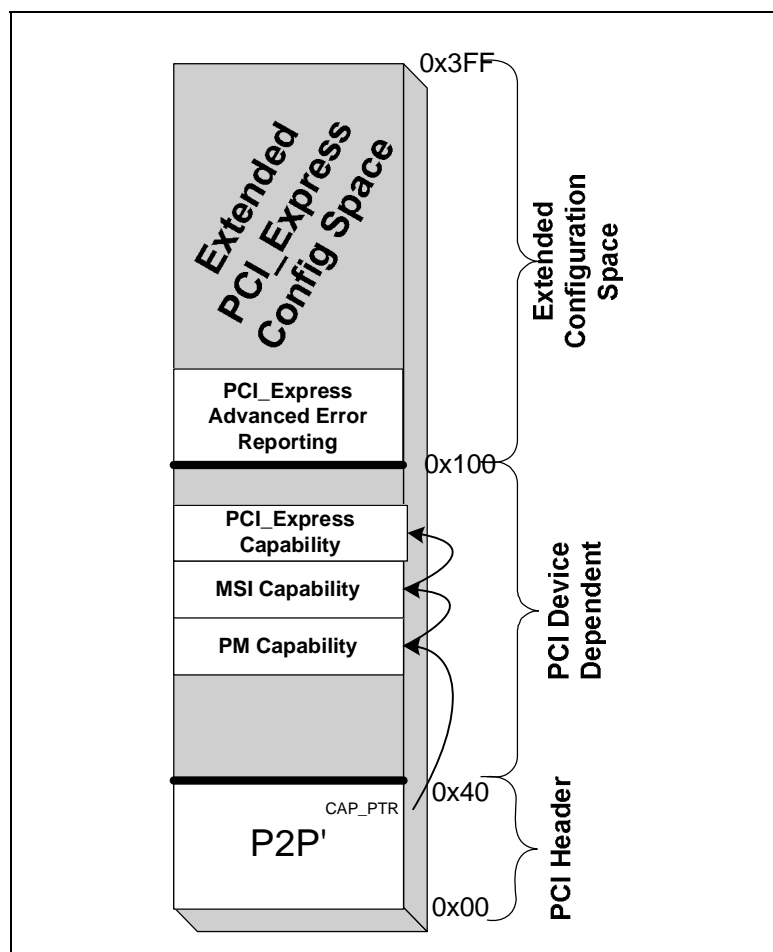


Figure 4-1 shows the configuration register offset addresses. Each port is a separate device. As defined in the *PCI Express Specification*, the PCI 2.3 compatible capability structure is a linked list in which each capability has a pointer to the next capability. For PCI Express capabilities, the first structure is required to start at 0x100 offset.

The PCI Express and Extended PCI Express registers are fully explained in [Section 4.11](#) and [Section 4.12](#).

## 4.9 Configuration Space Map

All devices on the NB reside on BUS 0. [Table 4-8](#) provides a quick cross-reference for the devices and functions that the NB implements or routes specially, followed by the configuration maps for each device. Please note that this document will only explain the NB devices; hence, for devices not handled by the NB, readers should refer to the corresponding documentations as indicated in the table.

**Table 4-8. PCI Devices and Functions Handled by Intel® E8501 Chipset North Bridge (NB) (Sheet 1 of 2)**

| Component | Register Group   | DID Register Value | Device | Function |
|-----------|--|--------------------|--------|----------|
| NB        | Hub Interface  | 2600h              | 0      | 0        |
| NB        | PCI Express D  | 2601h              | 1      | 0        |
| NB        | PCI Express C0   | 2602h <sup>a</sup> | 2      | 0        |
| NB        | PCI Express C1   | 2603h              | 3      | 0        |
| NB        | PCI Express B0   | 2604h <sup>b</sup> | 4      | 0        |
| NB        | PCI Express B1   | 2605h              | 5      | 0        |
| NB        | PCI Express A0   | 2606h <sup>c</sup> | 6      | 0        |
| NB        | PCI Express A1   | 2607h              | 7      | 0        |
| NB        | IMI A  | 260Ch              | 8      | 0        |
| XMB_A     | All (Refer to <i>Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet</i> ) | 2620h - 2627h      | 9      | 0 - 7    |
| NB        | IMI B  | 260Ch              | 10     | 0        |
| XMB_B     | All (Refer to <i>Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet</i> ) | 2620h - 2627h      | 11     | 0 - 7    |
| NB        | IMI C  | 260Ch              | 12     | 0        |
| XMB_C     | All (Refer to <i>Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet</i> ) | 2620h - 2627h      | 13     | 0 - 7    |
| NB        | IMI D  | 260Ch              | 14     | 0        |
| XMB_D     | All (Refer to <i>Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet</i> ) | 2620h - 2627h      | 15     | 0 - 7    |
| NB        | Front Side Bus, Boot, and Interrupt  | 2610h              | 16     | 0        |
| NB        | Address Mapping  | 2611h              | 16     | 1        |
| NB        | RAS (FSB and HI Error Registers)   | 2612h              | 16     | 2        |

**Table 4-8. PCI Devices and Functions Handled by Intel® E8501 Chipset North Bridge (NB) (Sheet 2 of 2)**

| Component | Register Group  | DID Register Value | Device | Function |
|-----------|-----------------|--------------------|--------|----------|
| NB        | Miscellaneous   | 2613h - 2615h      | 17     | 0-2      |
| NB        | <i>Reserved</i> |                    | 18     | All      |
| NB        | <i>Reserved</i> | 2617h - 261Eh      | 19     | 0-7      |
| NB        | <i>Reserved</i> |                    | 20     | All      |
| ICH5      | Compatibility   |                    | Other  | All      |

**NOTES:**

- Software should program this to 2608h if this is connected to an x8 link.
- Software should program this to 2609h if this is connected to an x8 link.
- Software should program this to 260Ah if this is connected to an x8 link.

If a port is disabled or disconnected, then the NB will not forward transactions to the downstream side of the link. These accesses will be Master Aborted by the NB. Configuration registers resident on the NB will still be accessible, however, and it is the responsibility of Software to comprehend the presence of configuration registers even for ports that are disabled even if disabled simply because a wider port (e.g. x8) is using the link wires.

To comply with the PCI specification, accesses to these non-existent functions, registers, and bits will be treated as follows:

**Table 4-9. Access to “Non-Existent” Register Bits**

| Access to                         | Writes  | Reads                 |
|-----------------------------------|---|-----------------------|
| Functions not listed in Table 4-8 | Have no effect  | NB returns all ones   |
| Registers not listed in Table 4-3 | Have no effect  | NB returns all zeroes |
| Reserved bits in registers        | Software must read modify-write to preserve the value | NB returns all zeroes |

Table 4-10. Device 0, Function 0: Hub Interface 1.5 Registers

|         |        |        |         |     |        |     |     |      |     |     |     |
|---------|--------|--------|---------|-----|--------|-----|-----|------|-----|-----|-----|
| DID     |        | VID    |         | 00h |        | 80h |     |      |     |     |     |
| PCISTS  |        | PCICMD |         | 04h |        | 84h |     |      |     |     |     |
| CCR     |        |        | RID     | 08h |        | 88h |     |      |     |     |     |
| HDR     |        |        |         |     |        | 0Ch | 8Ch |      |     |     |     |
|         |        |        |         |     |        | 10h | 90h |      |     |     |     |
|         |        |        |         |     |        | 14h | 94h |      |     |     |     |
|         |        |        |         |     |        | 18h | 98h |      |     |     |     |
|         |        |        |         |     |        | 1Ch | 9Ch |      |     |     |     |
|         |        |        |         |     |        | 20h | A0h |      |     |     |     |
|         |        |        |         |     |        | 24h | A4h |      |     |     |     |
|         |        |        |         |     |        | 28h | A8h |      |     |     |     |
|         |        |        |         |     |        | SID |     | SVID |     | 2Ch | ACh |
|         |        |        |         |     |        |     |     |      | 30h | B0h |     |
| 34h     | B4h    |        |         |     |        |     |     |      |     |     |     |
| 38h     | B8h    |        |         |     |        |     |     |      |     |     |     |
| 3Ch     | BCh    |        |         |     |        |     |     |      |     |     |     |
| 40h     | C0h    |        |         |     |        |     |     |      |     |     |     |
| 44h     | C4h    |        |         |     |        |     |     |      |     |     |     |
| 48h     | C8h    |        |         |     |        |     |     |      |     |     |     |
| HINERR  |        | HIFERR |         | 4Ch |        |     |     |      | CCh |     |     |
| NRECHI  |        |        |         | 50h | HICTL  |     |     |      |     |     |     |
| RECHI   |        |        |         | 54h | HICTL2 |     |     |      |     |     |     |
|         |        |        | HIEMASK | 58h |        | D8h |     |      |     |     |     |
| HIMCERR | HIERR2 | HIERR1 | HIERR0  | 5Ch |        | DCh |     |      |     |     |     |
|         |        |        |         | 60h |        | E0h |     |      |     |     |     |
|         |        |        |         | 64h |        | E4h |     |      |     |     |     |
|         |        |        |         | 68h |        | E8h |     |      |     |     |     |
|         |        |        |         | 6Ch |        | ECh |     |      |     |     |     |
|         |        |        |         | 70h |        | F0h |     |      |     |     |     |
|         |        |        |         | 74h |        | F4h |     |      |     |     |     |
|         |        |        |         | 78h |        | F8h |     |      |     |     |     |
|         |        |        |         | 7Ch |        | FCh |     |      |     |     |     |

**Table 4-11. Device 1 - 7, Function 0: PCI Express Space Registers**

|            |        |             |           |     |             |  |     |
|------------|--------|-------------|-----------|-----|-------------|--|-----|
| DID        |        | VID         |           | 00h | EXP_SLOTCAP |  | 80h |
| EXP_STS    |        | EXP_CMD     |           | 04h | EXP_SLOTSTS |  | 84h |
| CCR        |        |             | RID       | 08h | EXP_RTCTRL  |  | 88h |
| BIST       | HDR    | PRI_LT      | CLS       | 0Ch | EXP_RTSTS   |  |     |
|            |        |             |           | 10h |             |  |     |
|            |        |             |           | 14h |             |  |     |
| SEC_LT     | SUBUSN | SBUSN       | PBUSN     | 18h |             |  |     |
| SECSTS     |        | IOLIM       | IOBASE    | 1Ch |             |  |     |
| MLIMIT     |        | MBASE       |           | 20h |             |  |     |
| PMLIMIT    |        | PMBASE      |           | 24h |             |  |     |
| PMBU       |        |             |           | 28h |             |  |     |
| PMLU       |        |             |           | 2Ch |             |  |     |
|            |        |             | CAPPTR    | 30h |             |  |     |
|            |        |             |           | 34h |             |  |     |
|            |        |             |           | 38h |             |  |     |
| BCTRL      |        | INTP        | INTL      | 3Ch |             |  |     |
|            |        |             |           | 40h |             |  |     |
|            |        |             |           | 44h |             |  |     |
| EXP_CTRL   |        |             |           | 48h |             |  |     |
|            |        |             | EXP_CTRL2 | 4Ch |             |  |     |
| PMCAP      |        |             |           | 50h |             |  |     |
| PMSCR      |        |             |           | 54h |             |  |     |
| MSICTRL    |        | MSINXPTR    | MSICAPID  | 58h |             |  |     |
| MSIAR      |        |             |           | 5Ch |             |  |     |
| MSIDR      |        |             |           | 60h |             |  |     |
|            |        |             |           | 64h |             |  |     |
|            |        |             |           | 68h |             |  |     |
| EXP_CAP    |        | EXP_CAPL    |           | 6Ch |             |  |     |
| EXP_DEVCAP |        |             |           | 70h |             |  |     |
| EXP_DEVSTS |        | EXP_DEVCTRL |           | 74h |             |  |     |
| EXP_LNKCAP |        |             |           | 78h |             |  |     |
| EXP_LNKSTS |        | EXP_LNKCTRL |           | 7Ch |             |  |     |

Table 4-12. Device 1 - 7, Advanced Function 0: PCI Express Extended Registers

|               |      |  |      |
|---------------|------|--|------|
| ENHCAPSTS     | 100h |  | 180h |
| UNCERRSTS     | 104h |  | 184h |
| UNCERRMSK     | 108h |  | 188h |
| UNCERRSEV     | 10Ch |  | 18Ch |
| CORERRSTS     | 110h |  | 190h |
| CORERRMSK     | 114h |  | 194h |
| AERCACR       | 118h |  | 198h |
| HDRLOG0       | 11Ch |  | 19Ch |
| HDRLOG1       | 120h |  | 1A0h |
| HDRLOG2       | 124h |  | 1A4h |
| HDRLOG3       | 128h |  | 1A8h |
| RPERRCMD      | 12Ch |  | 1ACh |
| RPERRMSGSTS   | 130h |  | 1B0h |
| ERRSID        | 134h |  | 1B4h |
|               | 138h |  | 1B8h |
|               | 13Ch |  | 1BCh |
| NBSPCAPID     | 140h |  | 1C0h |
| EXP_UNITERR   | 144h |  | 1C4h |
| EXP_ERR_DOCMD | 148h |  | 1C8h |
| UNCEDMASK     | 14Ch |  | 1CCh |
| COREDMASK     | 150h |  | 1D0h |
| RPEDMASK      | 154h |  | 1D4h |
| EXP_UNITDMASK | 158h |  | 1D8h |
|               | 15Ch |  | 1DCh |
| EXP_FERR      | 160h |  | 1E0h |
| EXP_NERR      | 164h |  | 1E4h |
| EXP_UNITEMASK | 168h |  | 1E8h |
|               | 16Ch |  | 1ECh |
|               | 170h |  | 1F0h |
|               | 174h |  | 1F4h |
|               | 178h |  | 1F8h |
|               | 17Ch |  | 1FCh |



**Table 4-13. Device 8,10,12,14 Function 0: IMI Registers**

|         |         |        |         |           |           |         |          |     |     |
|---------|---------|--------|---------|-----------|-----------|---------|----------|-----|-----|
| DID     |         | VID    |         | 00h       |           | 80h     |          |     |     |
|         |         |        |         | 04h       |           | 84h     |          |     |     |
| CCR     |         | RID    |         | 08h       |           | 88h     |          |     |     |
| HDR     |         |        |         | 0Ch       |           | 8Ch     |          |     |     |
|         |         |        |         | 10h       |           | 90h     |          |     |     |
|         |         |        |         | 14h       |           | 94h     |          |     |     |
|         |         |        |         | 18h       |           | 98h     |          |     |     |
|         |         |        |         | 1Ch       |           | 9Ch     |          |     |     |
|         |         |        |         | 20h       |           | A0h     |          |     |     |
|         |         |        |         | 24h       |           | A4h     |          |     |     |
|         |         |        |         | 28h       |           | A8h     |          |     |     |
| SID     | SVID    |        |         | 2Ch       |           | ACH     |          |     |     |
|         |         |        |         | 30h       |           | B0h     |          |     |     |
|         |         |        |         | 34h       |           | B4h     |          |     |     |
|         |         |        |         | 38h       |           | B8h     |          |     |     |
|         |         |        |         | 3Ch       |           | BCh     |          |     |     |
| IMISC   |         |        |         | 40h       | IMI_FERR  |         | C0h      |     |     |
|         |         |        |         | 44h       | IMI_NERR  |         | C4h      |     |     |
| IMIST   |         |        |         | 48h       |           |         |          | C8h |     |
| IMIHPC  |         |        |         | 4Ch       |           |         |          | CCh |     |
|         |         |        |         | 50h       |           |         |          | D0h |     |
|         |         |        |         | 54h       | RECIMI    |         | NRECIMI  |     | D4h |
|         |         |        |         | REDIMIL   |           |         |          | D8h |     |
|         |         |        |         | EMASK_IMI |           | REDIMIH |          | DCh |     |
| IMICHNK | IMILINE | IMIOFF | IMIAPR  | 60h       | IMI_ERR1  |         | IMI_ERR0 |     | E0h |
|         |         |        | IMICODE | 64h       | IMI_MCERR |         | IMI_ERR2 |     | E4h |
|         |         |        |         | 68h       |           |         |          |     | E8h |
|         |         |        |         | 6Ch       |           |         |          |     | ECh |
|         |         |        |         | 70h       |           |         |          |     | F0h |
|         |         |        |         | 74h       |           |         |          |     | F4h |
|         |         |        |         | 78h       |           |         |          |     | F8h |
|         |         |        |         | 7Ch       |           |         |          |     | FCh |

Table 4-14. Device 16, Function 0: Front Side Bus, Boot and Interrupt Registers

|              |          |     |        |     |
|--------------|----------|-----|--------|-----|
| DID          | VID      | 00h | XTPR0  | 80h |
|              |          | 04h | XTPR1  | 84h |
| CCR          | RID      | 08h | XTPR2  | 88h |
| HDR          |          | 0Ch | XTPR3  | 8Ch |
|              |          | 10h | XTPR4  | 90h |
|              |          | 14h | XTPR5  | 94h |
|              |          | 18h | XTPR6  | 98h |
|              |          | 1Ch | XTPR7  | 9Ch |
|              |          | 20h | XTPR8  | A0h |
|              |          | 24h | XTPR9  | A4h |
|              |          | 28h | XTPR10 | A8h |
| SID          | SVID     | 2Ch | XTPR11 | ACH |
|              |          | 30h | XTPR12 | B0h |
|              |          | 34h | XTPR13 | B4h |
|              |          | 38h | XTPR14 | B8h |
|              |          | 3Ch | XTPR15 | BCh |
|              | SYRE     | 40h | BOFL0  | C0h |
|              |          | 44h | BOFL1  | C4h |
|              |          | 48h | BOFL2  | C8h |
|              |          | 4Ch | BOFL3  | CCh |
|              | REDIRCTL | 50h | SPAD0  | D0h |
| REDIRDIS     |          | 54h | SPAD1  | D4h |
| REDIRBUCKETS |          | 58h | SPAD2  | D8h |
|              |          | 5Ch | SPAD3  | DCh |
| POC_FSBA     |          | 60h | SPADS0 | E0h |
|              | POC_AUXA | 64h | SPADS1 | E4h |
|              |          | 68h | SPADS2 | E8h |
|              |          | 6Ch | SPADS3 | ECh |
| POC_FSBB     |          | 70h |        | F0h |
|              | POC_AUXB | 74h |        | F4h |
|              |          | 78h |        | F8h |
|              |          | 7Ch |        | FCh |

**Table 4-15. Device 16, Function1: Address Mapping Registers**

|            |        |        |      |     |       |  |     |     |
|------------|--------|--------|------|-----|-------|--|-----|-----|
| DID        |        | VID    |      | 00h | IMIR0 |  | 80h |     |
|            |        |        |      | 04h | IMIR1 |  | 84h |     |
| CCR        |        |        | RID  | 08h | IMIR2 |  | 88h |     |
| HDR        |        |        |      |     |       |  |     | 8Ch |
|            |        |        |      |     |       |  |     | 90h |
|            |        |        |      |     |       |  |     | 94h |
|            |        |        |      |     |       |  |     | 98h |
|            |        |        |      |     |       |  |     | 9Ch |
|            |        |        |      |     |       |  |     | A0h |
|            |        |        |      |     |       |  |     | A4h |
|            |        |        |      |     |       |  |     | A8h |
|            |        |        |      |     |       |  |     | ACH |
|            |        |        |      |     |       |  |     | B0h |
|            |        | B4h    |      |     |       |  |     |     |
|            |        | B8h    |      |     |       |  |     |     |
|            |        | BCh    |      |     |       |  |     |     |
|            |        | C0h    |      |     |       |  |     |     |
|            |        | C4h    |      |     |       |  |     |     |
|            |        | C8h    |      |     |       |  |     |     |
|            |        | CCh    |      |     |       |  |     |     |
|            |        | D0h    |      |     |       |  |     |     |
|            |        | D4h    |      |     |       |  |     |     |
|            |        | D8h    |      |     |       |  |     |     |
|            |        | DCh    |      |     |       |  |     |     |
|            |        | E0h    |      |     |       |  |     |     |
|            |        | E4h    |      |     |       |  |     |     |
|            |        | E8h    |      |     |       |  |     |     |
|            |        | ECh    |      |     |       |  |     |     |
|            |        | F0h    |      |     |       |  |     |     |
|            |        | F4h    |      |     |       |  |     |     |
|            |        | F8h    |      |     |       |  |     |     |
|            |        | FCh    |      |     |       |  |     |     |
| SID        |        | SVID   |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
| PAM2       | PAM1   | PAM0   |      |     |       |  |     |     |
| PAM6       | PAM5   | PAM4   | PAM3 |     |       |  |     |     |
| EXSMRTOP   | EXSMRC | SMRAMC | FDHC |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |
| EXP_ECBASE |        |        |      |     |       |  |     |     |
|            |        | TOLM   |      |     |       |  |     |     |
|            |        |        |      |     |       |  |     |     |

Table 4-16. Device 16, Function 2: RAS Registers

|             |          |     |                |            |     |
|-------------|----------|-----|----------------|------------|-----|
| DID         | VID      | 00h | FSBA_NERR      | FSBA_FERR  | 80h |
|             |          | 04h | RECF_SBA_LOG   |            | 84h |
| CCR         | RID      | 08h | NRECF_SBA_LOG0 |            | 88h |
| HDR         |          | 0Ch | NRECF_SBA_LOG1 |            | 8Ch |
|             |          | 10h | NRECF_SBA_LOG2 |            | 90h |
|             |          | 14h | ERR0_FSBA      | EMASK_FSBA | 94h |
|             |          | 18h | ERR2_FSBA      | ERR1_FSBA  | 98h |
|             |          | 1Ch | ICHRST_FSBA    | MCERR_FSBA | 9Ch |
|             |          | 20h | FSBB_NERR      | FSBB_FERR  | A0h |
|             |          | 24h | RECF_SBB_LOG   |            | A4h |
|             |          | 28h | NRECF_SBB_LOG0 |            | A8h |
| SID         | SVID     | 2Ch | NRECF_SBB_LOG1 |            | ACh |
|             |          | 30h | NRECF_SBB_LOG2 |            | B0h |
|             |          | 34h | ERR0_FSBB      | EMASK_FSBB | B4h |
|             |          | 38h | ERR2_FSBB      | ERR1_FSBB  | B8h |
|             |          | 3Ch | ICHRST_FSBB    | MCERR_FSBB | BCh |
| Global_FERR |          | 40h | INT_NERR       | INT_FERR   | C0h |
| Global_NERR |          | 44h | NRECNB         |            | C4h |
|             |          | 48h | RECNB          |            | C8h |
|             |          | 4Ch |                | EMASK_INT  | CCh |
|             |          | 50h | MCERR_INT      | ERR2_INT   | D0h |
|             |          | 54h | INT1_INT       | ERR0_INT   | D4h |
|             |          | 58h | RECINT_LOG0    |            | D8h |
|             |          | 5Ch | RECINT_LOG1    |            | DCh |
|             | EXSMRAMC | 60h | RECINT_LOG2    |            | E0h |
|             |          | 64h | RECINT_LOG3    |            | E4h |
|             |          | 68h | RECINT_LOG4    |            | E8h |
|             |          | 6Ch | INTLOGC        |            | ECh |
|             |          | 70h |                |            | F0h |
|             |          | 74h |                |            | F4h |
|             |          | 78h |                |            | F8h |
|             |          | 7Ch |                |            | FCh |

**Table 4-17. Device 17, Function 0: Miscellaneous Registers**

|            |             |     |                  |     |
|------------|-------------|-----|------------------|-----|
| <b>DID</b> | <b>VID</b>  | 00h |                  | 80h |
|            |             | 04h |                  | 84h |
| <b>CCR</b> | <b>RID</b>  | 08h |                  | 88h |
| <b>HDR</b> |             | 0Ch |                  | 8Ch |
|            |             | 10h |                  | 90h |
|            |             | 14h |                  | 94h |
|            |             | 18h |                  | 98h |
|            |             | 1Ch |                  | 9Ch |
|            |             | 20h |                  | A0h |
|            |             | 24h | <b>FSBDC[0]</b>  | A4h |
|            |             | 28h |                  | A8h |
| <b>SID</b> | <b>SVID</b> | 2Ch |                  | ACH |
|            |             | 30h | <b>FSB[0]AC2</b> | B0h |
|            |             | 34h |                  | B4h |
|            |             | 38h | <b>FSB[0]AC</b>  | B8h |
|            |             | 3Ch |                  | BCh |
|            |             | 40h |                  | C0h |
|            |             | 44h |                  | C4h |
|            |             | 48h |                  | C8h |
|            |             | 4Ch |                  | CCh |
|            |             | 50h |                  | D0h |
|            |             | 54h |                  | D4h |
|            |             | 58h |                  | D8h |
|            |             | 5Ch |                  | DCh |
|            |             | 60h |                  | E0h |
|            |             | 64h |                  | E4h |
|            |             | 68h |                  | E8h |
|            |             | 6Ch |                  | ECh |
|            |             | 70h |                  | F0h |
|            |             | 74h |                  | F4h |
|            |             | 78h |                  | F8h |
|            |             | 7Ch |                  | FCh |

Table 4-18. Device 17, Function 1: Miscellaneous Registers

| DID | VID  | 00h | 80h           |
|-----|------|-----|---------------|
|     |      | 04h | 84h           |
| CCR | RID  | 08h | 88h           |
| HDR |      | 0Ch | 8Ch           |
|     |      | 10h | 90h           |
|     |      | 14h | 94h           |
|     |      | 18h | 98h           |
|     |      | 1Ch | 9Ch           |
|     |      | 20h | A0h           |
|     |      | 24h | FSBDC[1] A4h  |
|     |      | 28h | A8h           |
|     |      | 2Ch | ACCh          |
| SID | SVID | 30h | FSB[1]AC2 B0h |
|     |      | 34h | B4h           |
|     |      | 38h | FSB[1]AC B8h  |
|     |      | 3Ch | BCCh          |
|     |      | 40h | C0h           |
|     |      | 44h | C4h           |
|     |      | 48h | C8h           |
|     |      | 4Ch | CCCh          |
|     |      | 50h | D0h           |
|     |      | 54h | D4h           |
|     |      | 58h | D8h           |
|     |      | 5Ch | EXP_GCTRL DCh |
|     |      | 60h | E0h           |
|     |      | 64h | E4h           |
|     |      | 68h | E8h           |
|     |      | 6Ch | ECh           |
|     |      | 70h | F0h           |
|     |      | 74h | F4h           |
|     |      | 78h | F8h           |
|     |      | 7Ch | FCh           |

**Table 4-19. Device 17, Function 2: Miscellaneous Registers**

|            |             |     |                  |     |
|------------|-------------|-----|------------------|-----|
| <b>DID</b> | <b>VID</b>  | 00h |                  | 80h |
|            |             | 04h |                  | 84h |
| <b>CCR</b> | <b>RID</b>  | 08h |                  | 88h |
| <b>HDR</b> |             | 0Ch |                  | 8Ch |
|            |             | 10h |                  | 90h |
|            |             | 14h |                  | 94h |
|            |             | 18h |                  | 98h |
|            |             | 1Ch |                  | 9Ch |
|            |             | 20h |                  | A0h |
|            |             | 24h |                  | A4h |
|            |             | 28h |                  | A8h |
| <b>SID</b> | <b>SVID</b> | 2Ch |                  | ACH |
|            |             | 30h | <b>IMI_HPTIM</b> | B0h |
|            |             | 34h | <b>REDUN</b>     | B4h |
|            |             | 38h |                  | B8h |
|            |             | 3Ch |                  | BCh |
|            |             | 40h |                  | C0h |
|            |             | 44h |                  | C4h |
|            |             | 48h |                  | C8h |
|            |             | 4Ch |                  | CCh |
|            |             | 50h |                  | D0h |
|            |             | 54h |                  | D4h |
|            |             | 58h |                  | D8h |
|            |             | 5Ch |                  | DCh |
|            |             | 60h |                  | E0h |
|            |             | 64h |                  | E4h |
|            |             | 68h |                  | E8h |
|            |             | 6Ch |                  | ECh |
|            |             | 70h |                  | F0h |
|            |             | 74h |                  | F4h |
|            |             | 78h |                  | F8h |
|            |             | 7Ch |                  | FCh |

## 4.10 Hub Interface 1.5 (Device 0, Function 0)

The Hub Interface 1.5 (HI1.5) registers are in device 0 (D0), function 0 (F0). For quick reference on the register address map, please refer to [Table 4-10](#).

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.10.1 VID: Vendor Identification Register (D0, F0)

This register identifies Intel as the manufacturer of the Intel® E8501 chipset North Bridge (NB). Writes to this register have no effect.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 00 - 01h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:0   | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.10.2 DID: Device Identification Register (D0, F0)

This register, combined with the Vendor Identification register uniquely, identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 02h - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2600h   | <b>Device Identification Number</b><br>Identifies each function of the <b>NB</b> . |



### 4.10.3 PCICMD:PCI Command Register (D0, F0)

| <b>Device: 0</b><br><b>Function: 0</b><br><b>Offset: 04h</b> |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:9   | RV   | 00h     | <b>Reserved</b>   |
| 8  | RO   | 0       | <b>SIG_SYS_ERR: Signalled System Error.</b><br>The NB never initiates a system error special cycle (DO_SERR), so this bit will always return a 0 when read.   |
| 7  | RV   | 0b      | <b>Reserved</b>   |
| 6  | RWST | 0       | <b>IERRE: Parity Error Response (IERRE).</b><br>Controls the NB response when a parity error (on function 0) or multi-bit ECC error is detected on the Hub Interface. This bit only controls the detection in PCISTS.DetIntErr and PCISTS.MstrDataIE.<br>The NB reports all parity errors on the Hub Interface. |
| 5:4  | RV   | 00b     | <b>Reserved</b>   |
| 3  | RO   | 0b      | <b>spec_cyc_en: Special Cycle Enable.</b><br>Controls the ability to forward PCI-type (legacy) special cycles. Devices on the Hub Interface are not capable of accepting legacy special cycles. This bit does not apply to Hub Interface specific special cycles.   |
| 2  | RO   | 1b      | <b>BM_en: Bus Master Enable.</b><br>Controls the ability for the NB to initiate Hub Interface cycles. The NB can always issue Hub Interface bus cycles.   |
| 1  | RO   | 1b      | <b>MemAccEn: Memory Access Enable.</b><br>Controls the ability for the NB to respond to memory transactions initiated on the Hub Interface. The NB can always accept memory transactions.   |
| 0  | RO   | 0b      | <b>IOAccEn: I/O Access Enable.</b><br>Controls the ability for the NB to respond to I/O transactions initiated on the Hub Interface. This chipset does not support inbound I/O cycles.  |

### 4.10.4 PCISTS: PCI Status Register (D0, F0)

| <b>Device: 0</b><br><b>Function: 0</b><br><b>Offset: 06h - 07h</b> |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RWC  | 0       | <b>DetIntErr: Detected Integrity Error</b><br>This bit indicates that a parity error was observed on the Hub Interface. This bit is not affected by the state of PCICMD.IERR.                                |
| 14   | RO   | 0       | <b>SSE: Signalled System Error</b><br>This bit indicates if a system error special cycle (DO_SERR) is initiated by the NB component. This bit should never be asserted since the NB never initiates DO_SERR. |
| 13   | RWC  | 0       | <b>RcvMstrAbSts: Received Master Abort Status</b><br>This bit indicates if the NB receives a Master Abort completion cycle or an unimplemented Special Cycle command.  |

| <b>Device: 0</b><br><b>Function: 0</b><br><b>Offset: 06h - 07h</b> |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 12   | RWC  | 0       | <b>RcvTgtAbSts: Received Target Abort Status</b><br>This bit indicates if the NB receives a Target Abort completion cycle in response to a NB-initiated Hub Interface cycle.   |
| 11   | RWC  | 0       | <b>SigTgtAbSts: Signalled Target Abort Status</b><br>The NB sets this bit when it issues a Target Abort completion cycle to the Hub Interface agent.   |
| 10:9   | RV   | 00h     | <b>Reserved</b>  |
| 8  | RWC  | 0       | <b>MstrDataIE: Master Data Integrity Error</b><br>This bit indicates that a data parity or multi-bit ECC error was detected on the Hub Interface. This bit is set when all of the following conditions are met: <ul style="list-style-type: none"> <li>• The NB detected a data parity for an outbound read completion</li> <li>• PCICMD.IERR is set to 1</li> </ul> |
| 7:0  | RV   | 00h     | <b>Reserved</b>  |

#### 4.10.5 RID: Revision Identification Register (D0, F0)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

Intel® E8501 chipset North Bridge (NB) implements the Revision Identification Registers with a Compatibility Revision Id function in addition to standard revision identification functionality. This Compatibility Revision Id functionality is present in order to allow vendors to replace hardware while maintaining the software visible hardware revision identification registers the same as in previous steppings of the NB.

In order to access the Compatibility Revision Id functionality, the RID registers as a whole can be written to exactly one time with a specific code value (key). This key, when written correctly as the first write to any of the RID registers inside NB will cause NB to return the *compatibility id* value for all future reads of any NB RID register. Table 4-20 describes this compatibility revision identification functionality.

**Table 4-20. Intel® E8501 Chipset North Bridge (NB) Compatibility Revision ID Function**

| Key value written to any RID register | B0 read value | Description             |
|---------------------------------------|---------------|-------------------------|
| 0x79                                  | 0x0           | Return compatibility id |
| Any other value                       | 0x10          | Return stepping id      |

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 08h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7:4   | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br>1: B stepping   |
| 3:0   | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br>0h : x0 stepping<br>1h : x1 stepping<br>2h : x2 stepping |

#### 4.10.6 CCR: Class Code Register (D0, F0)

This register contains the Class Code for the device.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 09h - 0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function. For device 0, this field is hardwired to 00h, indicating it is a "Host Bridge".  |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device-independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.10.7 HDR: Header Type Register (D0, F0)

This register identifies the header layout of the configuration space.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 0Eh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 7   | RO   | 0h      | <b>Mfd: Multi-function Device.</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0   | RO   | 00h     | <b>CfgLayout: Configuration Layout.</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device the default is 00h, indicating a conventional type 00h PCI header. |

### 4.10.8 SVID: Subsystem Vendor Identification Register (D0, F0)

This register identifies the manufacturer of the system. This 16-bit register, combined with the Device Identification Register, uniquely identifies any PCI device.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 2Ch |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RWO  | 8086h   | <b>Vin: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

### 4.10.9 SID: Subsystem Identity (D0, F0)

This register identifies the system.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RWO  | 8086h   | <b>Sid: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

### 4.10.10 HIFERR: Hub Interface First Fatal Error Register (D0, F0)

For a description of the Errors (IOxx) refer to the [Table 6-39 “Errors Detected by the NB”](#) on [page 328](#).

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 4Ch |       |         |   |
|---|-------|---------|---|
| Bit   | Attr  | Default | Description   |
| 7   | RWCST | 0       | <b>IO6bErr: Received STOP during SRC</b><br>Fatal Error         |
| 6   | RWCST | 0       | <b>IO6Err: Parity error on Address</b><br>Fatal Error           |
| 5   | RWCST | 0       | <b>IO5Err: Illegal Access</b><br>Fatal Error                    |
| 4   | RWCST | 0       | <b>IO4Err: Outbound poison</b><br>Non-fatal Error               |
| 3   | RWCST | 0       | <b>IO3Err: Parity Error on outbound data</b><br>Non-fatal Error |
| 2   | RWCST | 0       | <b>IO2Err: Data Phase Parity Error</b><br>Non-fatal Error       |
| 1   | RWCST | 0       | <b>IO1Err: Cmd Parity Error</b><br>Non-fatal <sup>a</sup> Error |
| 0   | RWCST | 0       | <b>IO0Err: Target Abort</b><br>Non-fatal Error                  |

**NOTES:**

- a. Transaction is retried.

### 4.10.11 HINERR: Hub Interface Next Fatal Error Register (D0, F0)

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 4Eh |       |         |   |
|---|-------|---------|---|
| Bit   | Attr  | Default | Description   |
| 7   | RWCST | 0       | <b>IO6bErr: Received STOP during SRC</b><br>Fatal Error |
| 6   | RWCST | 0       | <b>IO6Err: Parity error on Address</b><br>Fatal Error   |
| 5   | RWCST | 0       | <b>IO5Err: Illegal Access</b><br>Fatal Error            |
| 4   | RWCST | 0       | <b>IO4Err: Outbound poison</b><br>Non-fatal Error       |

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 4Eh |       |         |   |
|---|-------|---------|---|
| Bit   | Attr  | Default | Description   |
| 3   | RWCST | 0       | <b>IO3Err: Parity Error on outbound data</b><br>Non-fatal Error |
| 2   | RWCST | 0       | <b>IO2Err: Data Phase Parity Error</b><br>Non-fatal Error       |
| 1   | RWCST | 0       | <b>IO1Err: Cmd Parity Error</b><br>Non-fatal <sup>a</sup> Error |
| 0   | RWCST | 0       | <b>IO0Err: Target Abort</b><br>Non-fatal Error                  |

**NOTES:**

- a. Transaction is retried.

#### 4.10.12 NRECHI: Non-Recoverable Hub Interface Error Log Register (D0, F0)

The contents of this register depends on whether the error is detected on a request or a response. This is the bit mapping for Hub Interface *Requests* (IF Bit 31 = 0).

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 50h - 53h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31  | ROST | 0h      | <b>NRECHI31: Rq/Cp</b><br>Request/completion field                       |
| 30  | ROST | 0h      | <b>NRECHI30: R/W</b><br>Read/Write field                                 |
| 29  | ROST | 0h      | <b>NRECHI29: CR</b><br>Completion required field                         |
| 28  | ROST | 0h      | <b>NRECHI28: AF</b><br>Address format                                    |
| 27  | ROST | 0h      | <b>NRECHI27: LK</b><br>Lock cycle  |
| 26:21   | ROST | 0h      | <b>NRECHI26DT21: TD Routing</b><br>Transaction Description routing field |
| 20  | ROST | 0h      | <b>NRECHI20</b><br>Reserved Field on the packet                          |
| 19:16   | ROST | 0h      | <b>NRECHI19DT16: TD Attribute</b><br>Transaction Descriptor Attribute    |
| 15:14   | ROST | 00      | <b>NRECHI15DT14: Spac</b><br>Address space                               |

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 50h - 53h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 13:8  | ROST | 0h      | <b>NRECHI13DT8: Data Length</b><br>Dword data length  |
| 7:0   | ROST | 0h      | <b>NRECHI7DT0: Byte Enables</b><br>7:4 is the Last DW Byte Enables and 3:0 is the First Byte Enables<br><i>Special Cycle Encoding: when Space field indicates a Special Cycle</i> |

This is the bit mapping for Hub Interface *Completions* (IF Bit 31 = 1).

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 50h - 53h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31  | ROST | 0b      | <b>NRECHI31: Rq/Cp</b><br>Request/completion field                           |
| 30  | ROST | 0b      | <b>NRECHI30: R/W</b><br>Read/Write field                                     |
| 29  | ROST | 0b      | <b>NRECHI29</b><br>Reserved 1b Field of the packet                           |
| 28  | ROST | 0b      | <b>NRECHIH28</b><br>Reserved 1a field of the packet                          |
| 27  | ROST | 0b      | <b>NRECHI27: LK</b><br>Lock cycle  |
| 26:21   | ROST | 00h     | <b>NRECHI26DT21: TD Routing</b><br>Transaction Description routing field     |
| 20  | ROST | 0b      | <b>NRECHI20</b><br>Reserved field on the packet                              |
| 19:16   | ROST | 00h     | <b>NRECHI19DT16: N TD Attribute</b><br>Transaction Descriptor Attribute      |
| 15:14   | ROST | 00h     | <b>NRECHI15DT14: Space</b><br>Address space                                  |
| 13:8  | ROST | 00h     | <b>NRECHI13DT8: Data Length</b><br>Dword data length                         |
| 7:0   | ROST | 00h     | <b>NRECHI7DT0: Completion Status</b><br>Indicates the status of the request. |

### 4.10.13 RECH: Recoverable Hub Interface Error Log Register (D0, F0)

The contents of this register depends on whether the error is detected on a request or a response. This is the bit mapping for Hub Interface *Requests* (RECH[31] = 0):

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 54h - 57h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31  | ROST | 0b      | <b>RECH31: Rq/Cp</b><br>Request/completion field  |
| 30  | ROST | 0b      | <b>RECH30:R/W</b><br>Read/Write field   |
| 29  | ROST | 0b      | <b>RECH29:CR</b><br>Completion required field   |
| 28  | ROST | 0b      | <b>RECH28:AF</b><br>Address Format  |
| 27  | ROST | 0b      | <b>RECH27:LK</b><br>Lock Cycle  |
| 26:21   | ROST | 0b      | <b>RECH26DT21:TD Routing</b><br>Transaction Description routing field   |
| 20  | ROST | 0b      | <b>RECH20</b><br>Reserved Field on the packet   |
| 19:16   | ROST | 00h     | <b>RECH19DT16: TD Attribute</b><br>Transaction Descriptor Attribute   |
| 15:14   | ROST | 00h     | <b>RECH15DT14: Space</b><br>Address Space   |
| 13:8  | ROST | 00h     | <b>RECH13DT8:Data Length</b><br>Dword Data Length   |
| 7:0   | ROST | 00h     | <b>RECH7DT0: Byte Enables</b><br>7:4 is the Last DW Byte Enables and 3:0 is the First Byte Enables<br><i>Special Cycle Encoding: when Space field indicates a Special Cycle</i> |



This is the bit mapping for Hub Interface *Completions* (RECHI[31] = 1):

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 54h - 57h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31  | ROST | 0b      | <b>RECHI31: Rq/Cp</b><br>Request/completion field                           |
| 30  | ROST | 0b      | <b>RECHI30: R/W</b><br>Read/Write field                                     |
| 29  | ROST | 0b      | <b>RECHI29</b><br>Reserved 1b Field of the packet                           |
| 28  | ROST | 0b      | <b>RECHI28</b><br>Reserved 1a Field of the packet                           |
| 27  | ROST | 0b      | <b>RECHI27: LK</b><br>Lock cycle  |
| 26:21   | ROST | 00h     | <b>RECHI26DT21: TD Routing</b><br>Transaction Description routing field     |
| 20  | ROST | 0b      | <b>RECHI20</b><br>Reserved Field on the packet                              |
| 19:16   | ROST | 0h      | <b>RECHI19DT16: TD Attribute</b><br>Transaction Descriptor Attribute        |
| 15:14   | ROST | 00b     | <b>RECHI15DT14: Space</b><br>Address Space                                  |
| 13:8  | ROST | 00h     | <b>RECHI13DT8: Data Length</b><br>Dword Data Length                         |
| 7:0   | ROST | 00h     | <b>RECHI7DT0: Completion Status</b><br>Indicates the status of the request. |

#### 4.10.14 HIEMASK: Hub Interface Error Mask Register (D0, F0)

A '0' in any field enables that error.

| <b>Device</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 58h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RW   | 1       | <b>IO6bMsk:</b> Received STOP during SRC<br>Suggested value: 0h |
| 6   | RW   | 1       | <b>IO6Msk:</b> Parity error on Address<br>Suggested value: 0h   |
| 5   | RW   | 1       | <b>IO5Msk:</b> Illegal Access<br>Suggested value: 0h            |

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 58h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 4  | RW   | 1       | <b>IO4Msk:</b> Outbound poison<br>Suggested value: 0h               |
| 3  | RW   | 1       | <b>IO3Msk:</b> Parity Error on outbound data<br>Suggested value: 0h |
| 2  | RW   | 1       | <b>IO2Msk:</b> Data Phase Parity Error<br>Suggested value: 0h       |
| 1  | RW   | 1       | <b>IO1Msk:</b> Cmd Parity Error<br>Suggested value: 0h              |
| 0  | RW   | 1       | <b>IO0Msk:</b> Target Abort<br>Suggested value: 0h                  |

#### 4.10.15 HIERR0: Hub Interface Error 0 Mask Register (D0, F0)

This register enables the signaling of Err[0] when an error flag is set. Note that one and only one error signal should be enabled at a time.

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 5Ch |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description                                   |
| 7  | RWST | 0       | <b>IO6bErr0:</b> Received STOP during SRC     |
| 6  | RWST | 0       | <b>IO6Err0:</b> Parity error on Address       |
| 5  | RWST | 0       | <b>IO5Err0:</b> Illegal Access                |
| 4  | RWST | 0       | <b>IO4Err0:</b> Outbound poison               |
| 3  | RWST | 0       | <b>IO3Err0:</b> Parity Error on outbound data |
| 2  | RWST | 0       | <b>IO2Err0:</b> Data Phase Parity Error       |
| 1  | RWST | 0       | <b>IO1Err0:</b> Cmd Parity Error              |
| 0  | RWST | 0       | <b>IO0Err0:</b> Target Abort                  |

#### 4.10.16 HIERR1: Hub Interface Error 1 Mask Register (D0, F0)

This register enables the signaling of Err[1] when an error flag is set. Note that one and only one error signal should be enabled at a time.

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 5Dh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description                                   |
| 7  | RWST | 0       | <b>IO6bErr1:</b> Received STOP during SRC     |
| 6  | RWST | 0       | <b>IO6Err1:</b> Parity error on Address       |
| 5  | RWST | 0       | <b>IO5Err1:</b> Illegal Access                |
| 4  | RWST | 0       | <b>IO4Err1:</b> Outbound poison               |
| 3  | RWST | 0       | <b>IO3Err1:</b> Parity Error on outbound data |
| 2  | RWST | 0       | <b>IO2Err1:</b> Data Phase Parity Error       |
| 1  | RWST | 0       | <b>IO1Err1:</b> Cmd Parity Error              |
| 0  | RWST | 0       | <b>IO0Err1:</b> Target Abort                  |

#### 4.10.17 HIERR2: Hub Interface Error 2 Mask Register (D0, F0)

This register enables the signaling of Err[2] when an error flag is set. Note that one and only one error signal should be enabled at a time.

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 5Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description                                   |
| 7  | RWST | 0       | <b>IO6bErr2:</b> Received STOP during SRC     |
| 6  | RWST | 0       | <b>IO6Err2:</b> Parity error on Address       |
| 5  | RWST | 0       | <b>IO5Err2:</b> Illegal Access                |
| 4  | RWST | 0       | <b>IO4Err2:</b> Outbound poison               |
| 3  | RWST | 0       | <b>IO3Err2:</b> Parity Error on outbound data |
| 2  | RWST | 0       | <b>IO2Err2:</b> Data Phase Parity Error       |
| 1  | RWST | 0       | <b>IO1Err2:</b> Cmd Parity Error              |
| 0  | RWST | 0       | <b>IO0Err2:</b> Target Abort                  |

#### 4.10.18 HIMCERR: Hub Interface MCERR Mask Register (D0, F0)

This register enables the signaling of MCERR when an error flag is set. Note that one and only one error signal should be enabled at a time.

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> 5Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RWST | 0       | <b>IO6bMCErr:</b> Received STOP during SRC                      |
| 6  | RWST | 0       | <b>IO6MCErr:</b> Parity error on Address                        |
| 5  | RWST | 0       | <b>IO5MCErr:</b> Illegal Access                                 |
| 4  | RWST | 0       | <b>IO4MCErr:</b> Outbound poison                                |
| 3  | RWST | 0       | <b>IO3MCErr:</b> Parity Error on outbound data                  |
| 2  | RWST | 0       | <b>IO2MCErr:</b> Data Phase Parity Error<br>Suggested value: 1h |
| 1  | RWST | 0       | <b>IO1MCErr:</b> Cmd Parity Error                               |
| 0  | RWST | 0       | <b>IO0MCErr:</b> Target Abort                                   |

#### 4.10.19 HICTL: Hub Interface Command Control Register (D0, F0)

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> D0h - D3h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:29  | RO   | 0h      | <b>HUB_SUB_FIRST:</b><br>This field stores the lowest subordinate Hub Interface hub number. This information is compared with the Hub ID to determine whether a completion packet should be forwarded further down the Hub Interface hierarchy.                                    |
| 28   | RV   | 0h      | <b>Reserved</b>  |
| 27:25  | RO   | 0h      | <b>HUB_SUB_LAST:</b><br>This field stores the highest subordinate Hub Interface hub number. This information is compared with the Hub ID to determine whether a completion packet should be forwarded further down the Hub Interface hierarchy.                                    |
| 24   | RV   | 0h      | <b>Reserved</b>  |
| 23:21  | RO   | 0h      | <b>HUB_ID:</b><br>This field identifies the Hub Interface ID number for the NB. The NB uses this field to determine when to accept a Hub Interface request packet and send any corresponding completion packets.   |
| 20   | RV   | 0       | <b>Reserved</b>  |
| 19:16  | RW   | 0h      | <b>HI_TIMESLICE:</b><br>This field sets the Hub Interface arbiter time-slice value with four base-clock granularity. A value of zero means that the timer immediately expires and the NB will allow the agent interfacing Hub Interface access to the bus every other transaction. |
| 15:14  | RO   | 0h      | <b>HI_WIDTH:</b><br>This field sets the Hub Interface data bus width. A value of 01 indicates a 16-bit data bus and 00 indicates an 8-bit data bus.  |

| <b>Device: 0</b><br><b>Function: 0</b><br><b>Offset: D0h - D3h</b> |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 13   | RO   | 1h      | <b>HI_RATE_VALID:</b><br>This bit is sampled by software and indicates when the Hub Interface bus rate is valid.  |
| 12:10  | RO   | 010b    | <b>HI_RATE:</b><br>This field indicates the Hub Interface data rate. Function 0 only supports a 4x data rate encoded with 010.  |
| 9:8  | RW   | 0h      | <b>RCOMP_INT:</b><br>Determines the time interval for impedance compensation. Encodings are:<br><br>00: 128 ms<br>01: 250 $\mu$ s<br>10: 16 ms<br>11: 2 ms  |
| 7:5  | RV   | 0h      | <b>Reserved</b>   |
| 4  | RWO  | 0       | <b>DIS_INB_CFG: Disable Inbound Configs</b><br>This bit is used for controlling configuration accesses to the chipset registers through the Hub Interface.<br><br>0: Allows access to the NB or XMB registers.<br>1: Inbound accesses to the NB or XMB registers will be dropped and logged as an illegal access.<br><br>This register bit is of type "write once" and is controlled by BIOS/special initialization firmware. |
| 3:1  | RO   | 001     | <b>MAX_DATA:</b><br>This field is programmed with the longest data stream the NB is permitted to send on the Hub Interface. MAX_DATA applies to both write request cycles and read completion cycles.<br><br>000: 32 bytes<br>001: 64 bytes<br>01X: 128 bytes<br>1XX: 256 bytes   |
| 0  | RV   | 0       | <b>EN64:</b> Enable 64 bit Addressing<br>The NB does not support 64-bit addressing on the Hub Interface   |

## 4.10.20 HICTL2: Hub Interface Command Control Register (D0, F0)

| <b>Device:</b> 0<br><b>Function:</b> 0<br><b>Offset:</b> D4h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:5  | RV   | 0       | <b>Reserved</b>  |
| 4:0  | RW   | 0       | <b>STOPGRANTACKCNT:</b><br>The NB will forward every (N+1)th StopGrantAck to the Hub Interface. The default provides for every StopGrantAck to be sent to the Hub Interface. Software is expected to set this to a value of THREADS-1 where THREAD is the number of threads that will issue a StopGrantAck in response to a StopClock request. |

## 4.11 PCI Express Ports (Device 1 - 7, Function 0)

The PCI Express registers are in Device 1 - 7 (D1-7), Function 0 (F0). For the register address map, please refer to [Table 4-11](#). The following registers define the standard PCI 2.3 compatible and extended PCI Express configuration space for each of the PCI Express x4 links in the NB. Unless otherwise specified, the registers are enumerated as a vector [7:1] mapping to each of the seven PCI Express ports uniquely.

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.11.1 VID[7:1]: Vendor Identification Register (D1-7, F0)

The VID Register contains Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 00 - 01h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value is assigned to Intel's standard notation. |

### 4.11.2 DID[7:1]: Device Identification Register (D1-7, F0)

This register combined with the Vendor Identification register uniquely identifies the NB function in the event that a driver is required. Writes to this register have no effect.

Device: 1 - 7  
Function: 0  
Offset: 02h - 03h

| Bit            | Attr   | Default         | Description   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
|----------------|--------|-----------------|---|----------------|--------|-----|---------------|---|-------|----------------|---|-------|----------------|---|-------|----------------|---|-------|----------------|---|-------|----------------|---|-------|----------------|---|-------|
| 15:0           | RWO    | See Description | <div><div>Device Identification Number</div><div>Identifies each function of the NB.</div><table><thead><tr><th>Register Group</th><th>Device</th><th>DID</th></tr></thead><tbody><tr><td>PCI Express D</td><td>1</td><td>2601h</td></tr><tr><td>PCI Express C0</td><td>2</td><td>2602h</td></tr><tr><td>PCI Express C1</td><td>3</td><td>2603h</td></tr><tr><td>PCI Express B0</td><td>4</td><td>2604h</td></tr><tr><td>PCI Express B1</td><td>5</td><td>2605h</td></tr><tr><td>PCI Express A0</td><td>6</td><td>2606h</td></tr><tr><td>PCI Express A1</td><td>7</td><td>2607h</td></tr></tbody></table></div> | Register Group | Device | DID | PCI Express D | 1 | 2601h | PCI Express C0 | 2 | 2602h | PCI Express C1 | 3 | 2603h | PCI Express B0 | 4 | 2604h | PCI Express B1 | 5 | 2605h | PCI Express A0 | 6 | 2606h | PCI Express A1 | 7 | 2607h |
| Register Group | Device | DID             |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express D  | 1      | 2601h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express C0 | 2      | 2602h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express C1 | 3      | 2603h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express B0 | 4      | 2604h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express B1 | 5      | 2605h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express A0 | 6      | 2606h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |
| PCI Express A1 | 7      | 2607h           |   |                |        |     |               |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |                |   |       |

### 4.11.3 EXP\_CMD[7:1]: Command Register (D1-7, F0)

This register defines the PCI 2.3 compatible command register values applicable to PCI Express space.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 04h - 05h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:11  | RV   | 00h     | <b>Reserved</b> (by PCI SIG)   |
| 10   | RO   | 0       | <b>INTxDisable: Interrupt Disable</b><br>Controls the ability of the PCI Express port to generate INTx messages.<br>Note that the NB does not have INTx pins and cannot generate interrupts internally. The default value is 0h (interrupt disabled). This bit does not affect the ability of the NB to route interrupt messages received at the PCI Express port for operations such as hot-plug, power management or MSI to either hub interface or the FSB's. |
| 9  | RO   | 0       | <b>FB2B: Fast Back-to-Back Enable</b><br>Not applicable to PCI Express and is hardwired to '0'.  |
| 8  | RW   | 0       | <b>SERRE: SERR Message Enable</b><br>This field handles the reporting of fatal and non-fatal errors by enabling the error pins ERR[2:0].<br><br>0: The NB is disabled from generating fatal/non-fatal errors.<br>1: The NB is enabled to send fatal/non-fatal errors.<br><br>The errors are also enabled by the EXP_DEVCTRL register (See <a href="#">Section 4.11.40</a> )  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 04h - 05h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7  | RO   | 0       | <b>IDSELWCC: IDSEL Stepping/Wait Cycle Control</b><br>Not applicable to PCI Express. Hardwired to 0.   |
| 6  | RW   | 0       | <b>PERRE: Parity Error Enable</b><br>When set, this field enables parity checking.   |
| 5  | RO   | 0       | <b>VGAPSE: VGA palette snoop Enable</b><br>Not applicable to PCI Express. Hardwired to 0.  |
| 4  | RO   | 0       | <b>MWIEN: Memory Write and Invalidate Enable</b><br>Not applicable to PCI Express. Hardwired to 0.   |
| 3  | RO   | 0       | <b>SCE: Special Cycle Enable</b><br>Not applicable to PCI Express. Hardwired to 0.   |
| 2  | RW   | 0       | <b>BME: Bus Master Enable</b><br>Controls the ability of the PCI Express port to forward memory or I/O transactions:<br><br>1: Enables the PCI Express port to successfully complete the memory or I/O read/write requests.<br><br>0: The Bus Master is disabled. The NB will treat upstream memory writes/reads, IO writes/reads, and MSIs as illegal cycles and return Unsupported Request Status (equivalent to Master abort) in PCI Express.<br><br>When the BME is disabled, the NB will treat upstream memory writes/reads, IO writes/reads, and MSIs as illegal cycles and return Unsupported Request Status (equivalent to Master abort) in PCI Express.<br><br>Requests other than inbound memory or I/O (e.g. configuration, outbound) are not controlled by this bit.<br><br>The BME is typically used by the system software for operations such as Hot-plug device configuration. |
| 1  | RW   | 0       | <b>MSE: Memory Space Enable</b><br><br>1: Enables the Memory and Pre-fetchable memory address ranges (MMIO) defined in the <b>MBASE/MLIMIT</b> , <b>PMBASE/PMLIMIT</b> registers.<br><br>0: Disables the entire memory space seen by the PCI Express port on the primary side (NB). Requests will then be subtractively claimed by ICH5.   |
| 0  | RW   | 0       | <b>IOAE: Access Enable</b><br><br>1: Enables the I/O address range defined in the <b>IOBASE</b> and <b>IOLIMIT</b> registers.<br><br>0: Disables the entire I/O space seen by the PCI Express port on the primary. Requests will then be subtractively claimed by ICH5.  |



#### 4.11.4 EXP\_STS[7:1]: Status Register (D1-7, F0)

The EXP\_STS is a 16-bit status register that reports the occurrence of error conditions associated with the primary side of the “virtual” PCI-PCI bridge embedded in the selected PCI Express cluster of the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 06 - 07h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15  | RWC  | 0       | <b>DPE: Detected Parity Error</b><br>This bit is set when the PCI Express port gets an uncorrectable data error or Address/Control parity errors regardless of the Parity Error Enable bit (PERRE). The detected parity error maps to T10 as defined in <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document.  |
| 14  | RWC  | 0h      | <b>SSE: Signaled System Error</b><br>1: The PCI Express port enables system errors through ERR[2:0] pins such as ERR_FATAL and ERR_NONFATAL messages provided SERRE is set. Software clears this bit by writing a 1 to it.<br>0: No system errors are generated by the PCI Express Port.  |
| 13  | RWC  | 0h      | <b>RMA: Received Master Abort</b><br>Master Abort does not exist on the primary side of the PCI Express port. This bit is hardwired to 0.   |
| 12  | RWC  | 0h      | <b>RTA: Received Target Abort</b><br>Target Abort does not exist on the primary side of the PCI Express port. This bit is hardwired to 0.   |
| 11  | RWC  | 0h      | <b>STA: Signaled Target Abort</b><br>Target Abort does not exist on the primary side of the PCI Express port. This bit is hardwired to 0.   |
| 10:9  | RO   | 0h      | <b>DEVSELT: DEVSEL# Timing</b><br>Not applicable to PCI Express. This bit is hardwired to 0.  |
| 8   | RWC  | 0h      | <b>MDPERR: Master Data Parity Error</b><br>This bit is set by the PCI Express port if the Parity Error Enable bit (PERRE) is set and it receives error T10 (uncorrectable data error or Address/Control parity errors or an internal failure). If the Parity Error Enable bit is cleared, this bit is never set. See <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document. |
| 7   | RO   | 0       | <b>FB2B: Fast Back-to-Back</b><br>Not applicable to PCI Express. This bit is hardwired to 0.  |
| 6   | RV   | 0       | <b>Reserved</b> (by PCI SIG)  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 06 - 07h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 5   | RO   | 0       | <b>66MHZCAP: 66 MHz capable</b><br>Not applicable to PCI Express. This bit is hardwired to 0.  |
| 4   | RO   | 1       | <b>CAPL: Capabilities List</b><br>This bit indicates the presence of PCI Express capabilities list structure in the PCI Express port. This bit is hardwired to 1(Mandatory).   |
| 3   | RO   | 0       | <b>INTxSTAT: INTx Status</b><br>Indicates that an INTx interrupt message is pending internally in the PCI Express port. This bit does not get set for interrupts forwarded up from downstream devices in the hierarchy or for messages converted to interrupts by the root port. |
| 2:0   | RV   | 00      | <b>Reserved</b> (by PCI SIG)   |

#### 4.11.5 RID[7:1]: Revision Identification Register (D1-7, F0)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 08h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br>1h : B stepping  |
| 3:0  | RO   | 0       | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br>0h: x0 stepping<br>1h: x1 stepping<br>2h: x2 stepping |

### 4.11.6 CCR[7:1]: Class Code Register (D1-7, F0)

This register contains the Class Code for the device.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 09-0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 04h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For PCI Express Devices 1,2,3,4,5,6,7 default is 040h, indicating "PCI to PCI Bridge".  |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.11.7 CLS[7:1]: Cache Line Size (D1-7, F0)

This register contains the Cache Line Size and is set by BIOS/Operating System. It does not affect the PCI Express port functionality in the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 0Ch |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RW   | 00h     | <b>CLS: Cache Line Size (CLS)</b><br>This is an 8-bit value that indicates the size of the cache line and is specified in DWORDs. It does not affect the NB. |

### 4.11.8 PRI\_LT[7:1]: Primary Latency Timer (D1-7, F0)

This register denotes the maximum timeslice for a burst transaction in legacy PCI 2.3 on the primary interface. It does not affect or influence PCI Express functionality.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 0Dh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 00h     | <b>PLatTim: Primary Latency Timer</b><br>Not applicable to PCI Express. Hardwired to 00h. |

### 4.11.9 HDR[7:1]: Header Type Register (D1-7, F0)

This register identifies the header layout of the configuration space.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 0Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 00h     | <b>Mfd: Multi-function Device.</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.   |
| 6:0  | RO   | 01h     | <b>CfgLayout: Configuration Layout.</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For PCI Express Devices 1,2,3,4,5,6,7 default is 01h, indicating "PCI to PCI Bridge". |

### 4.11.10 BIST[7:1]: Built-In Self Test (D1-7, F0)

This register is used for reporting control and status information of BIST checks within a PCI Express port. It is not supported in the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 0Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 00h     | <b>Btest: BIST Tests</b><br>Not supported. Hardwired to 00h |

### 4.11.11 PBUSN[7:1]: Primary Bus Number (D1-7, F0)

This register identifies that "virtual" PCI-PCI bridge is connected to bus #0.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 18h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 00h     | <b>PBUSN: Primary Bus Number</b><br>Configuration software typically programs this field with the number of the bus on the primary side of the bridge. Since the PCI Express virtual PCI-PCI bridge is an internal device and its primary bus is always 0, these bits are read only and are hardwired to 00h. |

### 4.11.12 SBUSN[7:1]: Secondary Bus Number (D1-7, F0)

This register identifies the bus number assigned to the secondary side of the “virtual” PCI-PCI bridge (the PCI Express connection). This number is programmed by the PCI configuration software to allow mapping of configuration cycles to a second bridge device connected to PCI Express.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 19h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RW   | 0h      | <b>BUSN: Secondary Bus Number</b><br>This field is programmed by configuration software with the lowest bus number of the buses connected to PCI Express. Since both bus 0, device (1 - 7) and the PCI-PCI bridge on the other end are considered by configuration software to be PCI-PCI bridges, this bus number will always correspond to the bus number assigned to PCI Express. |

### 4.11.13 SUBUSN[7:1]: Subordinate Bus Number (D1-7, F0)

This register identifies the subordinate bus (if any) that resides at the level below the secondary PCI Express interface. This number is programmed by the PCI configuration software to allow mapping of configuration cycles to devices subordinate to the secondary PCI Express port.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 1Ah |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RW   | 0h      | <b>SUBUSN: Subordinate Bus Number</b><br>This register is programmed by configuration software with the number of the highest subordinate bus that is behind the PCI Express port. |

### 4.11.14 SEC\_LT[7:1]: Secondary Latency Timer (D1-7, F0)

This register denotes the maximum time-slice for a burst transaction in legacy PCI 2.3 on the secondary interface. It does not affect or influence PCI Express functionality.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 1Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 00h     | <b>SEC_LT: Secondary Latency Timer</b><br>Not applicable to PCI Express. Hardwired to 00h. |

### 4.11.15 IOBASE[7:1]: I/O Base Register (D1-7, F0)

The I/O Base and I/O Limit (Section 4.11.16) registers define an address range that is used by the PCI Express bridge to determine when to forward I/O transactions from one interface to the other using the following formula:

$$IO\_BASE \leq A[15:12] \leq IO\_LIMIT$$

Only the upper 4 bits are programmable. For the purpose of address decode, address bits A[11:0] are treated as 0. The bottom of the defined I/O address range will be aligned to a 4KB boundary while the top of the region specified by IO\_LIMIT will be *one less than a 4 KB multiple*.

**Note:** If IOLIM < IOBASE, then the aperture is closed.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 1Ch |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RW   | 00h     | <b>IOBASE: I/O Base Address</b><br>Corresponds to A[15:12] of the I/O addresses passed by the PCI Express device.   |
| 3:0  | RO   | 00h     | <b>IOCAP: I/O Address Capability</b><br>0h: 16-bit I/O addressing (supported)<br>Others: <i>Reserved</i><br><b>NOTE:</b> The NB only supports 16-bit I/O addressing. These bits are hardwired to 00h. |

### 4.11.16 IOLIM[7:1]: I/O Limit Register (D1-7, F0)

The I/O Base and I/O Limit registers define an address range that is used by the PCI Express bridge to determine when to forward I/O transactions from one interface to the other using the following formula:

$$IO\_BASE \leq A[15:12] \leq IO\_LIMIT$$

Only the upper 4 bits are programmable. For the purpose of address decode, address bits A[11:0] of the I/O limit register is treated as FFFh.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 1Dh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RW   | 00h     | <b>I/O Address Limit (IOLIMIT)</b> - Corresponds to A[15:12] of the I/O addresses passed by the PCI Express device.   |
| 3:0  | RO   | 00h     | <b>I/O Address Limit Capability (IOLCAP)</b><br>0h: 16-bit I/O addressing (supported)<br>Others: <i>Reserved</i><br><b>NOTE:</b> The NB only supports 16-bit I/O addressing. These bits are hardwired to 00h. |

### 4.11.17 SECSTS[7:1]: Secondary Status (D1-7, F0)

SECSTS is a 16-bit status register that reports the occurrence of error conditions associated with the secondary side (i.e. PCI Express side) of the “virtual” PCI-PCI bridge embedded within the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 1Eh - 1Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RWC  | 0h      | <b>SDPE: Detected Parity Error</b><br>This bit is set by the NB whenever it receives a poisoned TLP in the PCI Express port regardless of the state of the Parity Error Response bit. This corresponds to IO14 as defined in <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document.  |
| 14   | RWC  | 0h      | <b>SRSE: Received System Error</b><br>This bit is set by the NB when it receives a ERR_FATAL or ERR_NONFATAL message, and the <b>BCSERRE</b> bit is set in BCTRL register ( <a href="#">Section 4.11.27</a> ). This corresponds to IO24, IO25 and IO26 as defined in <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document.  |
| 13   | RWC  | 0h      | <b>SRMAS: Received Master Abort Status</b><br>This bit is set when the PCI Express port receives a Completion with “Unsupported Request Completion” Status. This corresponds to IO12 as defined in <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document.  |
| 12   | RWC  | 0h      | <b>SRTAS: Received Target Abort Status</b><br>This bit is set when the PCI Express port receives a Completion with “Completer Abort” Status. This corresponds to IO17 as defined in <a href="#">Table 6-39 “Errors Detected by the NB” on page 328</a> of this document.   |
| 11   | RWC  | 0h      | <b>SSTAS: Signaled Target Abort</b><br>This bit is set when the PCI Express port completes a request with “Completer Abort” Status. The NB never generates completer aborts internally, therefore this bit is never set.   |
| 10:9   | RO   | 00h     | <b>SDEVT: DEVSEL# Timing</b><br>Not applicable to PCI Express. Hardwired to 00h.   |
| 8  | RWC  | 0h      | <b>SMDPERR: Master Data Parity Error</b><br>This bit is set by the PCI Express port on the secondary side (PCI Express link) if the Parity Error Response bit (PERRE) is set and either of the following two conditions occurs: <ul style="list-style-type: none"> <li>The PCI Express port receives a completion marked poisoned</li> <li>The PCI Express port poisons a write request</li> </ul> If the Parity Error Response bit is cleared, this bit is never set. |
| 7  | RO   | 0h      | <b>SFB2BTC: Fast Back-to-Back Transactions Capable</b><br>Not applicable to PCI Express. Hardwired to 00h.   |
| 6  | RV   | 0h      | <b>Reserved</b> (by PCI SIG)   |
| 5  | RO   | 0h      | <b>S66MHCAP: 66 MHz Capability</b><br>Not applicable to PCI Express. Hardwired to 00h.   |
| 4:0  | RV   | 00h     | <b>Reserved</b> (by PCI SIG)   |

#### 4.11.18 MBASE[7:1]: Memory Base (D1-7, F0)

The Memory Base and Memory Limit registers define a memory mapped I/O non-prefetchable address range (32-bit addresses) and the NB directs accesses in this range to the PCI Express port based on the following formula:

$$\text{MEMORY\_BASE} \leq A[31:20] \leq \text{MEMORY\_LIMIT}$$

The upper 12 bits of both the Memory Base and Memory Limit registers are read/write and corresponds to the upper 12 address bits, A[31:20], of 32-bit addresses. For the purpose of address decoding, the bridge assumes that the lower 20 address bits, A[19:0], of the memory base address are 00000h. Similarly, the bridge assumes that the lower 20 address bits, A[19:0], of the memory limit address (not implemented in the Memory Limit register) are FFFFFh. Thus, the bottom of the defined memory address range will be aligned to a 1 MB boundary and the top of the defined memory address range will be one less than a 1 MB boundary.

**Note:** If MLIMIT < MBASE, then the aperture is closed.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 20h - 21h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:4   | RW   | 0h      | <b>MBASE: Memory Base Address</b><br>Corresponds to A[31:20] of the memory address on the PCI Express port. |
| 3:0  | RO   | 0h      | <b>Reserved</b> (by PCI SIG)  |

#### 4.11.19 MLIMIT[7:1]: Memory Limit (D1-7, F0)

This register controls the processor to PCI Express non-prefetchable memory access routing based on the following formula as described above:

$$\text{MEMORY\_BASE} \leq A[31:20] \leq \text{MEMORY\_LIMIT}$$

The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32-bit address. The bottom 4 bits of this register are read-only and return 0h when read. This register must be initialized by the configuration software. For the purpose of address decode, address bits A[19:0] are assumed to be FFFFFh.

Memory range covered by MBASE and MLIMIT registers are used to map non-prefetchable PCI Express address ranges (typically where control/status memory-mapped I/O data structures reside). PMBASE and PMLIMIT are used to map prefetchable address ranges.

Note also that configuration software is responsible for programming all address range registers (prefetchable and non-prefetchable) with the values that provide exclusive address ranges (i.e. prevent overlap with each other and/or with the ranges covered with the main memory). There is no provision in the NB hardware to enforce prevention of overlap. Operations of the system in the case of overlap are not guaranteed.



| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 22h - 23h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:4   | RW   | 0h      | <b>MLIMIT: Memory Limit Address</b><br>Corresponds to A[31:20] of the memory address that corresponds to the upper limit of the range of memory accesses that will be passed by the PCI Express bridge. |
| 3:0  | RO   | 0h      | <b>Reserved</b> (by PCI SIG)  |

#### 4.11.20 PMBASE[7:1]: Prefetchable Memory Base (D1-7, F0)

The Prefetchable Memory Base and Memory Limit registers define a memory mapped I/O prefetchable address range (32-bit addresses) which is used by the PCI Express bridge to determine when to forward memory transactions from one interface to the other based on the following formula:

$$\text{PREFETCH\_MEMORY\_BASE} \leq \text{A}[31:20] \leq \text{PREFETCH\_MEMORY\_LIMIT}$$

The upper 12 bits of both the Prefetchable Memory Base and Memory Limit registers are read/write and corresponds to the upper 12 address bits, A[31:20], of 32-bit addresses. For the purpose of address decoding, the bridge assumes that the lower 20 address bits, A[19:0], of the memory base address are 00000h. Similarly, the bridge assumes that the lower 20 address bits, A[19:0], of the memory limit address (not implemented in the Memory Limit register) are FFFFFh. Thus, the bottom of the defined memory address range will be aligned to a 1 MB boundary and the top of the defined memory address range will be one less than a 1 MB boundary.

**Note:** If PMLIMIT < PMBASE, then the aperture is closed.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 24h - 25h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:4   | RW   | 00h     | <b>PMBASE: Prefetchable Memory Base Address</b><br>Corresponds to A[31:20] of the prefetchable memory address on the PCI Express port.  |
| 3:0  | RO   | 01h     | <b>PMBASE_CAP: Prefetchable Memory Base Address Capability</b><br><br>00h: 32-bit Prefetchable Memory addressing<br>01h: 64-bit Prefetchable Memory addressing<br>Others: <i>Reserved</i> |

The bottom 4 bits of both the Prefetchable Memory Base and Prefetchable Memory Limit registers are read-only, contain the same value, and encode whether or not the bridge supports 64-bit addresses. If these four bits have the value 0h, then the bridge supports only 32 bit addresses. If these four bits have the value 01h, then the bridge supports 64-bit addresses and the Prefetchable Base Upper 32 Bits and Prefetchable Limit Upper 32 Bits registers hold the rest of the 64-bit prefetchable base and limit addresses respectively.

### 4.11.21 PMLIMIT[7:1]: Prefetchable Memory Limit (D1-7, F0)

This register controls the processor to PCI Express prefetchable memory access routing based on the following formula as described above:

$$\text{extPMBASE}[n] = (\text{PMBU}[n] \ll 32) \mid \text{PMBASE}[n].\text{PMBASE}$$

$$\text{extPMLIM}[n] = (\text{PMLU}[n] \ll 32) \mid \text{PMLIMIT}[n].\text{PMBASE}$$

$$\text{extPMBASE}[n] \leq \text{zero\_extend}(A[39:20]) \leq \text{extPMLIM}[n]$$

The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32 bit address. This register must be initialized by the configuration software. For the purpose of address decode address bits A[19:0] are assumed to be FFFFh.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 26h - 27h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:4   | RW   | 0h      | <b>PMLIMIT: Prefetchable Memory Limit Address</b><br>Corresponds to A[31:20] of the memory address that corresponds to the upper limit of the prefetchable range of memory accesses that will be passed by the PCI Express bridge. |
| 3:0  | RO   | 1h      | <b>PMLIMIT_CAP: Prefetchable Memory Limit Address Capability</b><br>00h: 32-bit Prefetchable Memory addressing<br>01h: 64-bit Prefetchable Memory addressing<br>Others: <i>Reserved</i>  |

### 4.11.22 PMBU[7:1]: Prefetchable Memory Base (Upper 32 bits) (D1-7, F0)

The Prefetchable Base Upper 32 Bits is the extension to the Prefetchable Memory Base register. It concatenate with the PMLIMIT address fields to build a full address.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 28h - 2Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:0   | RW   | 0h      | <b>PUMBASE: Prefetchable Upper 32-bit Memory Base Address</b><br>A[63:32] of the memory address that corresponds to the upper base of the prefetchable range of memory accesses that will be passed by the PCI Express bridge. The operating system (OS) should program these bits based on the available physical limits of the system. |

### 4.11.23 PMLU[7:1]: Prefetchable Memory Limit (Upper 32 Limit) (D1-7, F0)

The Prefetchable Limit Upper 32 Bits registers is the extension to the Prefetchable Memory Limit register. It concatenate with the PMBASE address fields to build a full address.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 2Ch - 2Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:0   | RW   | 0h      | <b>PUMLIM: Prefetchable Upper 32-bit Memory Limit Address</b><br>A[63:32] of the memory address that corresponds to the upper limit of the prefetchable range of memory accesses that will be passed by the PCI Express bridge. The operating system (OS) should program these bits based on the available physical limits of the system. |

### 4.11.24 CAPPTR[7:1]: Capability Pointer (D1-7, F0)

The CAPPTR is used to point to a linked list of additional capabilities implemented by this device.

It provides the offset to the first set of capabilities registers located in the PCI-compatible space from 40h. Currently, the first structure is located at 50h to provide room for other registers.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 34h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 50h     | <b>CAPPTR: Capability Pointer</b><br>Points to the first capability structure (PM) in PCI 2.3 compatible space at 50h. |

### 4.11.25 INTL[7:1]: Interrupt Line Register (D1-7, F0)

The Interrupt Line register is used to communicate interrupt line routing information between initialization code and the device driver. The NB does not have a dedicated interrupt line and is not used.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 3Ch |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 00h     | <b>INTL: Interrupt Line</b><br>BIOS writes the interrupt routing information to this register to indicate which input of the interrupt controller this PCI Express Port is connected to. Not used in the NB since the PCI Express port does not have interrupt lines. |

### 4.11.26 INTP[7:1]: Interrupt Pin Register (D1-7, F0)

The INTP register identifies legacy interrupts for INTA, INTB, INTC and INTD. These features are not supported by the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 3Dh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 00h     | <b>Interrupt Pin (INTP)</b><br>Set to '00h' to indicate no interrupt pins. |

### 4.11.27 BCTRL[7:1]: Bridge Control Register (D1-7, F0)

This register provides extensions to the EXP\_CMD register that are specific to PCI-PCI bridges. The BCTRL provides additional control for the secondary interface (i.e. PCI Express) as well as some bits that affect the overall behavior of the “virtual” PCI-PCI bridge embedded within the NB (e.g. VGA compatible address range mapping).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 3Eh - 3Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:12  | RV   | 00h     | <b>Reserved.</b> (by PCI SIG)  |
| 11   | RO   | 0h      | <b>DTSS: Discard Timer SERR Status</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.  |
| 10   | RO   | 0h      | <b>DTS: Discard Timer Status</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.  |
| 9  | RO   | 0h      | <b>SDT: Secondary Discard Timer</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.   |
| 8  | RO   | 0h      | <b>PDT: Primary Discard Timer</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.   |
| 7  | RO   | 0h      | <b>FB2BEN: Fast Back-to-Back Enable</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.   |
| 6  | RW   | 0h      | <b>SRESET: Secondary Bus Reset</b><br>Setting this bit triggers a warm reset on the corresponding PCI Express port and the PCI Express hierarchy domain subordinate to the port. |
| 5  | RO   | 0h      | <b>MAMODE: Master Abort Mode</b><br>Not applicable to PCI Express. This bit is hardwired to 0h.  |
| 4  | RV   | 0h      | <b>Reserved</b> (by PCI SIG)   |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 3Eh - 3Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 3  | RW   | 0h      | <b>VGAEN: VGA Enable</b><br>Controls the routing of CPU initiated transactions targeting VGA compatible I/O and memory address ranges. This bit may only be set for one PCI Express port.  |
| 2  | RW   | 0h      | <b>ISAEN: ISA Enable</b><br>Modifies the response by the NB to an I/O access issued by the CPU that target ISA I/O addresses. This applies only to I/O addresses that are enabled by the IOBASE and IOLIMIT registers.<br><br>1h: The NB will not forward to PCI Express any I/O transactions addressing the last 768 bytes in each 1 KB block even if the addresses are within the range defined by the IOBASE and IOLIMIT registers. Instead of going to PCI Express these cycles will be forwarded to H10 where they can be subtractively or positively claimed by the ISA bridge.<br><br>0h: All addresses defined by the IOBASE and IOLIMIT for CPU I/O transactions will be mapped to PCI Express. |
| 1  | RW   | 0h      | <b>BCSERRE: SERR Enable</b><br>This bit controls forwarding of ERR_COR, ERR_NONFATAL and ERR_FATAL messages from the PCI Express port to the primary side.<br><br>1h: Enables forwarding of ERR_COR, ERR_NONFATAL and ERR_FATAL messages.<br><br>0h: Disables forwarding of ERR_COR, ERR_NONFATAL and ERR_FATAL messages.  |
| 0  | RW   | 0h      | <b>PRSPEN: Parity Error Response Enable</b><br>This bit controls the response to poisoned TLPs in the PCI Express port<br><br>1h: Enables reporting of poisoned TLP errors.<br><br>0h: Disables reporting of poisoned TLP errors.  |

## 4.11.28 EXP\_CTRL[7:1]: PCI Express Control Register (D1-7, F0)

This 32-bit register implements the chipset-specific operations for general control/accessibility such as device hiding, selective configuration cycles, interrupt signaling and MSI generation.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 48h - 4Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:30  | RV   | 0       | <b>Reserved</b>  |
| 29   | RW   | 0       | <b>DISABLE ABP</b><br>When set prevents bit 0 ABP: Attention Button Pressed in <a href="#">Section 4.11.47, "EXP_SLOTSTS[7:1]: PCI Express Slot Status Register (D1-7, F0)"</a> from getting set.<br>Suggested value: 1  |
| 28   | RV   | 0       | <b>Reserved</b>  |
| 27   | RW   | 0       | <b>DIS_TOGGLE_POP_PRI</b>  |
| 26   | RW   | 0       | <b>READ_INTERLOCK:</b><br>Cards that violate PCI ordering rules and have a read-to-read in-out dependency must set this bit to avoid deadlock during locks. The dependency is a card that expects the NB to provide completion for its upstream read before it can process a downstream read from the NB. Such cards must not participate in peer-to-peer transactions. Since the default is 0, it assumes that cards follow PCI ordering rules fully. |
| 25:24  | RW   | 3h      | <b>COALESCE_MODE:</b><br>Used to increase the amount of combining for completions.<br><br>X 1: #CPL_ENTRIES_FREE will restrict coalesce_hint<br>1 X: f set then #PF_PEND will restrict coalesce hint<br>0 0: Least restrictive<br>Suggested value: 00h   |
| 23   | RW   | 0       | <b>TIMEOUT_ENABLE_CFG:</b><br><br>1: Config transactions can time out<br>0: Config transactions cannot time out<br>Suggested value: 0h   |
| 22   | RW   | 1h      | <b>TIMEOUT_ENABLE:</b><br>1: Non config transactions can time out.<br>0: Non config transactions cannot time out.<br>Suggested value: 1h   |
| 21   | RW   | 1h      | <b>MALTLP_EN:</b><br><br>1: Check for certain malformed TLP types<br>0: Do not check for certain malformed TLP types   |
| 20   | RW   | 0h      | <b>DZLCW: Drop zero length config writes</b><br>Suggested value: 0h  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 48h - 4Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 19   | RW   | 0h      | <b>DZLIW: Drop zero length I/O writes</b><br>Suggested value: 0h  |
| 18   | RW   | 0h      | <b>DZLMW: Drop zero length memory writes</b><br>Suggested value: 0h   |
| 17   | RW   | 0h      | <b>DZLCR: Drop zero length config reads</b><br>Suggested value: 0h  |
| 16   | RW   | 0h      | <b>DZLIR: Drop zero length I/O reads</b><br>Suggested value: 0h   |
| 15   | RW   | 0h      | <b>DZLMR: Drop zero length memory reads</b><br>Suggested value: 0h  |
| 14   | RW   | 1h      | <b>STREAM_INTERLEAVE_CHECK_EN:</b><br><br>1: Not supported<br>0: Do not check for stream interleaving<br><br>Suggested value: 0h  |
| 13   | RW   | 1h      | <b>INTERLEAVE_EN:</b><br><br>1: Interleaved<br>0: Not interleaved<br><br>Suggested value: 1h  |
| 12   | RW   | 1h      | <b>256B_EN:</b><br><br>1: Increases likelihood of 256B return when <b>COALESCE_EN</b> = 1<br>0: Decreases likelihood of 256B return when <b>COALESCE_EN</b> = 1<br><br>Suggested value: 1h            |
| 11   | RW   | 0h      | <b>CF: Force coalescing of accesses</b><br>When 1, forces the NB to wait for all coalescable data before sending the transaction as opposed to forwarding as much as possible.<br>Suggested value: 0h |
| 10   | RW   | 1h      | <b>COALESCE_EN: When 1, enables read return of &gt;64B</b><br><br>1: Returns of >64B enabled. See <b>256B_EN</b><br>0: Returns are 64B or less<br><br>Suggested value: 1h                             |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 48h - 4Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 9  | RW   | 0h      | <b>MSIPMEN: MSI PME Enable</b><br><br>1: Enables MSI messages to be sent to the CPU for PME events.<br>0: Disables sending of MSI messages to the CPU for PME events<br><br>Note that for MSI PME messages to be sent, both MSIPMEN and at least one of MSICTRL[7:1].MSIEN bits have to be set.  |
| 8  | RW   | 0h      | <b>MSIHPEN: MSI Hot-Plug Enable</b><br><br>1: Enables MSI messages to be sent to the CPU for Hot-plug events and enables signaling hot plug events on the EXP_HPINT pin.<br>0: Disables sending of MSI messages for Hot-plug events to the CPU<br><br>Note that for MSI Hot-plug messages to be sent, both MSIHPEN and at least one of MSICTRL[7:1].MSIEN bits defined in <a href="#">Section 4.11.34</a> have to be set.                                  |
| 7  | RWO  | 0h      | <b>DIS_INB_CFG: Disable Inbound Configurations</b><br>This bit is used for controlling configuration accesses to the chipset registers through the PCI Express device.<br><br>1: Inbound accesses to the NB or XMB registers will be master aborted<br>0: Allows access to the NB or XMB registers. (typically for internal debug, test, etc.)<br><br>This register bit is of type “write once” and is controlled by BIOS/special initialization firmware. |
| 6:3  | RW   | 00h     | <b>VPP: Virtual Pin Port</b><br>[6:4] = SMBus Address, [3] =IO Port<br>defines the 8-bit IO port that is used for routing power, attention, Hot-Plug, presence, MRL and other events defined in <a href="#">Table 6-34</a> .   |
| 2  | RW   | 0h      | <b>EN_VPP: Enable VPP</b><br>The NB will use this bit to decide whether VPP is enabled or disabled for the given PCI Express port as set by configuration software. For example, to distinguish Hot-Plug events for a legacy card or PCI Express module, this bit can be used.<br><br>1: VPP is enabled for this PCI Express port<br>0: VPP is disabled for this PCI Express port  |
| 1  | RW   | 0h      | <b>DIS_APIC_EOI: Disable APIC EOI</b><br>The NB will use this bit to decide whether end of interrupts (EOI) need to be sent to an APCI controller/bridge (e.g. PXH) through this PCI Express device.<br><br>1: No EOIs are sent (disabled). Should be set by BIOS if link never came up.<br>0: EOIs are dispatched to the APIC Controller<br><br>Suggested Value: 1 Unless an Intel device is attached.  |
| 0  | RV   | 0h      | <b>Reserved</b>  |



## 4.11.29 EXP\_CTRL2: PCI Express Control Register 2 (D1-7, F0)

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 4Ch |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:1  | RV   | 00h     | <b>Reserved</b>   |
| 0  | RW   | 0       | <b>NO_COMPLIANCE:</b><br>Set by software to enable link operation in the presence of single wire failures on the link. If clear, then specified link behavior in the presence of a wire failure will be Polling.<br>Suggested value: 1h |

## 4.11.30 PMCAP[7:1]: Power Management Capabilities Register (D1-7, F0)

The PM Capabilities Register defines the capability ID, next pointer and other power management related support. The following PM registers /capabilities are added for software compliance.

Device: 1 - 7  
Function: 0  
Offset: 50h - 53h

| Bit    | Attr   | Default | Description  |        |  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
|--------|--------|---------|--|--------|--|--------|--------|--------|---------|---|---|---|---|---|---------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|
| 31:27  | RO     | 11001b  | <b>PMES: PME Support</b><br>Identifies power states which asserts PME_OUT. Bits 31, 30 and 27 must be set to '1' for PCI-PCI bridge structures representing ports on root complexes. The definition of these bits is taken from the PCI Bus Power Management Interface Specification Revision 1.1. <table><tr><th>Bit 31</th><th>Bit 30</th><th>Bit 29</th><th>Bit 28</th><th>Bit 27</th><th>PME_OUT</th></tr><tr><td>X</td><td>X</td><td>X</td><td>X</td><td>1</td><td>PME_OUT can be asserted from D0</td></tr><tr><td>X</td><td>X</td><td>X</td><td>1</td><td>X</td><td>PME_OUT can be asserted from D1 (Not supported by the NB)</td></tr><tr><td>X</td><td>X</td><td>1</td><td>X</td><td>X</td><td>PME_OUT can be asserted from D2 (Not supported by the NB)</td></tr><tr><td>X</td><td>1</td><td>X</td><td>X</td><td>X</td><td>PME_OUT can be asserted from D3 hot (Not supported by the NB)</td></tr><tr><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>PME_OUT can be asserted from D3 cold (Not supported by the NB)</td></tr></table> | Bit 31 | Bit 30   | Bit 29 | Bit 28 | Bit 27 | PME_OUT | X | X | X | X | 1 | PME_OUT can be asserted from D0 | X | X | X | 1 | X | PME_OUT can be asserted from D1 (Not supported by the NB) | X | X | 1 | X | X | PME_OUT can be asserted from D2 (Not supported by the NB) | X | 1 | X | X | X | PME_OUT can be asserted from D3 hot (Not supported by the NB) | 1 | X | X | X | X | PME_OUT can be asserted from D3 cold (Not supported by the NB) |
| Bit 31 | Bit 30 | Bit 29  | Bit 28   | Bit 27 | PME_OUT  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| X      | X      | X       | X  | 1      | PME_OUT can be asserted from D0                                |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| X      | X      | X       | 1  | X      | PME_OUT can be asserted from D1 (Not supported by the NB)      |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| X      | X      | 1       | X  | X      | PME_OUT can be asserted from D2 (Not supported by the NB)      |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| X      | 1      | X       | X  | X      | PME_OUT can be asserted from D3 hot (Not supported by the NB)  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| 1      | X      | X       | X  | X      | PME_OUT can be asserted from D3 cold (Not supported by the NB) |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| 26     | RO     | 0h      | <b>D2S: D2 Support</b><br>The <b>NB</b> does not support power management state D2.  |        |  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| 25     | RO     | 0h      | <b>D1S: D1 Support</b><br>The <b>NB</b> does not support power management state D1.  |        |  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| 24:22  | RO     | 0h      | <b>AUXCUR: AUX Current</b>   |        |  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |
| 21     | RO     | 0h      | <b>DSI: Device Specific Initialization</b>   |        |  |        |        |        |         |   |   |   |   |   |                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 50h - 53h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 20   | RV   | 0h      | <b>Reserved</b>   |
| 19   | RO   | 0h      | <b>PMECLK: PME Clock</b><br>This field is hardwired to 0h as it does not apply to PCI Express.  |
| 18:16  | RO   | 010b    | <b>VER: Version</b><br>This field is set to '010b' as version number from the PCI Express 1.0 specification.  |
| 15:8   | RO   | 58h     | <b>NXTCAPPTR: Next Capability Pointer</b><br>This field is set to offset 58h for the next capability structure (MSI) in the PCI 2.3 compatible space. |
| 7:0  | RO   | 01h     | <b>CAPID: Capability ID</b><br>Provides the PM capability ID assigned by PCI-SIG.   |

#### 4.11.31 PMSCR[7:1]: Power Management Status and Control Register (D1-7, F0)

This register provides status and control information for PM events in the PCI Express ports of the NB.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 54h - 57h |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 31:24  | RO    | 0h      | <b>Data: Data</b><br>Data read out based on data select (DSEL).   |
| 23   | RO    | 0h      | <b>BPCEN: Bus Power/Clock Control Enable</b><br>This field is hardwired to 0h as it does not apply to PCI Express.  |
| 22   | RO    | 0h      | <b>B2B3S: B2/B3 Support</b><br>This field is hardwired to 0h as it does not apply to PCI Express.   |
| 21:16  | RV    | 0h      | <b>Reserved</b>   |
| 15   | RWCST | 0h      | <b>PMESTS: PME Status</b><br>This PME Status is a sticky bit. When set, the PCI Express port generates a PME internally independent of the PMEEN bit defined below. Software clears this bit by writing a '1'.<br>As a root port, the NB will never set this bit, because it never generates a PME internally independent of the PMEEN bit. |
| 14:13  | RO    | 0h      | <b>DSCL: Data Scale</b>   |
| 12:9   | RW    | 0h      | <b>DSEL: Data Select</b>  |
| 8  | RWST  | 0h      | <b>PMEEN: PME Enable</b><br>This field, when set enables forwarding of PME messages received at the PCI Express port to the NB core.  |
| 7:2  | RV    | 0h      | <b>Reserved</b>   |
| 1:0  | RW    | 0h      | <b>PS: Power State</b>  |

### 4.11.32 MSICAPID[7:1]: MSI Capability ID (D1-7, F0)

Message Signaled Interrupts (MSI) is an optional feature that enables a device to request service by writing a system-specified message to a system-specified address in the form of an interrupt message. The transaction address (e.g. FEEx\_xxxxh) specifies the message destination and the transaction data specifies the message. The MSI mechanism is supported by the following registers: MSICAPID, MSINXPTR, MSICTRL, MSIAR and MSIDR described below.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 58h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 05h     | <b>CAPID: Capability ID</b><br>Assigned by PCI-SIG for message signaling capability. |

### 4.11.33 MSINXPTR[7:1]: MSI Next Pointer (D1-7, F0)

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 59h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 6Ch     | <b>NXTPTR: Next Ptr</b><br>This field is set to 6Ch for the next capability list (PCI Express capability structure - EXP_CAP) in the chain. |

### 4.11.34 MSICTRL[7:1]: Message Control Register (D1-7, F0)

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 5Ah - 5Bh |      |         |                 |
|--|------|---------|-----------------|
| Bit  | Attr | Default | Description     |
| 15:8   | RV   | 0h      | <b>Reserved</b> |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 5Ah - 5Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 0h      | <b>AD64CAP: 64-bit Address Capable</b><br>This field is hardwired to 0h since the message writes addresses are only 32-bit addresses (e.g. FEEx_xxxxh).   |
| 6:4  | RW   | 0h      | <b>MMEN: Multiple Message Enable</b><br>Software writes to this field to indicate the number of allocated messages which is aligned to a power of two. When MSI is enabled, the software will allocate at least one message to the device. If two MSI messages are enabled, "message 0" is used for normal interrupts and "message 1" is used for abort/error interrupts. If only one MSI message is enabled, "message 0" is used for both normal and error interrupts. |
| 3:1  | RO   | 001     | <b>MMCAP: Multiple Message Capable</b><br>Software reads this field to determine the number of requested messages that are aligned to a power of two. It is set to 2 messages (encoding of 001).  |
| 0  | RW   | 0h      | <b>MSIEN: MSI Enable</b><br>The software sets this bit to select legacy interrupts or transmit MSI messages: <ul style="list-style-type: none"> <li>0: The NB will not use MSI to communicate an event to the processor.</li> <li>1: Enables the NB to use MSI messages to request context specific service through register bits defined in the <a href="#">Section 4.11.28, "EXP_CTRL[7:1]: PCI Express Control Register (D1-7, F0)"</a> on page 102.</li> </ul>      |

### 4.11.35 MSIAR[7:1]: MSI Address Register (D1-7, F0)

The MSI Address Register (MSIAR) contains the system specific address information to route MSI interrupts and is broken into its constituent fields.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 5Ch - 5Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:20  | RW   | FEh     | <b>AMSB: Address MSB</b><br>This field specifies the 12 most significant bits of the 32-bit MSI address.                                  |
| 19:12  | RW   | 00h     | <b>ADSTID: Address Destination ID</b><br>This field is initialized by software for routing the interrupts to the appropriate destination. |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 5Ch - 5Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 11:4   | RW   | 00h     | <b>AEXDSTID: Address Extended Destination ID</b><br>This field is not used by IA-32 processor. |
| 3  | RW   | 0h      | <b>ARDHINT: Address Redirection Hint</b><br><br>0: Directed<br>1: Redirectable                 |
| 2  | RW   | 0h      | <b>ADM: Address Destination Mode</b><br><br>0: Physical<br>1: Logical                          |
| 1:0  | RV   | 0h      | <b>Reserved</b>  |

### 4.11.36 MSIDR[7:1]: MSI Data Register (D1-7, F0)

The MSI Data Register (MSIDR) contains all the data-related information to route MSI interrupts.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 60h - 63h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:16  | RV   | 00h     | <b>Reserved</b>  |
| 15   | RW   | 0h      | <b>TM: Trigger Mode</b><br><br>0: Edge<br>1: Level<br><br>This field Specifies the type of trigger operation   |
| 14   | RW   | 0h      | <b>LVL: Level</b><br>If TM is 0h, then this field is a don't care.<br>Edge triggered messages are always treated as assert messages.<br><br>For level triggered interrupts, this bit reflects the state of the interrupt input if TM is 1h, then<br><br>0: Deassert Messages<br>1: Assert Messages |
| 13:11  | RW   | 0h      | These bits are don't care in IOxAPIC interrupt message data field specification.   |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 60h - 63h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 10:8   | RW   | 0h      | <b>DM: Delivery Mode</b><br><br>000: Fixed<br>001: Lowest Priority<br>010: SMI/PMI<br>011: <i>Reserved</i><br>100: NMI<br>101: INIT<br>110: <i>Reserved</i><br>111: ExtINT |
| 7:0  | RW   | 0h      | <b>IV: Interrupt Vector</b>  |

#### 4.11.37 EXP\_CAPL[7:1]: PCI Express Capability List Register (D1-7, F0)

The PCI Express capability structure describes PCI Express related functionality, identification and other information such as control/status associated with the ports. It is located in the PCI 2.3-Compatible space and supports legacy operating system by enabling PCI software transparent features.

The PCI Express Capability List register enumerates the PCI Express Capability structure in the PCI 2.3 configuration space.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 6Ch - 6Dh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:8   | RO   | 00h     | <b>NXTCAPPTR: Next Capability Pointer</b><br>This field is set to NULL (00h) as there is no new structure defined from the current PCI Express capability list (i.e last in the link list of PCI 2.3 compatible space). |
| 7:0  | RO   | 10h     | <b>CAPID: Capability ID</b><br>Provides the PCI Express capability ID assigned by PCI-SIG.  |

### 4.11.38 EXP\_CAP[7:1]: PCI Express Capabilities Register (D1-7, F0)

The PCI Express Capabilities register identifies the PCI Express device type and associated capabilities.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 6Eh - 6Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:14  | RV   | 0h      | <b>Reserved</b>   |
| 13:9   | RO   | 00h     | <b>IMN: Interrupt Message Number</b><br>This field indicates the interrupt message number that is generated from the PCI Express port. When there are more than one MSI interrupt Number, this register field is required to contain the offset between the base Message Data and the MSI Message that is generated when the status bits in the slot status register or root port status registers are set. |
| 8  | RWO  | 0h      | <b>SLOT: Slot Implemented</b><br><br>0: Indicates that the PCI Express link associated with the port is connected to a non-removable device or is disabled.<br><br>1: Indicates that the PCI Express link associated with the port is connected to a slot.<br><br>This register bit is of type "write once" and is controlled by BIOS/special initialization firmware.                                      |
| 7:4  | RO   | 0100b   | <b>DPT: Device/Port Type</b><br>This field identifies the type of device. It is set to 0100b as defined in the spec since the PCI Express port is a "root port" in the NB.  |
| 3:0  | RO   | 0001b   | <b>VERS: Capability Version</b><br>This field identifies the version of the PCI Express capability structure. Set to 0001 by PCI SIG.   |

### 4.11.39 EXP\_DEVCAP[7:1]: PCI Express Device Capabilities Register (D1-7, F0)

The PCI Express Device Capabilities register identifies PCI Express specific capabilities with this port.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 70h - 73h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:28  | RV   | 0h      | <b>Reserved</b>  |
| 27:26  | RO   | 0h      | <b>CSPLS: Captured Slot Power Limit Scale</b><br>Specifies the scale used for the Slot Power Limit Value. It does not apply to the NB as it is a Root complex.<br>Hardwired to 0h. |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 70h - 73h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 25:18  | RO   | 00h     | <b>CSPLV: Captured Slot Power Limit Value</b><br>This field specifies upper limit on power supplied by a slot in an upstream port. It does not apply to the NB as it is a Root complex.<br>Hardwired to 00h.  |
| 17:15  | RV   | 0h      | <b>Reserved</b>   |
| 14   | RO   | 0h      | <b>PIPD: Power Indicator Present on Device</b><br>When set, this bit indicates that a Power Indicator is implemented.<br><br>0: PIPD is disabled in the NB<br>1: <i>Reserved</i>  |
| 13   | RO   | 0h      | <b>AIPD: Attention Indicator Present</b><br>When set, this bit indicates that an Attention Indicator is implemented.<br><br>0: AIPD is disabled in the NB<br>1: <i>Reserved</i>   |
| 12   | RO   | 0h      | <b>ABPD: Attention Button Present</b><br>This bit when set indicates that an Attention Button is implemented.<br><br>0: ABPD is disabled in the NB<br>1: <i>Reserved</i>  |
| 11:9   | RO   | 111     | <b>EPL1AL: Endpoints L1 Acceptable Latency</b><br>This field indicates the acceptable latency that an Endpoint can withstand due to the transition from L1 state to the L0 state.<br><br>000: Less than 1µs<br>001: 1 µs to less than 2 µs<br>010: 2 µs to less than 4 µs<br>011: 4 µs to less than 8 µs<br>100: 8 µs to less than 16 µs<br>101: 16 µs to less than 32 µs<br>110: 32 µs to 64 µs<br>111: <b>More than 64 µs</b><br><br><b>NOTE:</b> The NB does not support L1 acceptable latency and is set to the maximum value for safety. |



| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 70h - 73h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 8:6  | RO   | 111b    | <b>EPL0AL: Endpoints L0s Acceptable Latency</b><br>This field indicates the acceptable latency that an Endpoint can withstand due to the transition from L0s state to the L0 state.<br><br>000: Less than 64 ns<br>001: 64 ns to less than 128 ns<br>010: 128 ns to less than 256 ns<br>011: 256 ns to less than 512 ns<br>100: 512 ns to less than 1 $\mu$ s<br>101: 1 $\mu$ s to less than 2 $\mu$ s<br>110: 2 $\mu$ s to 4 $\mu$ s<br>111: <b>More than 4 <math>\mu</math>s</b><br><b>NOTE:</b> The NB does not support L0s implementation and for safety, this field is set to the maximum value. |
| 5  | RO   | 0h      | <b>ETFS: Extended Tag Field Supported</b><br>This field indicates the maximum supported size of the Tag field.<br><br>0: For root ports such as the NB, only 5-bit Tag field is supported<br>1: <i>Reserved</i>   |
| 4:3  | RO   | 0h      | <b>PFS: Phantom Functions Supported</b><br>This field indicates the number of most significant bits of the function number portion of Requester ID in a TLP that are logically combined with the Tag identifier.<br><br>0: For root ports, no function number bits for phantom functions are supported<br>1: <i>Reserved</i>  |
| 2:0  | RO   | 001b    | <b>MPLSS: Max Payload Size Supported</b><br>This field indicates the maximum payload size that the PCI Express* port can support for TLPs.<br>Defined encodings are:<br><br>000: 128B max payload size<br>001: 256B max payload size<br>Others: <i>Reserved</i><br><br><b>NOTE:</b> The NB only supports up to a maximum of 256B payload (e.g. writes and read completions) for each TLP and violations will be flagged as PCI Express errors.  |

#### 4.11.40 EXP\_DEVCTRL[7:1]: PCI Express Device Control Register (D1-7, F0)

The PCI Express Device Control register controls PCI Express specific capabilities parameters associated with this port.

Device: 1 - 7  
Function: 0  
Offset: 74h - 75h

| Bit   | Attr | Default | Description  |
|-------|------|---------|--|
| 15    | RV   | 0h      | <b>Reserved</b>  |
| 14:12 | RW   | 101b    | <b>MRRS: Max_Read_Request_Size</b><br>This field sets maximum Read Request size generated by the NB. The PCI Express port must not generate read requests with size exceeding the set value.<br><br>000: 128B max read request size<br>001: 256B max read request size<br>010: 512B max read request size<br>011: 1024B max read request size<br>100: 2048B max read request size<br>101: 4096B max read request size<br>110: <i>Reserved</i><br>111: <i>Reserved</i>  |
| 11    | RW   | 1h      | <b>ENNOSNP: Enable No Snoop</b><br>When set, the PCI Express port is permitted to set the “No Snoop bit” in the Requester Attributes of transactions it initiates that do not require hardware enforced cache coherency. Typically the “No Snoop bit” is set by an originating PCI Express device down in the hierarchy.<br><br>The NB never sets or modifies the “No snoop bit” in the received TLP even if ENNOSNP is enabled. For outbound traffic, the NB does not need to snoop.  |
| 10    | RWST | 0h      | <b>APPME: Auxiliary Power Management Enable</b><br><br>0: Disables the PCI Express port to draw AUX power independent of PME AUX power.<br><br>1: Enables the PCI Express port to draw AUX power independent of PME AUX power.<br><br>Devices that require AUX power on legacy operating systems should continue to indicate PME AUX power requirements. AUX power is allocated as requested in the AUX_Current field on the Power Management Capabilities Register (PMC), independent of the PMEEN bit in the Power Management Control/Status Register (PMSCR) defined in <a href="#">Section 4.11.31</a> . |
| 9     | RO   | 0h      | <b>PFE: Phantom Functions Enable</b><br>This bit enables the PCI Express port to use unclaimed functions as Phantom Functions for extending the number of outstanding transaction identifiers. The NB does not implement this bit (Root complex) and is hardwired to '0'.  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 74h - 75h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 8  | RO   | 0h      | ETFE: Extended Tag Field Enable<br>This bit enables the PCI Express port to use an 8-bit Tag field as a requester. The NB does not use this field (Root complex) and is hardwired to '0'.  |
| 7:5  | RW   | 01h     | MPS: Max Payload Size<br>This field is set by configuration software for the maximum TLP payload size for the PCI Express port. As a receiver, the NB must handle TLPs as large as the set value. As a transmitter, it must not generate TLPs exceeding the set value. Permissible values that can be programmed are indicated by the Max_Payload_Size_Supported in the Device Capabilities register:<br><br>000: 128B max payload size<br>001: 256B max payload size<br>010: <i>Reserved</i><br>011: <i>Reserved</i><br>100: <i>Reserved</i><br>101: <i>Reserved</i><br>110: <i>Reserved</i><br>111: <i>Reserved</i><br><br><b>NOTE:</b> The NB supports max payload sizes up to 256B. These bits should be programmed to the smallest of the max payload size supported between NB and the target. |
| 4  | RW   | 0h      | ENRORD: Enable Relaxed Ordering<br>If this bit is set, the device is permitted to set the Relaxed Ordering bit in the Attributes field of transactions it initiates that do not require strong write ordering.<br>The NB enforces strict ordering only and hence it is initialized to '0'.   |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 74h - 75h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 3  | RW   | 0h      | <b>URREN: Unsupported Request Reporting Enable</b><br>This bit controls the reporting of unsupported requests to the NB in the PCI Express port.<br><br>0: Fatal error reporting is disabled.<br>1: Fatal error reporting is enabled.<br><br>Note that the reporting of error messages (such as ERR_CORR, ERR_NONFATAL, ERR_FATAL) received by PCI Express port is controlled exclusively by the PCI Express Root Control register (EXP_RTCTRL) described in <a href="#">Section 4.11.28</a> .<br>Suggested value: 1h |
| 2  | RW   | 0h      | <b>FERE: Fatal Error Reporting Enable</b><br>This bit controls the reporting of fatal errors internal to the NB in the PCI Express port.<br><br>0: Fatal error reporting is disabled.<br>1: Fatal error reporting is enabled.<br><br>Suggested value: 1h  |
| 1  | RW   | 0h      | <b>NFERE: Non Fatal Error Reporting Enable</b><br>This bit controls the reporting of non fatal errors internal to the NB in the PCI Express port.<br><br>0: Non Fatal error reporting is disabled.<br>1: Non Fatal error reporting is enabled.<br><br>Suggested value: 1h   |
| 0  | RW   | 0h      | <b>CERE: Correctable Error Reporting Enable</b><br>This bit controls the reporting of correctable errors internal to the NB in the PCI Express port.<br><br>0: Correctable error reporting is disabled.<br>1: Correctable Fatal error reporting is enabled<br><br>Suggested value: 1h   |

## 4.11.41 EXP\_DEVSTS[7:1]: PCI Express Device Status Register (D1-7, F0)

The PCI Express Device Status register provides information about PCI Express device-specific parameters associated with this port.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 76h - 77h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:6   | RV   | 000h    | <b>Reserved</b>   |
| 5  | RO   | 0h      | <b>TP: Transactions Pending</b><br>0: A device reports this bit cleared only when all Completions for any outstanding Non-Posted Requests have been received.<br>1: Indicates that the PCI Express port has issued Non-Posted Requests which have not been completed.   |
| 4  | RO   | 0       | <b>APD: AUX Power Detected</b><br>0: No AUX power is detected.<br>1: AUX power is detected by the PCI Express port.   |
| 3  | RWC  | 0       | <b>URD: Unsupported Request Detected</b><br>This bit indicates that the device received an Unsupported Request in the PCI Express port. Errors are logged in this register regardless of whether error reporting is enabled or not in the Device Control Register.<br>1: Denotes Unsupported Request detected<br>0: <i>Reserved</i><br>This records the detection of receiving an unsupported request, error IO12 (Refer to <a href="#">Table 6-39 "Errors Detected by the NB" on page 328</a> ). |
| 2  | RWC  | 0       | <b>FED: Fatal Error Detected</b><br>This bit indicates status of fatal errors detected in the PCI Express port. Errors are logged in this register regardless of whether error reporting is enabled or not in the Device Control register.<br>1: Denotes Non Fatal errors detected<br>0: <i>Reserved</i>  |
| 1  | RWC  | 0       | <b>NFED: Non Fatal Error Detected</b><br>This bit indicates the status of non-fatal errors detected. Errors are logged in this register regardless of whether error reporting is enabled or not in the Device Control register.<br>1: Denotes Non Fatal errors detected   |
| 0  | RWC  | 0       | <b>CED: Correctable Error Detected</b><br>This bit indicates the status of correctable errors which are detected in the PCI Express port. Errors are logged in this register regardless of whether error reporting is enabled or not in the PCI Express Device Control register.<br>1: Denotes correctable errors detected  |

#### 4.11.42 EXP\_LNKCAP[7:1]: PCI Express Link Capabilities Register (D1-7, F0)

The Link Capabilities register identifies the PCI Express specific link capabilities.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 78h -7Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:24   | RWO  | 00h     | <b>PN: Port Number</b><br>This field indicates the PCI Express port number for the link and is initialized by software/BIOS.  |
| 23:18   | RV   | 00h     | <b>Reserved</b>   |
| 17:15   | RO   | 111b    | <b>L1EL: L1 Exit Latency</b><br>This field indicates the L1 exit latency for the given PCI Express port. It indicates the length of time this port requires to complete transition from L1 to L0.<br><br>000: <1µs<br>001: 1 µs to less than 2 µs<br>010: 2 µs to less than 4 µs<br>011: 4 µs to less than 8 µs<br>100: 8 µs to less than 16 µs<br>101: 16 µs to less than 32 µs<br>110: 32 µs to 64 µs<br>111: > 64 µs   |
| 14:12   | RO   | 7h      | <b>L0sEL: L0s Exit Latency</b><br>This field indicates the L0s exit latency (i.e L0s to L0) for the PCI Express port.<br><br>000: <64 ns<br>001: 64 ns to less than 128 ns<br>010: 128 ns to less than 256 ns<br>011: 256 ns to less than 512 ns<br>100: 512 ns to less than 1 µs<br>101: 1 µs to less than 2 µs<br>110: 2 µs to 4 µs<br>111: > 4 ns<br><br><b>NOTE:</b> Note that NB does not support L0 Exit Latency implementation and for safety, this field is set to the maximum value. |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 78h -7Bh |      |                                |  |
|---|------|--------------------------------|--|
| Bit   | Attr | Default                        | Description  |
| 11:10   | RO   | 0h                             | <b>ACTPMS: Active State Link PM Support</b><br>This field indicates the level of active state power management supported on the given PCI Express port.<br><br>00: Reserved (Disabled)<br>01: L0s Entry (Supported)<br>10: <i>Reserved</i><br>11: L0s and L1 (Supported)<br>The NB responds to link initiated power management requests, but does not initiate any power management requests on its own even if software attempts to tell the NB to do so. |
| 9:4   | RO   | See <a href="#">Table 4-21</a> | <b>MLW: Maximum Link Width</b><br>This field indicates the maximum width of the given PCI Express Link attached to the port.<br><br>000100: x4<br>001000: x8<br>Others: <i>Reserved</i><br><br>Refer to <a href="#">Table 4-21</a> for the allowed port configurations and maximum link width.   |
| 3:0   | RO   | 1h                             | <b>MLS: Maximum Link Speed</b><br>This field indicates the maximum Link speed of the given PCI Express port.<br><br>0001: 2.5 Gb/s<br>Others: <i>Reserved</i>  |

### 4.11.43 EXP\_LNKCTRL[7:1]: PCI Express Link Control Register (D1-7, F0)

The PCI Express Link Control register controls the PCI Express Link specific parameters.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 7Ch - 7Dh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:8   | RV   | 000h    | <b>Reserved</b>  |
| 7  | RW   | 0h      | <b>EXTENDED_SYNCH:</b><br>This bit when set forces extended transmission of FTS ordered sets in FTS and extra TS2 at exit from L1 prior to entering L0. This mode provides external devices monitoring the link time to achieve bit and symbol lock before the link enters L0 state and resumes communication.   |
| 6  | RW   | 0h      | <b>CCCON: Common Clock Configuration</b><br>0: Indicates that this PCI Express port and its counterpart at the opposite end of the Link are operating with an <u>asynchronous reference clock</u> .<br>1: Indicates that this PCI Express port and its counterpart at the opposite end of the Link are operating with a <u>distributed common reference clock</u> .<br>Components utilize this common clock configuration information to report the correct L0s and L1 Exit Latencies. |
| 5  | WO   | 0h      | <b>RLNK: Retrain Link</b><br>This bit, when set by software, initiates link retraining in the given PCI Express port. It always returns '0' when read.   |
| 4  | RW   | 0h      | <b>LNKDIS: Link Disable</b><br>This field indicates whether the link associated with the PCI Express port is enabled or disabled.<br>0: Enables the link associated with the PCI Express port<br>1: Disables the link associated with the PCI Express port   |
| 3  | RO   | 0h      | <b>RCB: Read Completion Boundary</b><br>The NB supports only 64B read completion boundary and this bit is hardwired to 0h.   |
| 2  | RV   | 0h      | <b>Reserved</b>  |
| 1:0  | RW   | 0h      | <b>ACTPMCTRL: Active State Link PM Control</b><br>This field controls the level of active state power management supported on the given PCI Express port.<br>00: Disabled<br>01: L0s Entry Supported<br>10: <i>Reserved</i><br>11: L0s and L1 Supported<br>The NB responds to link initiated power management requests, but does not initiate any power management requests on its own even if software attempts to tell the NB to do so.  |



#### 4.11.44 EXP\_LNKLSTS[7:1]: PCI Express Link Status Register (D1-7, F0)

The PCI Express Link Status register provides information on the status of the PCI Express Link such as negotiated width, training, etc.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 7Eh - 7Fh |      |                 |  |
|--|------|-----------------|--|
| Bit  | Attr | Default         | Description  |
| 15:13  | RV   | 00h             | <b>Reserved</b>  |
| 12   | RO   | 0h              | <b>SCCON: Slot Clock Configuration</b><br>This bit indicates that the component uses the same physical reference clock that the platform provides on the connector. If the device uses an independent clock irrespective of the presence of a reference on the connector, this bit must be clear.<br><br>0: Indicates independent clock on the PCI Express connector from that of the platform.<br><br>1: Indicates same physical clock in the PCI Express connector as in the platform. |
| 11   | RO   | 0h              | <b>LNKTRG: Link Training</b><br>This field indicates the status of an ongoing link training session in the current PCI Express port<br><br>0: Indicates Link training not in progress - either it has completed or it has not begun.<br><br>1: Indicates Link training is in progress.<br><br>This read-only bit indicates that Link training is in progress; hardware clears this bit once Link training is complete.   |
| 10   | RV   | 0h              | <b>Reserved</b>  |
| 9:4  | RO   | See Description | <b>NLNKWD: Negotiated Link Width</b><br>This field indicates the negotiated width of the given PCI Express link.<br><br>000001: x1<br>000010: x2<br>000100: x4<br>001000: x8<br>Others <i>Reserved</i><br><br>For the port and link assignment refer to <a href="#">Table 4-21</a> .   |
| 3:0  | RO   | 01h             | <b>LNKSPD: Link Speed</b><br>This field indicates the negotiated Link speed of the given PCI Express Link:<br><br>0001: 2.5 Gb/s PCI Express link<br>Others <i>Reserved</i>  |

Table 4-21. Negotiated Link Width For Different PCI Express Ports

| Device        | Port                      | Negotiated Link Width | Default Value       |
|---------------|---------------------------|-----------------------|---------------------|
| 1,2,3,4,5,6,7 | D, C0, C1, B0, B1, A0, A1 | x1                    | 000001              |
| 1,2,3,4,5,6,7 | D, C0, C1, B0, B1, A0, A1 | X2                    | 000010              |
| 1,2,3,4,5,6,7 | D, C0, C1, B0, B1, A0, A1 | X4                    | 000100              |
| 2,4,6         | C0, B0, A0                | X8                    | 001000 <sup>a</sup> |

**NOTES:**

- a. Ports 3,5 and 7 report an undefined value

#### 4.11.45 EXP\_SLOTCAP[7:1]: PCI Express Slot Capabilities Register (D1-7, F0)

The Slot Capabilities register identifies the PCI Express specific slot capabilities. When this register is written, the NB sends the Slot Power Limit Value and Slot Power Limit Scale in a Slot Power Limit Message outbound.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 80h - 83h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:19  | RWO  | 0000h   | <b>PSN: Physical Slot Number</b><br>This field indicates the physical slot number connected to the PCI Express* port. It should be initialized to 0 for ports connected to devices that are either integrated on the system board or integrated within the same silicon as the Root port (NB). |
| 18:17  | RV   | 0h      | <b>Reserved</b>  |
| 16:15  | RWO  | 0h      | <b>SPLS: Slot Power Limit Scale</b><br>This field specifies the scale used for the Slot Power Limit Value.<br>Range of Values:<br>00: 1.0x<br>01: 0.1x<br>10: 0.01x<br>11: 0.001x  |
| 14:7   | RWO  | 00h     | <b>SPLV: Slot Power Limit Value</b><br>This field specifies the upper limit on power supplied by the slot in conjunction with the Slot Power Limit Scale value defined previously.<br>Power limit (in Watts) = SPLS x SPLV   |
| 6  | RWO  | 0h      | <b>HPC: Hot-plug Capable</b><br>This field defines hot-plug support capabilities for the PCI Express port.<br>0: Indicates that this slot is not capable of supporting Hot-plug operations.<br>1: Indicates that this slot is capable of supporting Hot-plug operations.                       |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 80h - 83h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 5  | RWO  | 0h      | <b>HPS: Hot-plug Surprise</b><br>This field indicates that a device in this slot may be removed from the system without prior notification.<br><br>0: Indicates that surprise hot-plug is not supported.<br>1: Indicates that surprise hot-plug is supported.  |
| 4  | RWO  | 0h      | <b>PIP: Power Indicator Present</b><br>This bit indicates that a Power Indicator is implemented on the chassis for this slot.<br><br>0: Indicates that Power Indicator is not present.<br>1: Indicates that Power Indicator is present.                        |
| 3  | RWO  | 0h      | <b>AIP: Attention Indicator Present</b><br>This bit indicates that an Attention Indicator is implemented on the chassis for this slot.<br><br>0: Indicates that an Attention Indicator is not present.<br>1: Indicates that an Attention Indicator is present. |
| 2  | RWO  | 0h      | <b>MRLSP: MRL Sensor Present</b><br>This bit indicates that an MRL Sensor is implemented on the chassis for this slot.<br><br>0: Indicates that an MRL Sensor is not present.<br>1: Indicates that an MRL Sensor is present.                                   |
| 1  | RWO  | 0h      | <b>PCP: Power Controller Present</b><br>This bit indicates that a Power Controller is implemented on the chassis for this slot.<br><br>0: Indicates that a Power Controller is not present.<br>1: Indicates that a Power Controller is present.                |
| 0  | RWO  | 0h      | <b>ABP: Attention Button Present</b><br>This bit indicates that an Attention Button is implemented on the chassis for this slot.<br><br>0: Indicates that an Attention Button is not present.<br>1: Indicates that an Attention Button is present.             |

#### 4.11.46 EXP\_SLOTCTRL[7:1]: PCI EXPRESS Slot Control Register (D1-7, F0)

The Slot Control register identifies the PCI Express specific slot control specific parameters for operations such as Hot-plug and Power Management.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 84h - 85h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:11  | RV   | 0h      | <b>Reserved</b>  |
| 10   | RW   | 0h      | <b>PWRCTRL: Power Control</b><br>This bit indicates the current state of the Power applied to the slot of the PCI Express port:<br>0: Power On<br>1: Power Off   |
| 9:8  | RW   | 0h      | <b>PWRLED: Power Indicator Control</b><br>This bit indicates the current state of the Power Indicator of the PCI Express port:<br>00: <i>Reserved. The NB drives the LED into BLINK state.</i><br>01: On<br>10: Blink (The NB drives 1.5 Hz square wave for Chassis mounted LEDs in the case of legacy card form factor for PCI Express devices)<br>11: Off<br>When this field is written, the NB sends appropriate POWER_INDICATOR messages through the PCI Express port. For legacy-card-based PCI Express devices, the event is signaled via the virtual pins (Refer to <a href="#">Section 6.6, "RAS" on page 320</a> ) of the NB. For PCI Express modules with advanced form factor that incorporate LEDs and on-board decoding logic, the PCI Express messages are interpreted directly (No virtual pins). |
| 7:6  | RW   | 0h      | <b>ATNLED: Attention Indicator Control</b><br>This bit indicates the current state of the Attention Indicator of the PCI Express port:<br>00: <i>Reserved. The NB drives the LED into BLINK state.</i><br>01: On<br>10: Blink (The NB drives 1.5 Hz square wave for Chassis mounted LEDs in the case of legacy card form factor for PCI Express devices).<br>11: Off<br>When this field is written, the NB sends appropriate ATTENTION_INDICATOR messages through the PCI Express port. For legacy card based PCI Express devices, the event is signaled via the virtual pins of the NB. For PCI Express modules with advanced form factor that incorporate LEDs and on-board decoding logic, the PCI Express messages are interpreted directly (No virtual pins).   |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 84h - 85h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 5  | RW   | 0h      | <b>HPINTEN: Hot-plug Interrupt Enable</b><br>This field enables the generation of Hot-plug interrupts and events in the PCI Express port.<br>0: Disables Hot-plug events and interrupts.<br>1: Enables Hot-plug events and interrupts.  |
| 4  | RW   | 0h      | <b>CCCIEN: Command Completed Interrupt Enable</b><br>This field enables the generation of Hot-plug interrupts when a command is completed by the Hot-plug controller connected to the PCI Express port:<br>0: Disables hot-plug interrupts on a command completion by a hot-plug Controller.<br>1: Enables hot-plug interrupts on a command completion by a hot-plug Controller.<br>Suggested Value: 0. |
| 3  | RW   | 0h      | <b>PRSINTEN: Presence Detect Changed Enable</b><br>This bit enables the generation of hot-plug interrupts or wake messages via a presence detect changed event.<br>0: Disables generation of hot-plug interrupts or wake messages when a presence detect changed event happens.<br>1: Enables generation of hot-plug interrupts or wake messages when a presence detect changed event happens.          |
| 2  | RW   | 0h      | <b>MRLINTEN: MRL Sensor Changed Enable</b><br>This bit enables the generation of hot-plug interrupts or wake messages via a MRL Sensor changed event.<br>0: Disables generation of hot-plug interrupts or wake messages when an MRL Sensor changed event happens.<br>1: Enables generation of hot-plug interrupts or wake messages when an MRL Sensor changed event happens.                            |
| 1  | RW   | 0h      | <b>PWRINTEN: Power Fault Detected Enable</b><br>This bit enables the generation of hot-plug interrupts or wake messages via a power fault event.<br>0: Disables generation of hot-plug interrupts or wake messages when a power fault event happens.<br>1: Enables generation of hot-plug interrupts or wake messages when a power fault event happens.   |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 84h - 85h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 0  | RW   | 0h      | <b>ATNINTEN: Attention Button Pressed Enable</b><br>This bit enables the generation of hot-plug interrupts or wake messages via an attention button pressed event.<br><br>0: Disables generation of hot-plug interrupts or wake messages when the attention button is pressed.<br><br>1: Enables generation of hot-plug interrupts or wake messages when the attention button is pressed. |

#### 4.11.47 EXP\_SLOTSTS[7:1]: PCI Express Slot Status Register (D1-7, F0)

The PCI Express Slot Status register defines important status information for operations such as Hot-plug and Power Management.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 86h - 87h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:7   | RV   | 0h      | <b>Reserved</b>   |
| 6  | RO   | 0h      | <b>PDS: Presence Detect State</b><br>This field conveys the Presence Detect status determined via an in-band mechanism or through the Present Detect pins and shows the presence of a card in the slot.<br><br>0: Slot Empty<br>1: Card Present in slot |
| 5  | RO   | 0h      | <b>MRLSS: MRL Sensor State</b><br>This bit reports the status of an MRL sensor if it is implemented.<br><br>0: MRL Closed<br>1: MRL Open  |
| 4  | RWC  | 0h      | <b>CMDCOMP: Command Completed</b><br>This bit is set by the NB when the hot-plug controller completes an issued command. It is subsequently cleared by software after the field has been read and processed.  |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 86h - 87h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 3  | RWC  | 0h      | <b>PRSINT: Presence Detect Changed</b><br>This bit is set by the NB when a Presence Detect Changed event is detected. It is subsequently cleared by software after the field has been read and processed.   |
| 2  | RWC  | 0h      | <b>MRLSC: MRL Sensor Changed</b><br>This bit is set by the NB when an MRL Sensor Changed event is detected. It is subsequently cleared by software after the field has been read and processed.   |
| 1  | RWC  | 0h      | <b>PWRINT: Power Fault Detected</b><br>This bit is set by the NB when a power fault event is detected by the power controller. It is subsequently cleared by software after the field has been read and processed.  |
| 0  | RWC  | 0h      | <b>ABP: Attention Button Pressed</b><br>This bit is set by the NB when the attention button is pressed. It is subsequently cleared by software after the field has been read and processed.<br>Note: This bit will not be set if bit 29 in "EXP_CTRL[7:1]: PCI Express Control Register (D1-7, F0)" is set. |

**Note:** Note that the EXP\_HPINT pin (Table 3-11 on page 3-48) is held asserted as long as any of the events defined in bits[4:0] (CMDCOMP, PRSINT, MRLSC, PWRINT, ABP) of the EXP\_SLOTSTS register are set provided the corresponding events in bits [4:0] of the EXP\_SLOTCTRL are enabled.

## 4.11.48 EXP\_RTCTRL[7:1]: PCI Express Root Control Register (D1-7, F0)

The PCI Express Root Control register specifies parameters specific to the root complex port.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 88h 89h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:4   | RV   | 0h      | <b>Reserved</b>  |
| 3  | RW   | 0h      | <b>PMEINTEN: PME Interrupt Enable</b><br>This field controls the generation of interrupts for PME messages:<br><br>0: Disables interrupt generation for PME messages.<br>1: Enables interrupt generation upon receipt of a PME message as reflected in the PME Status bit defined in the PCI Express RTSTS register. A PME interrupt is also generated if the PME Status register bit is set when this bit is set from a cleared state RW.   |
| 2  | RW   | 0h      | <b>SEFEEN: System Error on Fatal Error Enable</b><br>This field controls generation of system errors in the PCI Express port hierarchy for fatal errors:<br><br>0: No System Error should be generated on a fatal error (ERR_FATAL) reported by any of the devices in the hierarchy.<br>1: Indicates that a System Error should be generated if a fatal error (ERR_FATAL) is reported by any of the devices in the hierarchy associated with and including this PCI Express port.  |
| 1  | RW   | 0h      | <b>SENFEEN: System Error on Non-Fatal Error Enable</b><br>This field controls generation of system errors in the PCI Express port hierarchy for non-fatal errors:<br><br>0: No System Error should be generated on a non-fatal error (ERR_NONFATAL) reported by any of the devices in the hierarchy.<br>1: indicates that a System Error should be generated if a non-fatal error (ERR_NONFATAL) is reported by any of the devices in the hierarchy associated with and including this PCI Express port.   |
| 0  | RW   | 0h      | <b>SECEEN: System Error on Correctable Error Enable</b><br>This field controls generation of system errors in the PCI Express port hierarchy for correctable errors:<br><br>0: No System Error should be generated on a correctable error (ERR_COR) reported by any of the devices in the hierarchy associated with and including this PCI Express port.<br>1: Indicates that a System Error should be generated if a correctable error (ERR_COR) is reported by any of the devices in the hierarchy associated with and including this PCI Express port |



## 4.11.49 EXP\_RTSTS[7:1]: PCI Express Root Status Register (D1-7, F0)

The PCI Express Root Status register specifies parameters specific to the root complex port.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 8Ch - 8Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:18  | RV   | 0h      | <b>Reserved</b>   |
| 17   | RO   | 0h      | <b>PMEPEND: PME Pending</b><br>This field indicates that another PME is pending when the PME Status bit is set. When the PME Status bit is cleared by software, the pending PME is delivered by hardware by setting the PME Status bit again and updating the Requestor ID appropriately. The PME pending bit is cleared by hardware if no more PMEs are pending. |
| 16   | RWC  | 0h      | <b>PMESTS: PME Status<sup>a</sup></b><br>This field indicates status of a PME that is underway in the PCI Express port:<br><br>1: PME was asserted by a requester as indicated by the PMEREQID field.<br><br>This bit is cleared by software by writing a '1'. Subsequent PMEs are kept pending until the PME Status is cleared.                                  |
| 15:0   | RO   | 0h      | <b>PMEREQID: PME Requester ID</b><br>This field indicates the PCI requester ID of the last PME requestor.   |

### NOTES:

- The PME STATUS bit in each of the EXP\_RTSTS[7:1] registers are ORed together and the NB will assert the PME\_OUT pin to ICH5 for power management. When all the bits are clear, it will deassert PME\_OUT.

## 4.12 PCI Express Advanced Function (Device 1 - 7, Function 0)

The PCI Express Extended Registers are in Devices 1 -7 (D1-7), function 0 (F0). For the register address map, please refer to [Table 4-12](#).

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.12.1 ENHCAPSTS: Enhanced Advanced Error Reporting Capability Structure (D1-7, F0)

This register identifies the capability structure and points to the next structure.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 100h 103h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:20  | RO   | 140h    | <b>NXTCAPPTR: Next Capability Pointer</b><br>This field points to the next Capability in extended configuration space. |
| 19:16  | RO   | 1h      | <b>CV: Capability Version</b><br>Set to 1 for this version of the PCI Express logic.                                   |
| 15:0   | RO   | 1h      | <b>ECID: PCI Express Extended CAP_ID</b><br>Assigned for advanced error reporting.                                     |

### 4.12.2 UNCERRSTS: Uncorrectable Error Status (D1-7, F0)

This register identifies uncorrectable errors detected. for PCI Express Port. If an error occurs and is unmasked in the detect register (UNCEDMASK), the appropriate error bit will be recorded in this register. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB” on page 328](#).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 104h - 107h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 31:21  | RV    | 0h      | <b>Reserved</b>                                    |
| 20   | RWCST | 0h      | <b>IO12Err:</b> Received an Unsupported Request    |
| 19   | RV    | 0h      | <b>Reserved</b>                                    |
| 18   | RWCST | 0h      | <b>IO19Err:</b> Malformed TLP Status               |
| 17   | RWCST | 0h      | <b>IO20Err:</b> Receiver Buffer Overflow Status    |
| 16   | RWCST | 0h      | <b>IO18Err:</b> Unexpected Completion Status       |
| 15   | RWCST | 0h      | <b>IO17Err:</b> Completer Abort Status - Optional  |
| 14   | RWCST | 0h      | <b>IO16Err:</b> Completion Time-out Status         |
| 13   | RWCST | 0h      | <b>IO15Err:</b> Flow Control Protocol ERROR Status |
| 12   | RWCST | 0h      | <b>IO14Err:</b> Poisoned TLP Status                |
| 11:5   | RV    | 0h      | <b>Reserved</b>                                    |
| 4  | RWCST | 0h      | <b>IO21Err:</b> Data Link Layer Protocol Status    |
| 3:1  | RV    | 0h      | <b>Reserved</b>                                    |
| 0  | RWCST | 0h      | <b>IO13Err:</b> Training Error Status              |

### 4.12.3 UNCERRMSK: Uncorrectable Error Mask (D1-7, F0)

This register masks uncorrectable errors from being reported. If an error is recorded in the UNCERRSTS register and the appropriate bit is set (along with the severity bit of the UNCERRSEV register), it determines which bit in the EXP\_FERR/EXP\_NERR register is set. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 108h - 10Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:21  | RV   | 0       | <b>Reserved</b>                                     |
| 20   | RWST | 0       | <b>IO12Msk:</b> Received an Unsupported Request     |
| 19   | RV   | 0       | <b>Reserved</b>                                     |
| 18   | RWST | 0       | <b>IO19Msk:</b> Malformed TLP Status                |
| 17   | RWST | 0       | <b>IO20Msk:</b> Receiver Buffer Overflow Mask       |
| 16   | RWST | 0       | <b>IO18Msk:</b> Unexpected Completion Mask          |
| 15   | RWST | 0       | <b>IO17Msk:</b> Completer Abort Status (Optional)   |
| 14   | RWST | 0       | <b>IO16Msk:</b> Completion Time-out Mask            |
| 13   | RWST | 0       | <b>IO15Msk:</b> Flow Control Protocol ERROR Mask    |
| 12   | RWST | 0       | <b>IO14Msk:</b> Poisoned TLP Mask                   |
| 11:1   | RV   | 00h     | <b>Reserved</b>                                     |
| 4  | RWST | 0       | <b>IO21Msk:</b> Data Link Layer Protocol Error Mask |
| 3:1  | RV   | 00      | <b>Reserved</b>                                     |
| 0  | RWST | 0       | <b>IO13Msk:</b> Training Error Mask                 |

#### 4.12.4 UNCERRSEV: Uncorrectable Error Severity (D1-7, F0)

This register indicates the severity of the uncorrectable errors. If an error is recorded in the UNCERRSTS register, the appropriate bit of UNCERRSEV determines if the error gets reflected as a device fatal or nonfatal error in the EXP\_FERR/EXP\_NERR registers. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB” on page 328](#)

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 10Ch - 10Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:21  | RV   | 0h      | <b>Reserved</b>  |
| 20   | RWST | 0h      | <b>IO12Severity:</b> Received an Unsupported Request         |
| 19   | RV   | 0h      | <b>Reserved</b>  |
| 18   | RWST | 1       | <b>IO19Severity:</b> Malformed TLP Severity                  |
| 17   | RWST | 1       | <b>IO20Severity:</b> Receiver Buffer Overflow Severity       |
| 16   | RWST | 0h      | <b>IO18Severity:</b> Unexpected Completion Severity          |
| 15   | RWST | 0h      | <b>IO17Severity:</b> Completer Abort Status - Optional       |
| 14   | RWST | 0h      | <b>IO16Severity:</b> Completion Time-out Severity            |
| 13   | RWST | 1       | <b>IO15Severity:</b> Flow Control Protocol ERROR Severity    |
| 12   | RWST | 0h      | <b>IO14Severity:</b> Poisoned TLP Severity                   |
| 11:5   | RV   | 00h     | <b>Reserved</b>  |
| 4  | RWST | 1       | <b>IO21Severity:</b> Data Link Layer Protocol Error Severity |
| 3:2  | RV   | 0       | <b>Reserved</b>  |
| 0  | RWST | 1       | <b>IO13Severity:</b> Training Error Severity                 |

## 4.12.5 CORERRSTS: Correctable Error Status (D1-7, F0)

This register identifies which unmasked correctable error has been detected. The logical OR of these bits feed the device correctable error bit in the EXP\_FERR/EXP\_NERR registers (if the error is unmasked in the CORERRMSK register).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 110h - 113h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description                                  |
| 31:13  | RV    | 0h      | <b>Reserved</b>                              |
| 12   | RWCST | 0h      | <b>IO11Err:</b> Replay Timer Time-out Status |
| 11:9   | RWCST | 0h      | <b>Reserved</b>                              |
| 8  | RWCST | 0h      | <b>IO10Err:</b> Replay_Num Rollover Status   |
| 7  | RWCST | 0h      | <b>IO9Err:</b> Bad DLLP Status               |
| 6  | RWCST | 0h      | <b>IO8Err:</b> Bad TLP Status                |
| 5:1  | RV    | 0h      | <b>Reserved</b>                              |
| 0  | RWCST | 0h      | <b>IO7Err:</b> Receiver Error Status         |

## 4.12.6 CORERRMSK: Correctable Error Mask (D1-7, F0)

This register masks correctable errors to not be reported. They are still logged. The appropriate bit will prevent an error from being signaled in the EXP\_FERR/EXP\_NERR registers.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 114h - 117h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description                                |
| 31:13  | RV   | 0h      | <b>Reserved</b>                            |
| 12   | RWST | 0h      | <b>IO11Msk:</b> Replay Timer Time-out Mask |
| 11:9   | RV   | 0h      | <b>Reserved</b>                            |
| 8  | RWST | 0h      | <b>IO10Msk:</b> Replay_Num Rollover Mask   |
| 7  | RWST | 0h      | <b>IO9Msk:</b> Bad DLLP Mask               |
| 6  | RWST | 0h      | <b>IO8Msk:</b> Bad TLP Mask                |
| 5:1  | RV   | 0h      | <b>Reserved</b>                            |
| 0  | RWST | 0h      | <b>IO7Msk:</b> Receiver Error Mask         |

### 4.12.7 AERCACR: Advanced Error Capabilities and Control Register (D1-7, F0)

This register identifies the capability structure and points to the next structure.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 118h - 11Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:9   | RV   | 0       | <b>Reserved</b>  |
| 8  | RWST | 0       | <b>AERCACR[8]: ECRC Check Enable</b><br>This bit when set enables ECRC checking.   |
| 7  | RO   | 0       | <b>AERCACR[7]: ECRC Check Capable</b><br>The NB does not support ECRC.   |
| 6  | RWST | 0       | <b>AERCACR[6]: ECRC Generation Enable</b><br>The NB does not support ECRC.   |
| 5  | RO   | 0       | <b>AERCACR[5]: ECRC Generation Capable</b><br>The NB does not support ECRC.  |
| 4:0  | ROST | 0       | <b>AERCACR[4:0]: First error pointer</b><br>The First Error Pointer is a read-only register that identifies the bit position of the first error reported in the Uncorrectable Error. The pointer can be overwritten by a more severe error according to the PCI Express Spec (Left-most error bit if multiple bits occurred simultaneously). |

### 4.12.8 HDRLOG0: Header Log 0 (D1-7, F0)

This register contains the first 32 bits of the header log locked down when the first error occurs. If a subsequent error is more severe, this log will be overwritten, and the header log will be lost for the “true” first error.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 11Ch - 11F |      |         |                                    |
|---|------|---------|------------------------------------|
| Bit   | Attr | Default | Description                        |
| 31:0  | ROST | 0h      | <b>HDRLOG0[31:0]: Header Log 0</b> |

### 4.12.9 HDRLOG1: Header Log 1 (D1-7, F0)

This register contains the second 32 bits of the header log.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 120h - 123h |      |         |                             |
|--|------|---------|-----------------------------|
| Bit  | Attr | Default | Description                 |
| 31:0   | ROST | 0h      | HDRLOG1[31:0]: Header Log 1 |

### 4.12.10 HDRLOG2: Header Log 2 (D1-7, F0)

This register contains the third 32 bits of the header log.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 124h - 127h |      |         |                             |
|--|------|---------|-----------------------------|
| Bit  | Attr | Default | Description                 |
| 31:0   | ROST | 0h      | HDRLOG2[31:0]: Header Log 2 |

### 4.12.11 HDRLOG3: Header Log 3 (D1-7, F0)

This register contains the fourth 32 bits of the header log.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 128h - 12Bh |      |         |                             |
|--|------|---------|-----------------------------|
| Bit  | Attr | Default | Description                 |
| 31:0   | ROST | 0h      | HDRLOG3[31:0]: Header Log 3 |

#### 4.12.12 RPERRCMD: Root Port Error Command (D1-7, F0)

This register controls behavior upon detection of errors.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 12Ch - 12Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:8   | RV   | 0h      | <b>Reserved</b>   |
| 7:3  | RV   | 0h      | <b>Reserved</b>   |
| 2  | RW   | 0h      | <b>RPERRCMD_EN_FAT</b><br>Enable interrupt on fatal errors when set.            |
| 1  | RW   | 0h      | <b>RPERRCMD_EN_UNCORR</b><br>Enable interrupt on uncorrectable errors when set. |
| 0  | RW   | 0h      | <b>RPERRCMD_EN_CORR</b><br>Enable interrupt on correctable errors when set.     |

#### 4.12.13 RPERRMSGSTS: Root Port Error Message Status (D1-7, F0)

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 130h - 133h |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 31:27  | RO    | 0h      | <b>RPERRMSGSTS_INT_MSGS[4:0]</b><br>Advanced Error Interrupt Message Number offset between base message data an the MSI message if assigned more than one message number to be used of any status in this capability. |
| 26:7   | RV    | 0h      | <b>Reserved</b>   |
| 6  | RWCST | 0h      | <b>FATAL:</b> Fatal Error Message Detected  |
| 5  | RWCST | 0h      | <b>NONFATAL:</b> NonFatal Error Message Detected  |
| 4  | RWCST | 0h      | <b>1st_UNCOR_FATAL:</b> First Uncorrectable Fatal Error Message Detected  |
| 3  | RWCST | 0h      | <b>RPERRMSGSTS_NXT_UNCORR:</b> Next Uncorrectable Error Message Detected.   |
| 2  | RWCST | 0h      | <b>RPERRMSGSTS_1ST_UNCORR:</b> First Uncorrectable Error Message Detected.  |
| 1  | RWCST | 0h      | <b>RPERRMSGSTS_NXT_CORR:</b> Next Correctable Error Message Detected.   |
| 0  | RWCST | 0h      | <b>RPERRMSGSTS_1ST_CORR:</b> First Correctable Error Message Detected.  |



#### 4.12.14 ERRSID: Error Source ID (D1-7, F0)

This register identifies the ID of the first correctable and uncorrectable errors.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 134h - 137h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:16  | ROST | 0h      | <b>ERRSID_UNCORR_ID[15:0]: Uncorrectable Error Source ID</b><br>Requestor ID of the source when an uncorrectable error is received and the First Uncorrectable Error Detected is not already set. |
| 15:0   | ROST | 0h      | <b>ERRSID_CORR_ID[15:0]: Correctable Error Source ID</b><br>Requestor ID of the source when a correctable error is received and the First Correctable Error Detected is not already set.          |

#### 4.12.15 NBSPCAPID: NB Specific Capability ID (D1-7, F0)

This register identifies the capability structure and points to the next structure.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 140h - 143h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:20  | RO   | 0h      | <b>NXT_CAP_PTR[11:0]: Next Capability Pointer</b><br>This field points to the next Capability in extended configuration space. |
| 19:16  | RO   | 0h      | <b>MCH_VENDOR_ID[3:0]: Version Number</b>  |
| 15:0   | RO   | 0h      | <b>EXT_CAP_ID[15:0]: Extended CAP_ID</b>   |

#### 4.12.16 EXP\_unitERR: PCI Express Unit Error Register (D1-7, F0)

Host Bridge Error Commands for doing the various signaling: ERR[2:0] and MCERR. These errors correspond to the “unit” errors of the PCI Express block. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB” on page 328](#).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 144h - 147h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:4   | RV   | 0h      | <b>Reserved</b>  |
| 3  | RWST | 0h      | <b>T9Err:</b> SMBus Virtual Pin Interface Error (FATAL Error)            |
| 2  | RWST | 0h      | <b>T10Err:</b> I/O Unit Detected Failure (FATAL Error)                   |
| 1  | RWST | 0h      | <b>T2Err:</b> Received an uncorrectable ECC Error from CDC (FATAL Error) |
| 0  | RWST | 0h      | <b>T1Err:</b> Received a correctable ECC Error from CDC (Corr. Error)    |

### 4.12.17 EXP\_ERR\_DOCMD: PCI Express Error Do Command Register (D1-7, F0)

Link Error Commands for doing the various signaling: ERR[2:0] and MCERR. For this Register usage refer to Figure 6-16 “Error Integration Model” on page 6-327.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 148h - 14Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:16  | RV   | 0h      | <b>Reserved</b>  |
| 15   | RW   | 1       | <b>COR_RPT_EN:</b> Correctable internal error report enable<br>1: enable<br>0: disable   |
| 14   | RW   | 1       | <b>UNC_RPT_EN:</b> Uncorrectable internal error report enable<br>1: enable<br>0: disable   |
| 13:12  | RW   | 01      | <b>EXP_RP_FAT_MAP: Root Port steering for fatal errors</b><br>00: ERR[0]<br>01: ERR[1]<br>10: ERR[2]<br>11: MCERR (This encoding should not be used)<br>If the ERR[2] enable in the Root Command register is set for fatal errors, all fatal errors will be reported via ERR[2] regardless of the setting of this register.<br><b>MSI enable takes precedence for this capability feature.</b> |
| 11:10  | RW   | 01      | <b>EXP_RP_NF_MAP: Root Port steering for non-fatal errors</b><br>00: ERR[0]<br>01: ERR[1]<br>10: ERR[2]<br>11: MCERR<br>If the ERR[2] enable in the Root Command register is set for non-fatal errors, all non-fatal errors will be reported via ERR[2] regardless of the setting of this register.<br><b>MSI enable takes precedence for this capability feature.</b>                         |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 148h - 14Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 9:8  | RW   | 01      | <b>EXP_RP_CORR_MAP: Root Port steering for correctable errors</b><br><br>00: ERR[0]<br>01: ERR[1]<br>10: ERR[2]<br>11: MCERR<br><br>If the ERR[2] enable in the Root Command register is set for correctable errors, all correctable errors will be reported via ERR[2] regardless of the setting of this register.<br>MSI enable takes precedence for this capability feature.  |
| 7:6  | RV   | 0h      | <b>Reserved</b>  |
| 5:4  | RW   | 01      | <b>EXP_DEV_FAT_MAP: DEV report steering for fatal errors</b><br>Fatal error report enable is in the Device control register.<br><br>00: ERR[0] --> Generate ERR[0] if bit 2 (fatal error) is being set in EXP_DEVSTS register and EXP_DEVCTL register has fatal reporting enabled.<br><br>01: ERR[1] --> Generate ERR[1] if bit 2 (Fatal Error) is being set in EXP_DEVSTS register and EXP_DEVCTL register has fatal reporting enabled.<br><br>10: ERR[2] --> Generate ERR[2] if bit 2 (fatal error) is being set in EXP_DEVSTS register and DEVCTL has fatal reporting enabled.<br><br>11: MCERR --> Generate MCERR if bit 2 (Fatal Error) is being set in EXP_DEVSTS register and EXP_DEVCTL register has fatal reporting enabled.<br><br><b>MSI enable takes precedence for this capability feature.</b> |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 148h - 14Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 3:2  | RW   | 01      | <b>EXP_DEV_NF_MAP: DEV report steering for non-fatal errors</b><br>00: ERR[0]<br>01: ERR[1]<br>10: ERR[2]<br>11: MCERR<br>Non-fatal error report enable is in the Device control register.   |
| 1:0  | RW   | 01      | <b>EXP_DEV_CORR_MAP: DEV report steering for correctable errors</b><br>00: ERR[0]<br>01: ERR[1]<br>10: ERR[2]<br>11: MCERR<br>Correctable error report enable is in the EXP_DEVCTL register. |

#### 4.12.18 UNCEDMASK: Uncorrectable Error Detect Mask (D1-7, F0)

This register masks (blocks) the detection of the selected bits. Normally, all are detected. When a specific error is blocked, it does NOT get reported or logged. For this Register usage, refer to [Figure 6-16 “Error Integration Model” on page 6-327](#). For a description of the Errors (IOxx), refer to [Table 6-39 “Errors Detected by the NB” on page 328](#).

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 14Ch - 14Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:21  | RV   | 0h      | <b>Reserved</b>                                       |
| 20   | RW   | 1       | <b>IO12DetMsk:</b> Received an Unsupported Request    |
| 19   | RV   | 0h      | <b>Reserved</b>                                       |
| 18   | RW   | 1       | <b>IO19DetMsk:</b> Malformed TLP Status               |
| 17   | RW   | 1       | <b>IO20DetMsk:</b> Receiver Buffer Overflow Status    |
| 16   | RW   | 1       | <b>IO18DetMsk:</b> Unexpected Completion Status       |
| 15   | RW   | 1       | <b>IO17DetMsk:</b> Completer Abort Status             |
| 14   | RW   | 1       | <b>IO16DetMsk:</b> Completion Time-out Status         |
| 13   | RW   | 1       | <b>IO15DetMsk:</b> Flow Control Protocol ERROR Status |
| 12   | RW   | 1       | <b>IO14DetMsk:</b> Poisoned TLP Status                |

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 14Ch - 14Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 11:5   | RV   | 0h      | <i>Reserved</i>  |
| 4  | RW   | 1       | <b>IO21DetMsk:</b> Data Link Layer Protocol Error Status |
| 3:1  | RV   | 0h      | <i>Reserved</i>  |
| 0  | RW   | 1       | <b>IO13DetMsk:</b> Training Error Status                 |

#### 4.12.19 COREDMASK: Correctable Error Detect Mask (D1-7, F0)

This register masks (blocks) the detection of the selected bits.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 150h - 153h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:13  | RV   | 0h      | <i>Reserved</i>   |
| 12   | RW   | 1       | <b>IO11DetMsk:</b> Replay Timer Time-out Mask<br>Suggested Value: 1 |
| 11:9   | RW   | 0h      | <i>Reserved</i>   |
| 8  | RW   | 1       | <b>IO10DetMsk:</b> Replay_Num Rollover Mask                         |
| 7  | RW   | 1       | <b>IO9DetMsk:</b> Bad DLLP Mask                                     |
| 6  | RW   | 1       | <b>IO8DetMsk:</b> Bad TLP Mask                                      |
| 5:1  | RV   | 0h      | <i>Reserved</i>   |
| 0  | RW   | 1       | <b>IO7DetMsk:</b> Receiver Error Mask                               |

#### 4.12.20 RPEDMASK: Root Port Error Detect Mask (D1-7, F0)

This register masks (blocks) the detection of the selected bits.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 154h - 157h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:3   | RV   | 0h      | <i>Reserved</i>                                      |
| 2  | RW   | 1       | <b>IO26DetMsk:</b> Fatal Message Detect Mask         |
| 1  | RW   | 1       | <b>IO25DetMsk:</b> Uncorrectable Message Detect Mask |
| 0  | RW   | 1       | <b>IO24DetMsk:</b> Correctable Message Detect Mask   |

#### 4.12.21 EXP\_unitDMASK: PCI Express Unit Detect Mask Register (D1-7, F0)

This register masks the non-PCI Express unit errors from being recognized and therefore not logged, and no interrupt/messages are generated. These errors correspond to the “unit” errors of the PCI Express block. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 158h - 15Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:4   | RV   | 0h      | <b>Reserved</b>   |
| 3  | RW   | 1       | <b>T9DetMsk:</b> SMBus Virtual Pin Interface Error            |
| 2  | RW   | 1       | <b>T10DetMsk:</b> I/O Unit Detected Failure                   |
| 1  | RW   | 1       | <b>T2DetMsk:</b> Received an uncorrectable ECC Error from CDC |
| 0  | RW   | 1       | <b>T1DetMsk:</b> Received a correctable ECC Error from CDC    |

#### 4.12.22 EXP\_FERR: PCI Express First Error Register (D1-7, F0)

Locks down after first error in each category type. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 160h - 163h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 31:10  | RV    | 0h      | <b>Reserved</b>  |
| 9  | RWCST | 0h      | <b>Unit_FAT_Err:</b> Unit Fatal Error Detected         |
| 8  | RV    | 0h      | <b>Reserved</b>  |
| 7  | RWCST | 0h      | <b>Unit_Corr_Err:</b> Unit Correctable Error Detected  |
| 6  | RWCST | 0h      | <b>IO26Err:</b> Root Port Fatal Error Received         |
| 5  | RWCST | 0h      | <b>IO25Err:</b> Root Port Non-Fatal Error Received     |
| 4  | RWCST | 0h      | <b>IO24Err:</b> Root Port Correctable Error Received   |
| 3  | RWCST | 0h      | <b>IO12Err:</b> Device Unsupported Request Detected    |
| 2  | RWCST | 0h      | <b>Dev_FAT_Err:</b> Device Fatal Error Detected        |
| 1  | RWCST | 0h      | <b>Dev_NF_Err:</b> Device Non-Fatal Error Detected     |
| 0  | RWCST | 0h      | <b>Dev_Corr_Err:</b> Device Correctable Error Detected |

### 4.12.23 EXP\_NERR: PCI Express Next Error Register (D1-7, F0)

See EXP\_FERR for bit definitions. Logs errors after corresponding field in FERR register is locked down.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 164h - 167h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 31:10  | RV    | 0h      | <i>Reserved</i>  |
| 9  | RWCST | 0h      | <b>Unit_Nxt_FAT_Err:</b> Unit Fatal Error Detected         |
| 8  | RV    | 0h      | <i>Reserved</i>  |
| 7  | RWCST | 0h      | <b>Unit_Nxt_Corr_Err:</b> Unit Correctable Error Detected  |
| 6  | RWCST | 0h      | <b>IO26NXT_ERR:</b> Root Port Fatal Error Received         |
| 5  | RWCST | 0h      | <b>IO25NXT_ERR:</b> Root Port Non-Fatal Error Received     |
| 4  | RWCST | 0h      | <b>IO24NXT_ERR:</b> Root Port Correctable Error Received   |
| 3  | RWCST | 0h      | <b>IO12NXT_ERR:</b> Device Unsupported Request Detected    |
| 2  | RWCST | 0h      | <b>Dev_Nxt_FAT_Err:</b> Device Fatal Error Detected        |
| 1  | RWCST | 0       | <b>Dev_Nxt_NF_Err:</b> Device Non-Fatal Error Detected     |
| 0  | RWCST | 0h      | <b>Dev_Nxt_Corr_Err:</b> Device Correctable Error Detected |

### 4.12.24 EXP\_unitEMASK: PCI Express Unit Error Mask Register (D1-7, F0)

This register masks the non-PCI Express unit errors from being recognized (and therefore not logged), and no interrupt/messages are generated. These errors correspond to the “unit” errors of the PCI Express block. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328. A ‘1’ in any field enables that error.

| <b>Device:</b> 1 - 7<br><b>Function:</b> 0<br><b>Offset:</b> 168h - 16Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:4   | RV   | 0h      | <i>Reserved</i>  |
| 3  | RW   | 1       | <b>T9Msk:</b> SMBus Virtual Pin Interface Error            |
| 2  | RW   | 1       | <b>T10Msk:</b> I/O Unit Detected Failure                   |
| 1  | RW   | 1       | <b>T2Msk:</b> Received an uncorrectable ECC Error from CDC |
| 0  | RW   | 1       | <b>T1Msk:</b> Received a correctable ECC Error from CDC    |

## 4.13 IMI Registers (Device{8,10,12,14}, Function 0)

The IMI registers are in Devices 8,10, 12, 14 (D{8,10,12,14}), Function 0 (F0). For the register address map please refer to [Table 4-13](#).

**Note:** There are four sets of the following registers, one set for each IMI. They will all appear in function 0 of a different device as defined below in [Table 4-22](#).

**Table 4-22. Device Numbers of IMIs and XMBs**

| IMI | IMI Device Number | Device Number Of Connected XMB |
|-----|-------------------|--------------------------------|
| A   | 8d                | 9d                             |
| B   | 10d               | 11d                            |
| C   | 12d               | 13d                            |
| D   | 14d               | 15d                            |

### 4.13.1 VID: Vendor Identification Register (D{8,10,12,14}, F0)

This register identifies Intel as the manufacturer of the Intel® E8501 chipset North Bridge (NB). Writes to this register have no effect.

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 00h 01h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number-</b><br>The value assigned to Intel. |

### 4.13.2 DID: Device Identification Register (D{8,10,12,14}, F0)

This register combined with the Vendor Identification register uniquely identifies the NB. Writes to this register have no effect. All IMI devices will have the same DID in each function.

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 02h - 03h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 260Ch   | <b>DIN: Device Identification Number</b><br>Identifies each function of the <b>NB</b> . |



### 4.13.3 RID: Revision Identification Register (D{8,10,12,14}, F0)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 08h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7:4   | RO   | 00h     | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br>1: B stepping   |
| 3:0   | RO   | 00h     | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

### 4.13.4 CCR: Class Code Register (D{8,10,12,14}, F0)

This register contains the Class Code for the device.

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 09h - 0Bh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class.</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class.</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For these Devices default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface.</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.13.5 HDR: Header Type Register (D{8,10,12,14}, F0)

This register identifies the header layout of the configuration space.

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 0Eh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RO   | 0h      | <b>Mfd: Multi-function Device.</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts. Therefore, the IMI is defined to be a single function device, and this bit is hardwired to '0'.                       |
| 6:0   | RO   | 00h     | <b>CfgLayout: Configuration Layout.</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For devices - 8,10,12,14 default is 00h, indicating a conventional type 00h PCI header. |

### 4.13.6 SVID: Subsystem Vendor Identification Register (D{8,10,12,14}, F0)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identify any PCI device.

| <b>Device</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 2Ch - 2Dh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RWO  | 8086h   | <b>Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to this register will have no effect. |

### 4.13.7 SID: Subsystem Identity (D{8,10,12,14}, F0)

This register identifies the system.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:0   | RWO  | 8086h   | <b>Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to this register will have no effect. |

### 4.13.8 IMISC: IMI Issue Control (D{8,10,12,14}, F0)

This register controls outbound command issue on the IMI.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 40h - 43h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:27  | RW   | 10h     | <b>WRO: Number of Writes Outstanding</b><br>This field controls the number of writes the NB will issue to the XMB.   |
| 26:22  | RW   | 10000b  | <b>RDO: Number of Reads Outstanding</b><br>This field controls the number of reads the NB will issue before receiving read returns.  |
| 21:19  | RV   | 001b    | <b>Reserved</b>  |
| 18:16  | RV   | 010b    | <b>Reserved</b>  |
| 15:0   | RW   | 0AF0h   | <b>TIMEOUT_COUNT: Time-out Value</b><br>Defines the maximum interval between command and read return or write acknowledge. The interval is in NB core clocks. At 333 MHz, this is 3 ns per clock. Any retry will be triggered between 1x - 2x this interval. The default value is 8.4 $\mu$ s. |

### 4.13.9 IMIST: IMI Status (D{8,10,12,14}, F0)

These registers are inspected by software when it gets an IMI\_HPINT to determine the cause of an IMI\_HPINT interrupt. This register contains RAID and Mirroring recovery state, Initialization state, and Hot Plug Sequencing status. The IMI\_HPINT pin is asserted whenever MRLINT, XMBINT, ANTINT, FALINT, PRSINT or PWRINT bits are set.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 48h - 4Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:24  | RO   | 00h     | <b>STATE: IMI State</b><br>This field describes the current state of the IMI. It can be read by software to determine which IMI is being sequenced through recovery, and how far the IMI has progressed.<br><br>00h: Reset<br>10h: Init<br>20h: Ready<br>30h: Active<br>40h: Redundant<br>50h: Disabled<br>60h: Redundancy Loss<br>70h: Recovery Reset<br>80h: Recovery Init<br>90h: Recovery Ready<br>A0h: Resilver<br>B0h: Recovered<br>C0h: Recovery Failure |
| 23:9   | RW   | 0       | <b>SCRATCH: Software Scratchpad</b><br>This field is reserved for use by hot-plug software to record the status of an IMI.  |
| 8  | RW   | 0       | <b>PWRGOOD: Power Good State</b><br><br>0: The virtual pin PWRGOOD# is asserted.<br>1: The virtual pin PWRGOOD# is not asserted.<br><br>Indicates to software that the IMI_RESET signal can be deasserted.  |
| 7  | RW   | 0       | <b>MRL: Manually Operated Retention Latch State</b><br><br>0: The MRL is closed. The virtual pin MRL# is not asserted.<br>1: The MRL is open. The virtual pin MRL# is asserted.<br><br>Software can cause interrupts by writing this register when true Hot-Plug behavior is not enabled.   |

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 48h - 4Bh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 6  | RW   | 0       | <b>PRSNT: Presence Detect State</b><br><br>0: An XMB is not connected to the NB. The virtual pin PRSNT# is not asserted.<br><br>1: An XMB is connected to the NB. The virtual pin PRSNT# is asserted. The XMB may or may not be powered.<br><br>Software can cause interrupts by writing this register when true Hot-Plug behavior is not enabled. |
| 5  | RWC  | 0       | <b>XMBINT: XMB Interrupt</b><br>This bit is set whenever the XMB has asserted the "Assert IMI_HPINT" inband signal on the Independent Memory Interface. The MS register in the XMB holds the cause of the interrupt. After software has handled the event, it writes to 1 to clear.  |
| 4  | RWC  | 0       | <b>MRLINT: Manually Operated Retention Lever Sensor Changed Event</b><br>Set when the virtual pin MRL# changes state. After software has handled the event, it writes to 1 to clear.   |
| 3  | RWC  | 0       | <b>ATNINT: Attention Button Pressed</b><br>Set when the virtual pin ATNBTN# is pressed for this port. After software has handled the event, it writes to 1 to clear.   |
| 2  | RWC  | 0       | <b>FAILINT: Disabled State Interrupt</b><br>This bit is set whenever this IMI enters Disabled State. After software has handled the event, it writes to 1 to clear.  |
| 1  | RWC  | 0       | <b>PRSINT: Presence Detect Changed Event</b><br>Set when the virtual pin PRSNT# changes state. After software has handled the event, it writes to 1 to clear.  |
| 0  | RWC  | 0       | <b>PWRINT: Power Fault Detected</b><br>Set when the virtual pin PWRFLT# is sampled asserted. After software has handled the event, it writes to 1 to clear.  |

### 4.13.10 IMIHPC: IMI Hot-Plug Control (D{8,10,12,14}, F0)

This register controls the IMI for Initialization, Hot-Plug, RAID recovery and Mirroring Recovery. It consists of a State field, Hot-Plug Virtual Pin Controls, and Interrupt Enables. [Section 6.6, “RAS” on page 320](#) describes how the Hot-Plug pins controlled by this register are sampled and driven.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 4Ch - 4Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:24  | RW   | 00h     | <b>NEXTSTATE: IMI State Control field</b><br>This field is written by software to change the IMI state. It returns the last value written when read. Many states can only be entered under hardware control and should not be written by software. These settings are only valid if bit 18 NNEXTSTATE is set.<br><br>00h: Reset<br>10h: Init<br>20h: Ready<br>30h: Active<br>40h: Redundant<br>50h: Disabled<br>60h: Redundancy Loss - may not be written<br>70h: Recovery Reset<br>80h: Recovery Init<br>90h: Recovery Ready - may not be written<br>A0h: Resilver<br>B0h: Recovered - may not be written<br>C0h: Recovery Failure - may not be written |
| 23   | RW   | 1b      | <b>PWRCTL: Power Controller</b><br>Controls the PWREN# virtual pin.<br>0: Activate PWREN#. Apply power to the Memory Card.<br>1: De-activate PWREN#. Power is removed from the Memory Card.  |
| 22:21  | RW   | 11b     | <b>PWRLED: Power Indicator Control</b><br>Controls the Virtual PWRLED# pin.<br>00: Reserved<br>01: On (drive low)<br>10: Blink (PWRLED# VP toggles at 1.5 Hz)<br>11: Off (high impedance)  |
| 20:19  | RW   | 11b     | <b>ATNLED: Attention Indicator Control</b><br>Controls the virtual ATNLED# pin.<br>00: Reserved<br>01: On (drive low)<br>10: Blink (ATNLED# VP toggles at 1.5 Hz)<br>11: Off (high impedance)  |

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 4Ch - 4Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 18   | RW   | 0       | <b>NNEXTSTATE:</b><br>Software writing a 1 to this bit indicates to hardware that the <b>NNEXTSTATE</b> field is also being written at this time and that hardware should change the IMI State according to the new IMI State Control Field.<br>Hardware guarantees a 0 will always be read from this bit.  |
| 17:14  | RW   | 00h     | <b>PARTNERS: IMI's Redundant with this one</b><br>This field defines the IMI's which will cause a transition to "Redundancy Loss" state when they fail. If bit [17] is set, IMI[3] is a partner with this one ([16] for IMI[2], [15] for IMI[1], [14] for IMI[0]). If REDUN.MIRROR is set, the bit should be set for any IMI which appears in IMIR[i].IMIG0WAY[j] when this IMI appears in IMIR[i].IMIG1WAY[j] or vice versa for all i and j. |
| 13   | RW   | 0h      | <b>XMBHDR: XMB responds to config access to PCI Header</b><br>Normally, the NB responds to XMB Function 0 configuration requests whether the XMB is present or not. When set, the NB allows the XMB to respond to Function 0 to allow examination of the revision ID of the XMB.  |
| 12   | RW   | 0h      | <b>HPC: Hot-Plug Capable</b><br>Set by software to indicate that the I/O Port specified by VPP is valid.  |
| 11:8   | RW   | 00h     | <b>VPP: Virtual Pin Port</b><br>[11:9] = SMBus Address<br>[8] = IO Port<br>Defines the 8-bit IO port that has the Hot-Plug pins for this interface. If the HPC bit is set, the NB will write ANTLED, PWRLED, and PWREN values from this register to the specified IO Port. It will update the ATNBTN, PWRFLT, PRSNT, and MRL values from the IO Port to the IMIHPS register for this port.  |
| 7  | RV   | 0h      | <b>Reserved</b>   |
| 6  | RW   | 0h      | <b>HPINTEN: Hot-Plug Interrupt Enable</b><br>0: IMI_HPINT may not be asserted due to events on this IMI.<br>1: IMI_HPINT may be asserted due to events on this IMI. Each event is also individually enabled by bits in this register.   |
| 5  | RW   | 0h      | <b>XMBINTEN: XMB interrupt enable</b><br>When set, the NB will assert IMI_HPINT when the "Assert IMI_HPINT" inband signal appears on the IMI.   |
| 4  | RW   | 0h      | <b>MRLINTEN: Mechanical Retention Latch Interrupt Enable</b><br>If set, IMI_HPINT will be asserted when the virtual pin MRL# is asserted, indicating latch has opened.  |
| 3  | RW   | 0h      | <b>ATNINTEN: Attention Button Pressed Interrupt Enable</b><br>If set, IMI_HPINT will be asserted when the virtual pin ATNBTN# is asserted.  |
| 2  | RW   | 0h      | <b>FAILINTEN: Redundancy Failure Interrupt Enable</b><br>If set, IMI_HPINT will be asserted when the IMI transitions to Disabled State.   |
| 1  | RW   | 0h      | <b>PRSINTEN: Presence Detection Interrupt Enable</b><br>If set, IMI_HPINT will be asserted when a level change is sampled by the NB on the virtual pin PRSNT#.  |
| 0  | RW   | 0h      | <b>PWRINTEN: Power Fault Detected Interrupt Enable</b><br>If set, IMI_HPINT will be asserted when the virtual pin PWRFLT# is asserted.  |

#### 4.13.11 IMIAPR: IMI Read Return Aperture (D{8,10,12,14}, F0)

This register defines the read return aperture on this IMI.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 60h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:6  | RV   | 0h      | <b>Reserved</b>   |
| 5:0  | RWST | 000111b | <b>APERTURE: Read Return Aperture</b><br>This field sets the size of the window in which a data return may appear. Software should only set this register to values of 1, 3, 5 and 7. If set larger than 7, the NB will interpret as 7. |

#### 4.13.12 IMIOFF: IMI Read Return Offset (D{8,10,12,14}, F0)

This register defines the read return offset on this IMI.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 61h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:6  | RV   | 0h      | <b>Reserved</b>   |
| 5:0  | RWST | 000010  | <b>OFFSET: Read Return offset</b><br>This field sets the minimum delay between an early read return and inbound data on the IMI. Maximum legal value is 48.<br>This register has an additional reset behavior. It resets to the default value whenever the IMI_{A,B,C,D}_RST# signal is asserted to the attached XMB. Hardware performs this reset. |

#### 4.13.13 IMILINE: IMI Cache Line Size (D{8,10,12,14}, F0)

This register defines the cache line size on this IMI. It is present in case the NB is ever connected to an XMB that does not power up to this parameter value.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 62h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 40h     | <b>LINE: Cache line size</b><br>This encoding specifies 64B. |



#### 4.13.14 IMICHNK: IMI Chunk Size (D{8,10,12,14}, F0)

This register defines the Chunk size used by the NB on the IMI.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 63h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7:0  | RO   | 10h     | <b>CHUNK: Chunk size</b><br>This encoding specifies 16B. |

#### 4.13.15 IMICODE: IMI ECC Code Size (D{8,10,12,14}, F0)

This register defines the Error Correction Code used to cover read returns.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> 64h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:0  | RO   | 03h     | <b>CODE: Error Correction Code</b><br>This encoding specifies code that corrects x8 DRAM failures used by the NB. |

#### 4.13.16 IMI\_FERR: IMI First Errors (D{8,10,12,14}, F0)

The first error for an IMI is logged in this register. When an error is logged in this register the corresponding NRECIMI register latches the appropriate log information. For a description of the Errors (IMIxx) refer to the [Table 6-39 “Errors Detected by the NB” on page 328](#).

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> C0h - C3h |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 31:15  | RV    | 00h     | <b>Reserved</b>   |
| 14   | RWCST | 0       | <b>IMI14Err: NB Received a Fatal Error signal from the XMB</b><br>Fatal             |
| 13   | RWCST | 0       | <b>IMI13Err: Failed on last retry. Co-exist with IMI9Err</b><br>Nonfatal            |
| 12   | RWCST | 0       | <b>IMI12Err: The NB received an uncorrectable error signal from XMB</b><br>Nonfatal |
| 11   | RWCST | 0       | <b>IMI11Err: The NB received a correctable error signal from XMB</b><br>Nonfatal    |
| 10   | RWCST | 0       | <b>IMI10Err: The NB is sending a “poisoned” Config Write to XMB</b><br>Nonfatal     |
| 9  | RWCST | 0       | <b>IMI9Err: Failed on last retry. Co-exist with IMI13Err</b><br>Nonfatal            |

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> C0h - C3h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 8  | RWCST | 0       | <b>IMI8Err: Outstanding Requests are posted to a failed IMI Link</b><br>Nonfatal   |
| 7  | RWCST | 0       | <b>IMI7Err: VPP SMBus Hot-Plug error</b><br>Nonfatal   |
| 6  | RWCST | 0       | <b>IMI6Err: Abort</b><br>Nonfatal  |
| 5  | RWCST | 0       | <b>IMI5Err: Inbound link layer control error</b><br>Idle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag<br>Nonfatal |
| 4  | RWCST | 0       | <b>IMI4Err: Memory write data poisoned</b><br>The NB has poisoned the flit that contains the error and written the data to memory.<br>Nonfatal   |
| 3  | RWCST | 0       | <b>IMI3Err: Inbound CRC Error</b><br>May or may not get a M7 as well.<br>Nonfatal  |
| 2  | RWCST | 0       | <b>IMI2Err: command time-out</b><br>Nonfatal   |
| 1  | RWCST | 0       | <b>IMI1Err: Correctable error in read return packet</b><br>Nonfatal  |
| 0  | RWCST | 0       | <b>IMI0Err: Uncorrectable error in read return packet before retry limit exceeded</b><br>Nonfatal  |

### 4.13.17 IMI\_NERR: IMI Next Errors (D{8,10,12,14}, F0)

If an error is already logged in the IMI\_FERR register, all subsequent errors are logged in the IMI\_NERR. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> C4h - C7h |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 31:15  | RV    | 00h     | <b>Reserved</b>   |
| 14   | RWCST | 0       | <b>IMI14Err: The NB Received a Fatal Error signal from the XMB</b><br>Fatal   |
| 13   | RWCST | 0       | <b>IMI13Err: Failed on last retry. Co-exist with IMI9Err</b><br>Nonfatal  |
| 12   | RWCST | 0       | <b>IMI12Err: The NB received an uncorrectable error signal from XMB.</b><br>Nonfatal  |
| 11   | RWCST | 0       | <b>IMI11Err: The NB received a correctable error signal from XMB.</b><br>Nonfatal   |
| 10   | RWCST | 0       | <b>IMI10Err: The NB is sending a “poisoned” Config Write to XMB.</b><br>Nonfatal  |
| 9  | RWCST | 0       | <b>IMI9Err: Failed on last retry. Co-exist with IMI13Err</b><br>Nonfatal  |
| 8  | RWCST | 0       | <b>IMI8Err: Outstanding Requests are posted to a failed IMI Link</b><br>Nonfatal  |
| 7  | RWCST | 0       | <b>IMI7Err: SMBus Hot-Plug error.</b><br>Nonfatal   |
| 6  | RWCST | 0       | <b>IMI6Err: Abort</b><br>Nonfatal   |
| 5  | RWCST | 0       | <b>IMI5Err: Inbound link layer control error.</b><br>Idle flit sequence error<br>Link Layer Format Sequence Errors<br>Bad Data Size, info bit sequence error<br>Aperture Violation<br>Invalid Tag<br>Nonfatal |
| 4  | RWCST | 0       | <b>IMI4Err: Memory write data poisoned.</b> The NB has poisoned the flit that contains the error and written the data to memory.<br>Nonfatal  |

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> C4h - C7h |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 3  | RWCST | 0       | <b>IMI3Err: Inbound CRC Error</b><br>May or may not get an M7 as well.<br>Nonfatal                |
| 2  | RWCST | 0       | <b>IMI2Err: command time-out</b><br>Nonfatal  |
| 1  | RWCST | 0       | <b>IMI1Err: Correctable error in read return packet</b><br>Nonfatal                               |
| 0  | RWCST | 0       | <b>IMI0Err: Uncorrectable error in read return packet before retry limit exceeded</b><br>Nonfatal |

#### 4.13.18 NRECIMI: Non-recoverable IMI Error Log Register (D{8,10,12,14}, F0)

This register latches information when the IMI\_FERR latches the first detected fatal error.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> D4h - D5h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:8   | ROST | 00h     | <b>NR_IMI_Tran_ID:</b> IMI Transaction ID of the failed request |
| 7:0  | ROST | 00h     | <b>NR_IMI_CDC_Tag_ID:</b> CDC TAG ID of the failed request      |

#### 4.13.19 RECIMI: Recoverable IMI Error Log Register (D{8,10,12,14}, F0)

This register latches information when the IMI\_FERR latches the first detected non-fatal error.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> D6h - D7h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:8   | ROST | 00h     | <b>Rec_IMI_Tran_ID:</b> IMI Transaction ID of the failed request |
| 7:0  | ROST | 00h     | <b>Rec_IMI_CDC_Tag_ID:</b> CDC TAG ID of the failed request      |

### 4.13.20 REDIMIL: Recoverable Data IMI Error Log Register (D{8,10,12,14}, F0)

This register latches information when the IMI\_FERR latches the first detected non-fatal error.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> D8h - DBh |      |           |  |
|--|------|-----------|--|
| Bit  | Attr | Default   | Description  |
| 31:0   | ROST | 00000000h | <b>Syndrome: Syndrome Bits</b><br>ECC syndrome of correctable error. |

### 4.13.21 REDIMIH: Recoverable IMI Error Log Register (D{8,10,12,14}, F0)

This register latches information when the IMI\_FERR latches the first detected non-fatal error.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> DCh - DDh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:0   | ROST | 0000h   | <b>ECC_Locator:</b> identifies the symbol in error for correctable errors<br>The bit set identifies which DRAM had the bit in error according to the following list:<br>Bit 0: DRAM0, channel 0 had the error<br>Bit 1: DRAM1, channel 0 had the error<br>Bit 2: DRAM2, channel 0 had the error<br>Bit 3: DRAM3, channel 0 had the error<br>Bit 4: DRAM4, channel 0 had the error<br>Bit 5: DRAM5, channel 0 had the error<br>Bit 6: DRAM6, channel 0 had the error<br>Bit 7: DRAM7, channel 0 had the error<br>Bit 8: DRAM0, channel 1 had the error<br>Bit 9: DRAM1, channel 1 had the error<br>Bit 10: DRAM2, channel 1 had the error<br>Bit 11: DRAM3, channel 1 had the error<br>Bit 12: DRAM4, channel 1 had the error<br>Bit 13: DRAM5, channel 1 had the error<br>Bit 14: DRAM6, channel 1 had the error<br>Bit 15: DRAM7, channel 1 had the error<br><i>Using the NB locator bits, it is not possible to determine if the error is present in DRAM8 on either channel 0 or channel 1.</i> |

## 4.13.22 EMASK\_IMI[3:0]: IMI Error Mask Register (D{8,10,12,14}, F0)

For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on [page 328](#). A ‘0’ in any field enables that error.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> DEh - DFh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RV   | 1       | <b>Reserved</b>  |
| 14   | RW   | 1       | <b>IMI14Msk:</b> The NB Received a fatal error from the XMB  |
| 13   | RW   | 1       | <b>IMI13Msk:</b> Failed on last retry. Co-exist with IMI9Msk   |
| 12   | RW   | 1       | <b>IMI12Msk:</b> The NB Received a uncorrectable error from the XMB  |
| 11   | RW   | 1       | <b>IMI11Msk:</b> The NB Received a correctable error signal from XMB   |
| 10   | RW   | 1       | <b>IMI10Msk:</b> The NB is sending a “poisoned” Config Write to XMB  |
| 9  | RW   | 1       | <b>IMI9Msk:</b> Failed on last retry. Co-exist with IMI13Msk   |
| 8  | RW   | 1       | <b>IMI8Msk:</b> Outstanding Requests are posted to a failed IMI Link   |
| 7  | RW   | 1       | <b>IMI7Msk:</b> SMBus Hot-Plug error   |
| 6  | RW   | 1       | <b>IMI6Msk:</b> Inbound link abort   |
| 5  | RW   | 1       | <b>IMI11Msk:</b> Inbound link layer control error.<br>Idle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag |
| 4  | RW   | 1       | <b>IMI4Msk:</b> Memory write data poisoned<br>The NB has poisoned the flit that contains the error and written the data to memory.   |
| 3  | RW   | 1       | <b>IMI3Msk:</b> Inbound CRC Error  |
| 2  | RW   | 1       | <b>IMI2Msk:</b> 1st Request Time-out   |
| 1  | RW   | 1       | <b>IMI1Msk:</b> Inbound Correctable ECC Error  |
| 0  | RW   | 1       | <b>IMI0Msk:</b> Inbound UnCorrectable ECC Error #1   |

### 4.13.23 IMI\_ERR0: IMI Error 0 Enable Register (D{8,10,12,14}, F0)

This register enables the signaling of Err[0] when an error flag is set. Note that one (and only one) error signal should be enabled. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> E0h - E1h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RV   | 0       | <b>Reserved</b>  |
| 14   | RWST | 0       | <b>IMI14Err0Sel:</b> The NB Received a fatal error from the XMB  |
| 13   | RWST | 0       | <b>IMI13Err0Sel:</b> Failed on last retry. Co-exist with IMI9Err0Sel   |
| 12   | RWST | 0       | <b>IMI12Err0Sel:</b> The NB Received a uncorrectable error from the XMB  |
| 11   | RWST | 0       | <b>IMI11Err0Sel:</b> The NB Received a correctable error signal from XMB   |
| 10   | RWST | 0       | <b>IMI10Err0Sel:</b> The NB is sending a “poisoned” Config Write to XMB  |
| 9  | RWST | 0       | <b>IMI9Err0Sel:</b> Failed on last retry. Co-exist with IMI13Err0Sel   |
| 8  | RWST | 0       | <b>IMI8Err0Sel:</b> Outstanding Requests are posted to a failed IMI Link   |
| 7  | RWST | 0       | <b>IMI7Err0Sel:</b> VPP SMBus Hot-Plug error   |
| 6  | RWST | 0       | <b>IMI6Err0Sel:</b> Inbound link abort   |
| 5  | RWST | 0       | <b>IMI5Err0Sel:</b> Inbound link layer control error<br>Idle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag |
| 4  | RWST | 0       | <b>IMI4Err0Sel:</b> Memory write data poisoned<br>The NB has poisoned the flit that contains the error and written the data to memory  |
| 3  | RWST | 0       | <b>IMI3Err0Sel:</b> Inbound CRC Error  |
| 2  | RWST | 0       | <b>IMI2Err0Sel:</b> 1st Request Time-out   |
| 1  | RWST | 0       | <b>IMI1Err0Sel:</b> Inbound Correctable ECC Error  |
| 0  | RWST | 0       | <b>IMI0Err0Sel:</b> Inbound UnCorrectable ECC Error #1   |

#### 4.13.24 IMI\_ERR1: IMI Error 1 Enable Register (D{8,10,12,14}, F0)

This register enables the signaling of Err[1] when an error flag is set. Note that one and only one error signal should be enabled. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> E2h - E3h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RV   | 0       | <b>Reserved</b>  |
| 14   | RWST | 0       | <b>IMI14Err1Sel:</b> The NB Received a fatal error from the XMB  |
| 13   | RWST | 0       | <b>IMI13Err1Sel:</b> Failed on last retry. Co-exist with IMI9Err1Sel   |
| 12   | RWST | 0       | <b>IMI12Err1Sel:</b> The NB Received a uncorrectable error from the XMB  |
| 11   | RWST | 0       | <b>IMI11Err1Sel:</b> The NB Received a correctable error signal from XMB   |
| 10   | RWST | 0       | <b>IMI10Err1Sel:</b> The NB is sending a “poisoned” Config Write to XMB  |
| 9  | RWST | 0       | <b>IMI9Err1Sel:</b> Failed on last retry. Co-exist with IMI13Err1Sel   |
| 8  | RWST | 0       | <b>IMI8Err1Sel:</b> Outstanding Requests are posted to a failed IMI Link   |
| 7  | RWST | 0       | <b>IMI7Err1Sel:</b> VPP SMBus Hot-Plug error   |
| 6  | RWST | 0       | <b>IMI6Err1Sel:</b> Inbound link abort   |
| 5  | RWST | 0       | <b>IMI5Err1Sel:</b> Inbound link layer control error<br>Idle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag |
| 4  | RWST | 0       | <b>IMI4Err1Sel:</b> Memory write data poisoned<br>The NB has poisoned the flit that contains the error and written the data to memory  |
| 3  | RWST | 0       | <b>IMI3Err1Sel:</b> Inbound CRC Error  |
| 2  | RWST | 0       | <b>IMI2Err1Sel:</b> 1st Request Time-out   |
| 1  | RWST | 0       | <b>IMI1Err1Sel:</b> Inbound Correctable ECC Error  |
| 0  | RWST | 0       | <b>IMI0Err1Sel:</b> Inbound UnCorrectable ECC Error #1   |



### 4.13.25 IMI\_ERR2: IMI Error 2 Enable Register(D{8,10,12,14}, F0)

This register enables the signaling of Err[2] when an error flag is set. Note that one and only one error signal should be enabled. For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> E4h - E5h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15   | RV   | 0       | <b>Reserved</b>  |
| 14   | RWST | 0       | <b>IMI14Err2Sel:</b> The NB Received a fatal error from the XMB  |
| 13   | RWST | 0       | <b>IMI13Err2Sel:</b> Failed on last retry. Co-exist with IMI9Err2Sel   |
| 12   | RWST | 0       | <b>IMI12Err2Sel:</b> The NB Received a uncorrectable error from the XMB  |
| 11   | RWST | 0       | <b>IMI11Err2Sel:</b> The NB Received a correctable error signal from XMB   |
| 10   | RWST | 0       | <b>IMI10Err2Sel:</b> The NB is sending a “poisoned” Config Write to XMB  |
| 9  | RWST | 0       | <b>IMI9Err2Sel:</b> Failed on last retry. Co-exist with IMI13Err2Sel   |
| 8  | RWST | 0       | <b>IMI8Err2Sel:</b> Outstanding Requests are posted to a failed IMI Link   |
| 7  | RWST | 0       | <b>IMI7Err2Sel:</b> VPP SMBus Hot-Plug error   |
| 6  | RWST | 0       | <b>IMI6Err2Sel:</b> Inbound link abort   |
| 5  | RWST | 0       | <b>IMI5Err2Sel:</b> Inbound link layer control error<br>IDle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag |
| 4  | RWST | 0       | <b>IMI4Err2Sel:</b> Memory write data poisoned<br>The NB has poisoned the flit that contains the error and written the data to memory  |
| 3  | RWST | 0       | <b>IMI3Err2Sel:</b> Inbound CRC Error  |
| 2  | RWST | 0       | <b>IMI2Err2Sel:</b> 1st Request Time-out   |
| 1  | RWST | 0       | <b>IMI1Err2Sel:</b> Inbound Correctable ECC Error  |
| 0  | RWST | 0       | <b>IMI0Err2Sel:</b> Inbound UnCorrectable ECC Error #1   |

#### 4.13.26 IMI\_MCERR: IMI MCERR Enable Register (D{8,10,12,14}, F0)

This register enables the signaling of MCERR when an error flag is set. Note that one and only one error signal should be enabled.

| <b>Device:</b> 8, 10, 12, 14<br><b>Function:</b> 0<br><b>Offset:</b> E6h - E7h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15   | RV   | 0       | <i>Reserved</i>   |
| 14   | RW   | 0       | <b>IMI14MCErrSel:</b> The NB Received a fatal error from the XMB  |
| 13   | RW   | 0       | <b>IMI13MCErrSel:</b> Failed on Last retry. Co-exist with IMI9MCErrSel  |
| 12   | RW   | 0       | <b>IMI12MCErrSel:</b> The NB Received a uncorrectable error from the XMB  |
| 11   | RW   | 0       | <b>IMI11MCErrSel:</b> The NB Received a correctable error signal from XMB   |
| 10   | RW   | 0       | <b>IMI10MCErrSel:</b> The NB is sending a “poisoned” Config Write to XMB  |
| 9  | RW   | 0       | <b>IMI9MCErrSel:</b> Failed on Last retry. Co-exist with IMI13MCErrSel  |
| 8  | RW   | 0       | <b>IMI8MCErrSel:</b> Outstanding Requests are posted to a failed IMI Link   |
| 7  | RW   | 0       | <b>IMI7MCErrSel:</b> VPP SMBus Hot-Plug error   |
| 6  | RW   | 0       | <b>IMI6MCErrSel:</b> Inbound link abort   |
| 5  | RW   | 0       | <b>IMI5MCErrSel:</b> Inbound link layer control error<br>Idle Flit Sequence Error<br>Link Layer Format Sequence Errors<br>Bad Data Size, Info Bit Sequence Error<br>Aperture Violation<br>Invalid Tag |
| 4  | RW   | 0       | <b>IMI4MCErrSel:</b> Memory write data poisoned<br>The NB has poisoned the flit that contains the error and written the data to memory  |
| 3  | RW   | 0       | <b>IMI3MCErrSel:</b> Inbound CRC Error  |
| 2  | RW   | 0       | <b>IMI2MCErrSel:</b> 1st Request Time-out   |
| 1  | RW   | 0       | <b>IMI1MCErrSel:</b> Inbound Correctable ECC Error  |
| 0  | RW   | 0       | <b>IMI0MCErrSel:</b> Inbound UnCorrectable ECC Error #1   |

## 4.14 Front Side Bus, Boot and Interrupt Registers (Device 16, Function 0)

The Front Side Bus, Boot and Interrupt registers are in Device 16 (D16), function 0 (F0). For the register address map, please refer to [Table 4-14](#).

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.14.1 VID: Vendor Identification Register (D16, F0)

This register identifies Intel as the manufacturer of the Intel® E8501 chipset North Bridge (NB). Writes to this register have no effect.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 00 - 01h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.14.2 DID: Device Identification Register (D16, F0)

This register, combined with the Vendor Identification register, uniquely identifies the NB. Writes to this register have no effect. All PCI Express devices will have the same DID in each function. All IMI devices will have the same DID in each function.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 02 - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2610h   | <b>Device Identification Number</b><br>Identifies each function of the NB. |

### 4.14.3 RID: Revision Identification Register (D16, F0)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

### 4.14.4 CCR: Class Code Register (D16, F0)

This register contains the Class Code for the device.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 09h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 23:16  | RO   | 06h     | <b>Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".  |
| 15:8   | RO   | 00h     | <b>Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function. For the NB, this field is hardwired to 00h, indicating it is a "Host Bridge".  |
| 7:0  | RO   | 00h     | <b>Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device-independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.14.5 HDR: Header Type Register (D16, F0)

This register identifies the header layout of the configuration space.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 0Eh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7  | RO   | 1h      | <b>Mfd: Multi-function Device.</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0  | RO   | 00h     | <b>CfgLayout: Configuration Layout.</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device the default is 00h, indicating a conventional type 00h PCI header. |

### 4.14.6 SVID: Subsystem Vendor Identification Register (D16, F0)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register, uniquely identifies any PCI device.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 2Ch |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:0   | RWO  | 8086h   | <b>Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

### 4.14.7 SID: Subsystem Identity (D16, F0)

This register identifies the system.

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 2Eh - 2Fh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:0   | RWO  | 8086h   | <b>Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.14.8 SYRE: System Reset (D16, F0)

This register controls NB reset behavior. Any resets produced by a write to this register must be delayed until the configuration write is completed on the initiating interface (Front Side Bus, PCI Express, HI, SMBus and JTAG).

| <b>Device</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 40h - 41h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15   | RV   | 0       | <b>Reserved</b>   |
| 14   | RW   | 0       | <b>CPURST: Processor Reset</b><br>If set, the NB will assert processor RESET# immediately on both buses.  |
| 13   | RV   | 0       | <b>Reserved</b>   |
| 12   | RW   | 0       | <b>SYSRST: System Hard Reset</b><br>The rising edge on this bit will lead to the assertion of the ICHRST# pin. The timing of this ICHRST# assertion should not be affected by Hard Reset.     |
| 11:10  | RW   | 00h     | <b>REFIMI: Refresh from IMI to Gate ROR</b><br>Designates the PMI to supply the inband REFRESH for ROR-initiated processor reset.<br>00: IMI A<br>01: IMI B<br>10: IMI C<br>11: IMI D         |
| 9  | RW   | 0       | <b>ROR: Processor Reset on Refresh</b><br>If set, the NB will assert processor H_{A/B}_RST# on both buses when a "Refresh Cycle Complete" signal is received on the IMI designated by REFIMI. |
| 8:0  | RV   | 00h     | <b>Reserved</b>   |

### 4.14.9 REDIRECTL: Redirection Control Register (D16, F0)

This register controls the priority algorithm of the XTPR interrupt redirection mechanism.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 50h - 51h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:14   | RV   | 0       | <b>Reserved</b>  |
| 13  | RW   | 0       | <b>FFS:</b><br>0: Use an LRU algorithm to send interrupt to highest XTPR index value when tie.<br>1: Do not use the LRU algorithm in case of ties, instead, the highest XTPR index in the valid pool will always be chosen. This emulates the legacy policy. |
| 12  | RW   | 0       | <b>ARBRST: Arbitration Reset</b><br>Neither BIOS nor the OS should use this bit.<br>1: This bit resets the arbitration LRU state to a known state for repeatability of tests.  |
| 11:8  | RW   | Ch      | <b>BUCKET2: First priority number not in BUCKET0, BUCKET1, or BUCKET2</b><br>Must be programmed with the same or larger value than <b>BUCKET1</b> .<br>Suggested Value: 0h   |
| 7:4   | RW   | 8h      | <b>BUCKET1: First priority number not in BUCKET0 or BUCKET1</b><br>Must be programmed with the same or larger value than <b>BUCKET0</b> .<br>Suggested Value: 0h   |
| 3:0   | RW   | 4h      | <b>BUCKET0: First priority number not in BUCKET0</b><br>Suggested Value: 0h  |

### 4.14.10 REDIRDIS: Redirection Disable Register (D16, F0)

This register allows software to force *xtptr\_updates* from the given agent to be ignored. The agent number is specified by the thread index as described in eXternal Task Priority Registers, [Section 4.14.14](#).

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 54h - 57h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:0  | RW   | 00h     | <b>DIS: Disable XTPR_Updates from Agent</b><br>Each bit corresponds to one agent, and each bit has the following usage semantics:<br>0: Allow XTPR_Updates from this agent.<br>1: Ignore XTPR_Updates from this agent. |

#### 4.14.11 REDIRBUCKETS: Redirection Bucket Number Register (D16, F0)

This register allows software to read the current hardware bucket number assigned to each XTPR register.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 58h - 5Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:30   | RO   | 00      | <b>BUCKET15:</b> Redirection bucket number for XTPR[15] |
| 29:28   | RO   | 00      | <b>BUCKET14:</b> Redirection bucket number for XTPR[14] |
| 27:26   | RO   | 00      | <b>BUCKET13:</b> Redirection bucket number for XTPR[13] |
| 25:24   | RO   | 00      | <b>BUCKET12:</b> Redirection bucket number for XTPR[12] |
| 23:22   | RO   | 00      | <b>BUCKET11:</b> Redirection bucket number for XTPR[11] |
| 21:20   | RO   | 00      | <b>BUCKET10:</b> Redirection bucket number for XTPR[10] |
| 19:18   | RO   | 00      | <b>BUCKET9:</b> Redirection bucket number for XTPR[9]   |
| 17:16   | RO   | 00      | <b>BUCKET8:</b> Redirection bucket number for XTPR[8]   |
| 15:14   | RO   | 00      | <b>BUCKET7:</b> Redirection bucket number for XTPR[7]   |
| 13:12   | RO   | 00      | <b>BUCKET6:</b> Redirection bucket number for XTPR[6]   |
| 11:10   | RO   | 00      | <b>BUCKET5:</b> Redirection bucket number for XTPR[5]   |
| 9:8   | RO   | 00      | <b>BUCKET4:</b> Redirection bucket number for XTPR[4]   |
| 7:6   | RO   | 00      | <b>BUCKET3:</b> Redirection bucket number for XTPR[3]   |
| 5:4   | RO   | 00      | <b>BUCKET2:</b> Redirection bucket number for XTPR[2]   |
| 3:2   | RO   | 00      | <b>BUCKET1:</b> Redirection bucket number for XTPR[1]   |
| 1:0   | RO   | 00      | <b>BUCKET0:</b> Redirection bucket number for XTPR[0]   |

#### 4.14.12 POC\_FSB{A/B}: Power-on Configuration (D16, F0)

Contrary to its name, this register defines configuration values driven at reset by the NB to the CPU. This register only provides non-default configuration strapping on resets subsequent to the first reset.

The NB drives the contents of this register on A[35:4]# whenever it asserts H\_{A/B}\_RST#. These values are driven during processor RESET# assertion, and for three host clocks past the trailing edge of processor RESET#.

This register is sticky through reset; that is, the contents of the register remain unchanged during and following a Hard Reset. This allows system configuration software to modify the default values and reset the system to pass those values to all host bus devices. The default values shown in the table represent the state of the register following a *power-good* or *power-up* reset.

The POC\_FSB{A/B} bits do not affect the NB operation except for driving A[35:4]#. In order to enable external system logic to override the values driven by the NB, the value sampled on A[7]# can force the NB IOQ depth to 1.



There are other power-on configuration bits in the SYRE register ([Section 4.14.8](#)) and POC\_AUX{A/B} registers ([Section 4.14.13](#)).

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 60h - 63h, 70h - 73h |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:28  | RV   | 0h      | <b>Reserved</b>  |
| 27   | RWST | 0h      | <b>MTDIS: Disable Multi-Threading</b><br>If set, A[31]# is asserted, and the processor will disable Multi-threading.   |
| 26   | RV   | 0       | <b>Reserved</b>  |
| 25   | RWST | 0       | <b>A29: A[29]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 24   | RV   | 0       | <b>Reserved</b>  |
| 23   | RWST | 0       | <b>A27: A[27]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 22   | RWST | 0       | <b>A26: A[26]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 21   | RWST | 0       | <b>A25: A[25]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 20   | RWST | 0       | <b>A24: A[24]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 19   | RV   | 0h      | <b>Reserved</b>  |
| 18   | RWST | 0       | <b>A22: A[22]# Value</b><br>The use of this address bit during reset is reserved by the processor.   |
| 17:12  | RWST | 00h     | <b>CLKRATIO: Processor core to bus clock ratio</b><br>A[21:16]# define the bus-to-core clock ratio for the processor.  |
| 11   | RWST | 1       | <b>BUSPARK: Request Bus Parking Disable</b><br>If set, A[15]# is asserted and the processor may not park on the front side bus.  |
| 10   | RV   | 0       | <b>Reserved</b>  |
| 9  | RWST | 0       | <b>A13: Drive A[13]#</b><br>The use of this address bit during reset is reserved by the processor.   |
| 8  | RWST | 0       | <b>APICID1: APIC Cluster ID [1]</b><br>If set, A[12]# is asserted.   |
| 7  | RWST | 0       | <b>APICID0: APIC Cluster ID [0]</b><br>The NB will always assert A[11]# on FSB B, regardless of the value of APICID0. For FSB A, this bit can control the assertion of A[11]#. The default value of 0 causes A[11]# on FSB A to be deasserted. |
| 6  | RWST | 0       | <b>DISBINIT: Disable BINIT# Observation</b><br>If set, A[10]# will be asserted and All host bus agents will disable BINIT# observation logic.  |

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 60h - 63h, 70h - 73h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 5  | RWST | 0       | <b>DISERR: Disable MCERR# Input</b><br>If set, A[9]# will be asserted and all processors will disable MCERR# observation.   |
| 4  | RWST | 0       | <b>A8: Drive A[8]#</b><br>The use of this address bit during reset is reserved by the processor.  |
| 3  | RWST | 0       | <b>IOQDEP: In-Order Queue Depth 1</b><br>If set, A[7]# will be asserted, and all agents on the host bus will limit their In-Order Queue Depth to 1 (i.e. no pipelining support). The NB must sample the value on A[7]# rather than use this register bit directly so that this feature can be forced by external means. |
| 2:0  | RWST | 0       | <b>A6DT4: Drive A[6:4]#</b><br>The use of these address bits during reset is reserved by the processor. A[6]# is not used for 1M reset vector by the processor.   |

#### 4.14.13 POC\_AUX{A/B}: CPU Tristate Control (D16, F0)

These registers are extensions of the POC registers, unique to each bus. POC\_AUXA controls FSB A, and POC\_AUXB controls FSB B.

The NB drives the contents of these registers on A[39:36]# whenever it asserts H\_{A/B}\_RST#. These values are driven during processor RESET# assertion and for two host clocks past the trailing edge of processor RESET#.

These registers are sticky through reset; that is, the contents of the registers remain unchanged during and following a Hard Reset. This allows system configuration software to modify the default values and reset the system to pass those values to all host bus devices. The default values shown below represent the state of the register following a *power-good* or *power-up* reset.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 64h, 74h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:5  | RV   | 0       | <b>Reserved</b>   |
| 4  | RWST | 0h      | <b>BISTEN: CPU Built In Self Test Enable</b><br>If set, A[3]# is asserted and the processor will perform BIST when reset. |

| Device: 16<br>Function: 0<br>Offset: 64h, 74h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 3:0   | RWST | 0       | <b>CPUKILL: Processor Kill</b><br>Software may set processor kill bits when the corresponding processor is not present so that these bits can be used to reflect the number of working processors connected to the NB.<br><br>When cleared, the associated processor will be allowed to participate in the boot following the next reset.<br><br>When set, the NB will assert the associated front side bus address pin the next time it asserts processor RESET#. A processor is tri-stated when it's address input and it's associated bus request input are asserted during POC according to the following table: |
|   |      |         | Bit[3]: A[39]# is asserted, tristating Agent 3   |
|   |      |         | Bit[2]: A[38]# is asserted, tristating Agent 2   |
|   |      |         | Bit[1]: A[37]# is asserted, tristating Agent 1   |
|   |      |         | Bit[0]: A[36]# is asserted, tristating Agent 0   |

#### 4.14.14 XTPR[15:0]: eXternal Task Priority Registers (D16, F0)

These registers define the re-directable interrupt priority for xAPIC agents connected to the NB.

For convenience and 4-P dual-core, multi thread support, the NB defines a 5-bit thread index to uniquely identify every possible thread. This thread index is formed as:

```
thread_index = {fsb_num, DID[6:5], Attr[6:5]}
```

For indexing into the 16 XTPR registers, a carefully chosen function is used:

```
xtpr_index[3] = thread_index[4]
xtpr_index[2] = thread_index[2]
xtpr_index[1] = thread_index[1] XOR thread_index[3]
xtpr_index[0] = thread_index[0] XOR thread_index[1]
```

The NB only has 16 XTPR registers, so to support 16 threads (4 sockets of 2 cores of 2 threads each), the NB allows software to choose which threads will be disabled and ignored. This allows support for 4 sockets of single cores or 4 sockets of dual cores without needing any software reprogramming, and allows 4 sockets of dual cores to operate if the appropriate bits in the REDIRDIS[31:0] register are set.

These registers are used for lowest priority delivery through interrupt redirection by the chipset.

#### 4.14.14.1 XTPR0: External Task Priority 0 (D16, F0)

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> 80h - 83h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31  | RW   | 0       | <b>CLUSTER: Global Cluster Mode (XTPR[0] only)</b><br>Used in interrupt redirection for lowest priority delivery. Updated by every xTPR_Update transaction on either bus (Aa[3]).<br>0: Flat<br>1: Cluster |
| 30:24   | RV   | 00h     | <b>Reserved.</b>   |
| 23  | RW   | 0       | <b>TPREN: TPR Enable</b><br>This bit reflects the value of Ab[31]#. When Ab[31]# is asserted, the value of this bit will be 0h.  |
| 22:20   | RV   | 0h      | <b>Reserved</b>  |
| 19:16   | RW   | 0h      | <b>PRIORITY: Task Priority</b><br>The processor with the lowest enabled value will be assigned the re-directable interrupt. This field is updated with Ab[27:24] of the xTPR_Update transaction.           |
| 15:8  | RW   | 0       | <b>PHYSID: Physical APIC ID</b><br>The physical ID of the APIC agent associated with the XTPR entry.   |
| 7:0   | RW   | 0       | <b>LOGID: Logical APIC ID</b><br>The logical ID of the APIC agent associated with the XTPR entry. This field is updated with Aa[11:4] of the XTPR_Update transaction.                                      |

#### 4.14.14.2 XTPR[15:1]: External Task Priority 1-15 (D16, F0)

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> (88h - 8Bh), (90h - 93h), (98h - 9Bh), (A0h - A3h), (A8h - ABh), (B0h - B3h), (B8h - BBh) |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:24   | RV   | 00h     | <b>Reserved</b>  |
| 23  | RW   | 0       | <b>TPREN: TPR Enable</b><br>This bit reflects the value of Ab[31]#. When Ab[31]# is asserted, the value of this bit will be 0h.  |
| 22:20   | RV   | 0h      | <b>Reserved</b>  |
| 19:16   | RW   | 0h      | <b>PRIORITY: Task Priority</b><br>The processor with the lowest enabled value will be assigned the re-directable interrupt. This field is updated with Ab[27:24] of the XTPR_Update transaction. |
| 15:8  | RW   | 00h     | <b>PHYSID: Physical APIC ID</b><br>The physical ID of the APIC agent associated with the XTPR entry.   |
| 7:0   | RW   | 00h     | <b>LOGID: Logical APIC ID</b><br>The logical ID of the APIC agent associated with the XTPR entry. This field is updated with Aa[11:4] of the xTPR_Update transaction.                            |

### 4.14.15 BOFL[3:0]: Boot Flag (D16, F0)

These registers can be used to select the system boot strap processor or for other cross processor communication purposes. When this register is read, the contents of the register is cleared. Therefore, a processor that reads a non-zero value owns the semaphore. Any value can be written to this register at any time.

An example of usage would be for all processors to read the register. The first one gets a non-zero value and owns the semaphore. Since the read clears the value of the register, all other processors will see a zero value and will spin until they receive further notification. After the winning processor is done, it writes a non-zero value of its choice into the register, arming it for subsequent uses. These registers are also aliased to fixed memory addresses.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> (C0h - C3h), (C4h - C7h), (C8h - CBh), (CCh - CFh) |      |           |  |
|--|------|-----------|--|
| Bit  | Attr | Default   | Description  |
| 31:0   | RCW  | A5A5A5A5h | <b>SemaVal: Semaphore Value</b><br>Can be written to any value. Value is cleared when there is a read. |

### 4.14.16 SPAD[3:0]: Scratch Pad (D16, F0)

These scratch pad registers each provide 32 read/writable bits that can be used by software. They are also aliased to fixed memory addresses.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> (D0h - D3h), (D4h - D7h), (D8h - DBh), (DCh - DFh) |      |           |  |
|--|------|-----------|--|
| Bit  | Attr | Default   | Description  |
| 31:0   | RW   | 00000000h | <b>Scratch Pad Value</b><br>These bits have no effect on the hardware. |

### 4.14.17 SPADS[3:0]: Sticky Scratch Pad (D16, F0)

These sticky scratch pad registers each provide 32 read/writable bits that can be used by software. They are also aliased to fixed memory addresses.

| <b>Device:</b> 16<br><b>Function:</b> 0<br><b>Offset:</b> (E0h - E3h), (E4h - E7h), (E8h - EBh), (ECh - EFh) |      |           |   |
|--|------|-----------|---|
| Bit  | Attr | Default   | Description   |
| 31:0   | RWST | 00000000h | <b>Scratch Pad Value</b><br>These sticky bits have no effect on the hardware. |

## 4.15 Address Mapping (Device 16, Function 1)

The address mapping registers control transaction routing to the Independent Memory Interface types based on address. The Address Mapping registers are in Device 16 (D0), function 1 (F1). For the register address map, please refer to [Table 4-15](#).

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.15.1 VID: Vendor Identification Register (D16, F1)

This register identifies Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 00 - 01h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.15.2 DID: Device Identification Register (D16, F1)

This register combined with the Vendor Identification register uniquely identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 02 - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2611h   | <b>Device Identification Number</b><br>Identifies each function of the <b>NB</b> . |

### 4.15.3 RID: Revision Identification Register (D16, F1)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

### 4.15.4 CCR: Class Code Register (D16, F1)

This register contains the Class Code for the device.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 09 - 0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the <b>NB</b> , this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For this Device the default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.15.5 HDR: Header Type Register (D16, F1)

This register identifies the header layout of the configuration space.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 0Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 1h      | <b>Mfd: Multi-function Device</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts. Therefore, the IMI is defined to be a single function device, and this bit is hardwired to '0'.                  |
| 6:0  | RO   | 0h      | <b>CfgLayout: Configuration Layout</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this Device the default is 00h, indicating a conventional type 00h PCI header. |

### 4.15.6 SVID: Subsystem Vendor Identification Register (D16, F1)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identify any PCI device.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 2C - 2Dh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RWO  | 8086h   | <b>VIN: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to this register will have no effect. |

### 4.15.7 SID: Subsystem Identity (D16, F1)

This register identifies the system.

| <b>Device</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 2E - 2Fh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RWO  | 8086h   | <b>SID: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to this register will have no effect. |



## 4.15.8 PAM[6:0]: Programmable Attribute MAP (D16, F1)

The NB allows programmable memory attributes on 13 legacy memory segments of various sizes in the 640 KB to 1 MB address range. 7 Programmable Attribute Map (PAM) Registers are used to support these features.

Each PAM Register controls one or two regions (typically 16 KB in size).

### 4.15.8.1 PAM0: Programmable Attribute Map 0

This register controls the read, write, and shadowing attributes of the BIOS area from 0F0000h-0FFFFFh.

Two bits are used to specify memory attributes for each memory segment. These bits apply to both host accesses and PCI initiator accesses to the PAM areas. These attributes are:

**RE** - Read Enable. When RE = 1, the processor read accesses to the corresponding memory segment are claimed by the NB and directed to main memory. Conversely, when RE = 0, the host read accesses are directed to HI1.5 (ICH5) to be directed to the PCI bus.

**WE** - Write Enable. When WE = 1, the host write accesses to the corresponding memory segment are claimed by the NB and directed to main memory. Conversely, when WE = 0, the host write accesses are directed to HI1.5 (ICH5) to be directed to the PCI bus.

The RE and WE attributes permit a memory segment to be Read Only, Write Only, Read/Write, or disabled. For example, if a memory segment has RE = 1 and WE = 0, the segment is Read Only.

| Device 16<br>Function: 1<br>Offset: 59h |   |         |  |          |             |    |  |    |   |    |   |    |   |
|---|---|---------|--|----------|-------------|----|--|----|---|----|---|----|---|
| Bit                                     | Attr  | Default | Description  |          |             |    |  |    |   |    |   |    |   |
| 7:6                                     | RV  | 00      | Reserved   |          |             |    |  |    |   |    |   |    |   |
| 5:4                                     | RW  | 00      | <b>HIENABLE0: 0F0000-0FFFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0F0000h to 0FFFFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
| Encoding                                | Description   |         |  |          |             |    |  |    |   |    |   |    |   |
| 00                                      | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |         |  |          |             |    |  |    |   |    |   |    |   |
| 01                                      | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |         |  |          |             |    |  |    |   |    |   |    |   |
| 10                                      | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |         |  |          |             |    |  |    |   |    |   |    |   |
| 11                                      | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.         |         |  |          |             |    |  |    |   |    |   |    |   |
| 3:0                                     | RV  | 00h     | Reserved   |          |             |    |  |    |   |    |   |    |   |

### 4.15.8.2 PAM1: Programmable Attribute Map 1

This register controls the read, write, and shadowing attributes of the BIOS areas from 0C0000h-0C7FFFh.

| Device: 16<br>Function: 1<br>Offset: 5Ah |      |         |   |   |
|--|------|---------|---|---|
| Bit                                      | Attr | Default | Description   |   |
| 7:6                                      | RV   | 00      | Reserved  |   |
| 5:4                                      | RW   | 00      | <b>HIENABLE1: 0C4000-0C7FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0C4000h to 0C7FFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable. |   |
|  |      |         | <b>Encoding</b>   | <b>Description</b>  |
|  |      |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.                          |
|  |      |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |
|  |      |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |
|  |      |         | 11  | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.         |
| 3:2                                      | RV   | 00      | Reserved  |   |
| 1:0                                      | RW   | 00      | <b>LOENABLE1: 0C0000-0C3FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0C0000h to 0C3FFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable. |   |
|  |      |         | <b>Encoding</b>   | <b>Description</b>  |
|  |      |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |
|  |      |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |
|  |      |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |
|  |      |         | 11  | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.         |

### 4.15.8.3 PAM2: Programmable Attribute Map 2

This register controls the read, write, and shadowing attributes of the BIOS areas from 0C8000h-0CFFFFh.

| Device: 16<br>Function: 1<br>Offset: 5Bh |   |         |  |   |             |    |  |    |   |    |   |    |   |
|--|---|---------|--|---|-------------|----|--|----|---|----|---|----|---|
| Bit                                      | Attr  | Default | Description  |   |             |    |  |    |   |    |   |    |   |
| 7:6                                      | RV  | 00      | <b>Reserved</b>  |   |             |    |  |    |   |    |   |    |   |
| 5:4                                      | RW  | 00      | <b>HIENABLE1: 0CC000h- 0CFFFFh Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0CC000h to 0CFFFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable.   |   |             |    |  |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table>  | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding   | Description   |             |    |  |    |   |    |   |    |   |
|  |   |         | 00   | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |   |
|  |   |         | 01   | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |   |
|  |   |         | 10   | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
| 3:2                                      | RV  | 00      | <b>Reserved</b>  |   |             |    |  |    |   |    |   |    |   |
| 1:0                                      | RW  | 00      | <b>LOENABLE1: 0C8000-0CBFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0C8000h to 0CBFFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable.  |   |             |    |  |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b> - All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding   | Description   |             |    |  |    |   |    |   |    |   |
|  |   |         | 00   | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |   |
|  |   |         | 01   | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |   |
|  |   |         | 10   | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |
|  |   |         |  |   |             |    |  |    |   |    |   |    |   |

#### 4.15.8.4 PAM3: Programmable Attribute Map 3

This register controls the read, write, and shadowing attributes of the BIOS areas from 0D0000h-0D7FFFh.

| Device: 16<br>Function: 1<br>Offset: 5Ch |      |         |   |   |
|--|------|---------|---|---|
| Bit                                      | Attr | Default | Description   |   |
| 7:6                                      | RV   | 00      | <b>Reserved</b>   |   |
| 5:4                                      | RW   | 00      | <b>HIENABLE3: 0D4000-0D7FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0D4000h to 0D7FFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable. |   |
|  |      |         | <b>Encoding</b>   | <b>Description</b>  |
|  |      |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |
|  |      |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |
|  |      |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |
|  |      |         | 11  | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.         |
| 3:2                                      | RV   | 00      | <b>Reserved</b>   |   |
| 1:0                                      | RW   | 00      | <b>LOENABLE3: 0D0000-0D3FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0D0000h to 0D3FFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable. |   |
|  |      |         | <b>Encoding</b>   | <b>Description</b>  |
|  |      |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |
|  |      |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |
|  |      |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |
|  |      |         | 11  | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.         |

#### 4.15.8.5 PAM4: Programmable Attribute Map 4

This register controls the read, write, and shadowing attributes of the BIOS areas from 0D8000h-0DFFFFh.

| Device: 16<br>Function: 1<br>Offset: 5Dh |   |         |   |   |             |    |  |    |   |    |   |    |   |
|--|---|---------|---|---|-------------|----|--|----|---|----|---|----|---|
| Bit                                      | Attr  | Default | Description   |   |             |    |  |    |   |    |   |    |   |
| 7:6                                      | RV  | 00      | <b>Reserved</b>   |   |             |    |  |    |   |    |   |    |   |
| 5:4                                      | RW  | 00      | <b>HIENABLE4: 0DC000-0DFFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0DC000h to 0DFFFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable.   |   |             |    |  |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding  | Description   |             |    |  |    |   |    |   |    |   |
|  |   |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |   |
|  |   |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |   |
|  |   |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
| 3:2                                      | RV  | 00      | <b>Reserved</b>   |   |             |    |  |    |   |    |   |    |   |
| 1:0                                      | RW  | 00      | <b>LOENABLE4: 0D8000-0DBFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0D8000h to 0DBFFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable  |   |             |    |  |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding  | Description   |             |    |  |    |   |    |   |    |   |
|  |   |         | 00  | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |   |
|  |   |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |   |
|  |   |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |
|  |   |         |   |   |             |    |  |    |   |    |   |    |   |

#### 4.15.8.6 PAM5: Programmable Attribute Map 5

This register controls the read, write, and shadowing attributes of the BIOS areas from 0E0000h-0E7FFFh.

| Device: 16<br>Function: 1<br>Offset: 5Eh |   |         |   |   |             |    |   |    |   |    |   |    |   |
|--|---|---------|---|---|-------------|----|---|----|---|----|---|----|---|
| Bit                                      | Attr  | Default | Description   |   |             |    |   |    |   |    |   |    |   |
| 7:6                                      | RV  | 00      | <b>Reserved</b>   |   |             |    |   |    |   |    |   |    |   |
| 5:4                                      | RW  | 00      | <b>HIENABLE5: 0E4000-0E7FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0E4000h to 0E7FFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable.   |   |             |    |   |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled-</b> All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled-</b> All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding  | Description   |             |    |   |    |   |    |   |    |   |
|  |   |         | 00  | <b>DRAM Disabled-</b> All accesses are directed to HI1.5.                         |             |    |   |    |   |    |   |    |   |
|  |   |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |   |    |   |    |   |    |   |
|  |   |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |   |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
| 3:2                                      | RV  | 00      | <b>Reserved</b>   |   |             |    |   |    |   |    |   |    |   |
| 1:0                                      | RW  | 00      | <b>LOENABLE5: 0E0000-0E3FFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0E0000h to 0E3FFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable.   |   |             |    |   |    |   |    |   |    |   |
|  |   |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled-</b> All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled-</b> All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |
|  |   |         | Encoding  | Description   |             |    |   |    |   |    |   |    |   |
|  |   |         | 00  | <b>DRAM Disabled-</b> All accesses are directed to HI1.5.                         |             |    |   |    |   |    |   |    |   |
|  |   |         | 01  | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |   |    |   |    |   |    |   |
|  |   |         | 10  | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |   |    |   |    |   |    |   |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM. |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |
|  |   |         |   |   |             |    |   |    |   |    |   |    |   |

### 4.15.8.7 PAM6: Programmable Attribute Map 6

This register controls the read, write, and shadowing attributes of the BIOS areas from 0E8000h-0EFFFFh.

| Device: 16<br>Function: 1<br>Offset: 5Fh |  |         |  |   |             |    |  |    |   |    |   |    |  |
|--|--|---------|--|---|-------------|----|--|----|---|----|---|----|--|
| Bit                                      | Attr   | Default | Description  |   |             |    |  |    |   |    |   |    |  |
| 7:6                                      | RV   | 00      | <b>Reserved</b>  |   |             |    |  |    |   |    |   |    |  |
| 5:4                                      | RW   | 00      | <b>HIENABLE4: 0EC000-0EFFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0EC000h to 0DFFFFh.<br>Bit 5 = Write enable, Bit 4 = Read enable.  |   |             |    |  |    |   |    |   |    |  |
|  |  |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.b</td></tr></table> | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.b |
|  |  |         | Encoding   | Description   |             |    |  |    |   |    |   |    |  |
|  |  |         | 00   | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |  |
|  |  |         | 01   | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |  |
|  |  |         | 10   | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |  |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.b |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
| 3:2                                      | RV   | 00      | <b>Reserved</b>  |   |             |    |  |    |   |    |   |    |  |
| 1:0                                      | RW   | 00      | <b>LOENABLE4: 0E8000-0EBFFF Attribute Register</b><br>This field controls the steering of read and write cycles that address the BIOS area from 0E8000h to 0EBFFFh.<br>Bit 1 = Write enable, Bit 0 = Read enable.  |   |             |    |  |    |   |    |   |    |  |
|  |  |         | <table><tr><th>Encoding</th><th>Description</th></tr><tr><td>00</td><td><b>DRAM Disabled</b>- All accesses are directed to HI1.5.</td></tr><tr><td>01</td><td><b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5.</td></tr><tr><td>10</td><td><b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.</td></tr><tr><td>11</td><td><b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.</td></tr></table>  | Encoding  | Description | 00 | <b>DRAM Disabled</b> - All accesses are directed to HI1.5. | 01 | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. | 10 | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5. | 11 | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.  |
|  |  |         | Encoding   | Description   |             |    |  |    |   |    |   |    |  |
|  |  |         | 00   | <b>DRAM Disabled</b> - All accesses are directed to HI1.5.                        |             |    |  |    |   |    |   |    |  |
|  |  |         | 01   | <b>Read Only</b> - All reads are serviced by DRAM. Writes are forwarded to HI1.5. |             |    |  |    |   |    |   |    |  |
|  |  |         | 10   | <b>Write Only</b> - All writes are sent to DRAM. Reads are serviced by HI1.5.     |             |    |  |    |   |    |   |    |  |
| 11                                       | <b>Normal DRAM Operation</b> - All reads and writes are serviced by DRAM.  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |
|  |  |         |  |   |             |    |  |    |   |    |   |    |  |

### 4.15.9 FDHC: Fixed DRAM Hole Control (D16, F1)

This 8-bit register controls a fixed DRAM hole from 15-16 MB.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 60h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RW   | 0       | <b>HEN: Hole Enable</b><br>This field enables a memory hole in DRAM space. The DRAM that lies "behind" this space is not remapped.<br><br>0: No memory hole.<br><br>1: Memory hole from 15 MB to 16 MB. Accesses in this range will be sent to H11.5. |
| 6:0   | RV   | 00h     | <b>Reserved</b>   |

### 4.15.10 SMRAMC: System Management RAM Control (D16, F1)

The SMRAMC register controls the accessibility to Compatible and Extended SMRAM spaces. The Open, Close, and Lock bits function only when G\_SMROME bit in EXSMRC Register (Section 4.15.11) is set to a "1". Also, the OPEN bit must be reset before the LOCK bit is set.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 61h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 7   | RV   | 0       | <b>Reserved</b>  |
| 6   | RWL  | 0       | <b>D_OPEN: SMM Space Open</b><br>When D_OPEN=1 and D_LCK=0, the SMM space DRAM is made visible even when SMM decode is not active. This is intended to help BIOS initialize SMM space. Software should ensure that D_OPEN=1 and D_CLS=1 are not set at the same time. This register can be locked by D_LCK.  |
| 5   | RW   | 0       | <b>D_CLS: SMM Space Closed</b><br>When D_CLS = 1, SMM space DRAM is not accessible to data references (even if SMM decode is active). Code references may still access SMM space DRAM. This will allow SMM software to reference through SMM space to update the display (even when SMM is mapped over the VGA range). Software should ensure that D_OPEN=1 and D_CLS=1 are not set at the same time. Note that the D_CLS bit only applies to Compatible SMM space.  |
| 4   | RWL  | 0       | <b>D_LCK: SMM Space Locked</b><br>When D_LCK is set to 1, then D_OPEN is reset to 0 and D_LCK, D_OPEN, C_BASE_SEG, H_SMRAM_EN, TSEG_SZ and TSEG_EN become read only. D_LCK can be set to 1 via a normal configuration space write but can only be cleared by a Full Reset. The combination of D_LCK and D_OPEN provide convenience with security. The BIOS can use the D_OPEN function to initialize SMM space and then use D_LCK to "lock down" SMM space in the future so that no application software (or BIOS itself) can violate the integrity of SMM space (even if the program has knowledge of the D_OPEN function). |
| 3   | RV   | 0       | <b>Reserved</b>  |



| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 61h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 2:0   | RO   | 010b    | <b>C_BASE_SEG: Compatible SMM Space Base Segment</b><br>This field indicates the location of SMM space. SMM DRAM is not re-mapped. It is simply made visible if the conditions are right to access SMM space. Otherwise, the access is forwarded to H11.5/VGA. Since the NB supports only the SMM space between A0000 and BFFFF, this field is hardwired to 010. |

#### 4.15.11 EXSMRC: Extended System Management RAM Control (D16, F1)

The Extended SMRAM register controls the configuration of Extended SMRAM space. The Extended SMRAM (E\_SMRAM) memory provides a write-back cacheable SMRAM memory space that is above 1 MByte.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 62h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWL  | 0       | <b>H_SMFRAME: Enable High SMRAM</b><br>Controls the SMM memory space location (i.e. above 1 MByte or below 1 MByte). When G_SMFRAME is 1 and H_SMFRAME is set to 1, the high SMRAM memory space is enabled. SMRAM accesses within the range 0FEDA_0000h to 0FEDB_FFFFh are re-mapped to DRAM addresses within the range 000A0000h to 000BFFFFh. Once D_LCK has been set, this bit becomes read-only.  |
| 6   | RO   | 0       | <b>MDAP: MDA Present</b><br>Since the NB does not support MDA, this bit has no meaning.   |
| 5   | RW   | 0       | <b>APICDIS:APIC Memory Range Disable</b><br>When set to '1', the NB forwards accesses to the IOAPIC regions to the appropriate interface, as specified by the memory and PCI configuration registers.<br><br><b>When this bit is clear, the NB will send accesses as defined below:</b><br>between 0_FEC0_0000 and 0_FEC7_FFFF to H11.5,<br>between 0_FEC8_0000 and 0_FEC8_0FFF to PCI Express D,<br>between 0_FEC8_1000 and 0_FEC8_1FFF to PCI Express C0,<br>between 0_FEC8_2000 and 0_FEC8_2FFF to PCI Express C1,<br>between 0_FEC8_3000 and 0_FEC8_3FFF to PCI Express B0,<br>between 0_FEC8_4000 and 0_FEC8_4FFF to PCI Express B1,<br>between 0_FEC8_5000 and 0_FEC8_5FFF to PCI Express A0,<br>between 0_FEC8_6000 and 0_FEC8_6FFF to PCI Express A1. |

| <b>Device: 16</b><br><b>Function: 1</b><br><b>Offset: 62h</b> |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 4   | RV   | 0       | <b>Reserved</b>  |
| 3   | RWL  | 0       | <b>G_SMFRAME: Global SMRAM Enable</b><br>If set to a 1, then Compatible SMRAM functions are enabled (providing 128 KB of DRAM accessible at the A0000h address while in SMM (ADS# with SMM decode)). To enable Extended SMRAM function, this bit has be set to 1. Refer to the section on SMM for more details. Once D_LCK is set, this bit becomes "Read" only. (Moved from SMRAM bit3).  |
| 2:1   | RWL  | 00      | <b>TSEG_SZ: TSEG Size</b><br>Selects the size of the TSEG memory block if enabled. Memory from (ESMMTOP - TSEG_SZ) to ESMMTOP is partitioned away so that it may only be accessed by the processor interface and only then when the SMM bit (SMMEM#) is set in the request packet. Non-SMM accesses to this memory region are sent to HI1.5 when the TSEG memory block is enabled. Note that once D_LCK is set, these bits become read only.<br>The encodings for TSEG_SZ are:<br>00: 512K<br>01: 1M<br>10: 2M<br>11: 4M |
| 0   | RWL  | 0       | <b>T_EN: TSEG Enable</b><br>Enabling of SMRAM memory for Extended SMRAM space only. When G_SMFRAME =1 and TSEG_EN = 1, the TSEG is enabled to appear in the appropriate physical address space. Note that once D_LCK is set, this bit becomes "Read" only.   |

#### 4.15.12 EXSMRTOP: Extended System Management RAM Top (D16, F1)

This register defines the location of the Extended (TSEG) SMM range by defining the top of the TSEG SMM range (ESMMTOP).

| <b>Device: 16</b><br><b>Function: 1</b><br><b>Offset: 63h</b> |      |         |                 |
|---|------|---------|-----------------|
| Bit   | Attr | Default | Description     |
| 7:4   | RV   | 00h     | <b>Reserved</b> |

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 63h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 3:0   | RW   | 01h     | <b>ESMMTOP: Top of Extended SMM Space (TSEG)</b><br>This field contains address bits 31 to 28. This field points to the top of extended SMM space below 4 GB. Addresses below 4 GB that fall in this range are decoded to be in the extended SMM space and should be routed according to SMM address routing rules:<br>ESMMTOP-TSEG_SZ <= Address < ESMMTOP<br>ESMMTOP is relocatable to accommodate software that wishes to configure the TSEG SMM space before MMIO space is known. This field defaults to the same value that TOLM defaults to. |

#### 4.15.13 EXP\_ECBASE: PCI Express Enhanced Configuration Base Address (D16, F1)

This register defines the base address of the enhanced PCI Express configuration memory.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 68 - 6Bh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:24  | RV   | 00h     | <b>Reserved</b>   |
| 23:12  | RW   | 0001h   | <b>EXP_ECBASE: PCI Express Enhanced Configuration Base</b><br>This register contains the address that corresponds to bits 39 to 28 of the base address for PCI Express enhanced configuration space. Configuration software will read this register to determine where the 256 MB range of addresses resides for this particular host bridge. This register defaults to the same address as the default value for TOLM. |
| 11:0   | RV   | 00h     | <b>Reserved</b>   |

#### 4.15.14 TOLM: Top Of Low Memory (D16, F1)

This register contains the maximum address below 4 GB that should be treated as a memory access and is defined on a 256MB boundary.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> 6Ch - 6Dh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:12   | RW   | 01h     | <b>TOLM: Top of Low Memory</b><br>This register contains the address that corresponds to bits 31 to 28 of the maximum DRAM memory address that lies below 4 GB. Configuration software should set this value to either the maximum amount of memory in the system or to the minimum address allocated for PCI memory (low MMIO), whichever is smaller.<br><br>Addresses equal to or greater than the TOLM, and less than 4 G, are decoded as low MMIO, MMCFG, Chipset, Interrupt/SMM, or firmware (HI1.5) as described in the address mapping chapter ( <a href="#">Section 5</a> ). All accesses less than the TOLM are treated as DRAM accesses (except for the 15-16 MB or PAM gaps).<br><br>This register must be set to at least 1000h, for a minimum of 256 MB of DRAM. There is also a minimum of 256 MB of PCI space, since this register is on a 256 MB boundary.<br><br>Configuration software should set this value to either the maximum amount of memory in the system (same as the top IMIR.LIMIT), or to the lower 256 MB boundary of the Memory Mapped I/O range, whichever is smaller. The Memory Mapped I/O range may not get fully configured by software and the NB will send unmapped accesses to ICH5 via subtractive decoding. |
| 11:0  | RV   | 000h    | <b>Reserved</b>   |

#### 4.15.15 IMIR[5:0]: IMI Interleave Range, (D16, F1)

These registers define the IMI that services each address in the main memory space.

Each register defines a range. If the address falls in the range defined by an IMIR, the ways fields in that IMIR define which IMI services accesses with  $A[7:6] = A, B, C, D$ .

There are 2 sets of ways fields to support mirroring. The first set, Image0, defines the default primary (The default primary is the primary image at reset. After reset, the primary depends on error detection). If IMG1WAYi is set to the same value as IMG0WAY0, no mirroring occurs. If they are set to different values, writes are sent to both IMIs and reads are sent to the primary.

To bound validation of this capability and eliminate multiple equivalent configurations, any given configuration must obey one of the following 3 sets of rules for all 4 ways ( $i = A, B, C, D$ ).

- Scenario 1: **No Mirroring:**  
IMG0WAY[i] = IMG1WAY[i]
- Scenario 2: **Mirroring across card:**  
If IMG0WAY[i] = IMI A, IMG1WAY[i] must be IMI C  
If IMG0WAY [i] = IMI B, IMG1WAY[i] must be IMI D
- Scenario 3: **Mirroring across XMBs on a card:**  
If IMG0WAY[i] = IMI A, IMG1 WAY[i] must be IMI B  
If IMG0WAY [i] = IMI C, IMG1 WAY[i] must be IMI D

When the TOLM register is modified, the NB automatically adjusts the IMI interleaving registers to compensate for the new MMIO gap size. This is done by adjusting the limit of each range upward if it is above TOLM as shown in [Table 4-23](#).

**Table 4-23. Governing of Interleaving of an Address by IMIR[i]**

| Limit above TOLM <sup>a</sup>     | Match IMIR[i] if   |
|-----------------------------------|--|
| IMIR[i].LIMIT[3:0] <= TOLM[15:12] | IMIR[i].LIMIT[12:0] > A[27:12] >= IMIR[i-1].LIMIT[12:0]                        |
| IMIR[i].LIMIT[3:0] > TOLM[15:12]  | AIMIR[i].ADJLIMIT[12:0] > A[27:12] >= AIMIR[i-1].ADJLIMIT[12:0] <sup>b</sup> . |

**NOTES:**

- a. IMIR[i].LIMIT must be greater than or equal to IMIR[i-1].LIMIT  
b. for IMIR[0], IMIR[i-1] is defined to be 0

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> (80h - 83h), (84h - 87h), (88H - 8Bh), (8Ch, 8Fh), (90h, 93h), (94 h - 97h) |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:29   | RV   | 0       | <b>Reserved</b>   |
| 28  | RW   | 0       | <b>RFBI: Read from both Images</b><br><br>0: Reads are issued to Image0 when mirroring. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image.<br><br>1: Reads are issued to Image1 if A[22] XOR A[12] XOR A[8] when mirroring. Otherwise, the read is issued to Image0. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image. |
| 27:16   | RW   | 000h    | <b>LIMIT</b><br>This field defines the highest address in the range. This field is compared to A[39:28]. To disable range i, set IMIR[i].LIMIT == IMIR[i-1].LIMIT.  |
| 15:14   | RW   | 00      | <b>IMG1WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3 and which mirrors the IMI defined by IMG0WAY3.   |
| 13:12   | RW   | 00      | <b>IMG0WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3.   |

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> (80h - 83h), (84h - 87h), (88h - 8Bh), (8Ch, 8Fh), (90h, 93h), (94 h - 97h) |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 11:10   | RW   | 00      | <b>IMG1WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2 and which mirrors the IMI defined by IMG0WAY2. |
| 9:8   | RW   | 00      | <b>IMG0WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2.   |
| 7:6   | RW   | 00      | <b>IMG1WAY1</b><br>This field defines the IMI which services accesses for which A[7:6]=1 and which mirrors the IMI defined by IMG0WAY1. |
| 5:4   | RW   | 00      | <b>IMG0WAY1</b><br>This field defines the IMI which services accesses for which A[7:6]=1.   |
| 3:2   | RW   | 00      | <b>IMG1WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0 and which mirrors the IMI defined by IMG0WAY0. |
| 1:0   | RW   | 00      | <b>IMG0WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0.   |

#### 4.15.16 AIMIR[6:0]: Address of IMI Range(D16, F1)

For the convenience of software which is trying to determine the physical location to which a front side bus address is sent, 32 scratch bits are associated with each IMIR.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> (A0h - A3h), (A4h - A7h), (A8h - ABh), (ACh - AFh), (B0h - B3h), (B4h - B7h) |      |           |                                      |
|--|------|-----------|--------------------------------------|
| Bit  | Attr | Default   | Description                          |
| 31:0   | RW   | 00000000h | <b>ADJLIMIT:</b> Adjusted IMIR Limit |

### 4.15.17 SB\_A\_IMIR[5:0]: Independent Memory Interface Interleave Range for Front Side Bus A (D16, F1)

This is an additional copy of the IMIR registers duplicated for front side bus A as a micro-architectural convenience. Software must configure SB\_A\_IMIR[i] the same way as IMIR[i] (for i=0 to 5) before any memory accesses are initiated.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> (C0h - C3h), (C4h - C7h), (C8h - CBh), (CCh - CFh), (D0h - D3h), (D4h - D7h) |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 31:29  | RV   | 0       | <b>Reserved</b>   |
| 28   | RW   | 0       | <b>RFBI. Read from both Images</b><br>0: Reads are issued to Image0 when mirroring. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image.<br>1: Reads are issues to Image1, if A[22] OR A[12] OR A[8] are asserted when mirroring. Otherwise, the read is issued to Image0. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image. |
| 27:16  | RW   | 000h    | <b>LIMIT</b><br>This field defines the highest address in the range. This field is compared to A[39:28]. To disable range i, set IMIR[i].LIMIT == IMIR[i-1].LIMIT.  |
| 15:14  | RW   | 00      | <b>IMG1WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3 and which mirrors the IMI defined by IMG0WAY3.   |
| 13:12  | RW   | 00      | <b>IMG0WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3.   |
| 11:10  | RW   | 00      | <b>IMG1WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2 and which mirrors the IMI defined by IMG0WAY2.   |
| 9:8  | RW   | 00      | <b>IMG0WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2.   |
| 7:6  | RW   | 00      | <b>IMG1WAY1</b><br>This field defines the IMI which services accesses for which A[7:6]=1 and which mirrors the IMI defined by IMG0WAY1.   |
| 5:4  | RW   | 00      | <b>IMG0WAY1</b><br>This field Defines the IMI which services accesses for which A[7:6]=1.   |
| 3:2  | RW   | 00      | <b>IMG1WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0 and which mirrors the IMI defined by IMG0WAY0.   |
| 1:0  | RW   | 00      | <b>IMG0WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0.   |

### 4.15.18 SB\_B\_IMIR[5:0]: Independent Memory Interface Interleave Range for Front Side Bus B (D16, F1)

This is an additional copy of the IMIR registers duplicated for front side bus B as a micro-architectural convenience. Software must configure SB\_B\_IMIR[i] the same way as IMIR[i] (for i=0 to 5) before any memory accesses are initiated.

| <b>Device:</b> 16<br><b>Function:</b> 1<br><b>Offset:</b> (E0h - E3h), (E4h - E7h), (E8h - EBh), (ECh - EFh), (F0h - F3h), (F4h - F7h) |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:29  | RV   | 0       | <b>Reserved</b>  |
| 28   | RW   | 0       | <b>RFBI.</b> Read from both Images<br><br>0: Reads are issued to Image0 when mirroring. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image.<br><br>1: Reads are issues to Image1 if A[22] OR A[12] OR A[8] are asserted when mirroring. Otherwise, the read is issued to Image0. Once an error condition occurs that results in degrading to one memory image, reads are directed to the remaining healthy image. |
| 27:16  | RW   | 000h    | <b>LIMIT</b><br>This field defines the highest address in the range. This field is compared to A[39:28]. To disable range i, set IMIR[i].LIMIT == IMIR[i-1].LIMIT.   |
| 15:14  | RW   | 00      | <b>IMG1WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3 and which mirrors the IMI defined by IMG0WAY3.  |
| 13:12  | RW   | 00      | <b>IMG0WAY3</b><br>This field defines the IMI which services accesses for which A[7:6]=3.  |
| 11:10  | RW   | 00      | <b>IMG1WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2 and which mirrors the IMI defined by IMG0WAY2.  |
| 9:8  | RW   | 00      | <b>IMG0WAY2</b><br>This field defines the IMI which services accesses for which A[7:6]=2.  |
| 7:6  | RW   | 00      | <b>IMG1WAY1</b><br>This field defines the IMI which services accesses for which A[7:6]=1 and which mirrors the IMI defined by IMG0WAY1.  |
| 5:4  | RW   | 00      | <b>IMG0WAY1</b><br>This field defines the IMI which services accesses for which A[7:6]=1.  |
| 3:2  | RW   | 00      | <b>IMG1WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0 and which mirrors the IMI defined by IMG0WAY0.  |
| 1:0  | RW   | 00      | <b>IMG0WAY0</b><br>This field defines the IMI which services accesses for which A[7:6]=0.  |



## 4.16 RAS (Device 16, Function 2)

The PCI Express registers are in Device 16 (D16), Function 2 (F2). These registers record the first and next errors, logging, detection masks and signaling mask for the two Front Side Buses and Hub Interface. For the register address map, please refer to [Table 4-16](#).

**Warning:** Address locations that are not listed are considered reserved locations. Writes to “Reserved” registers may cause unpredictable behavior. Reads to “Reserved” registers may return a non-zero value.

### 4.16.1 VID: Vendor Identification Register (D16, F2)

This register identifies Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 00h - 01h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 8086h   | <b>VIN: Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.16.2 DID: Device Identification Register (D16, F2)

This register combined with the Vendor Identification register uniquely identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 02h - 03h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 2612h   | <b>DIN: Device Identification Number</b><br>Identifies each function of the NB. |

### 4.16.3 RID: Revision Identification Register (D16, F2)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br><br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br><br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

### 4.16.4 CCR: Class Code Register (D16, F2)

This register contains the Class Code for the device.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 09 - 0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For this device default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

### 4.16.5 HDR: Header Type Register (D16, F2)

This register identifies the header layout of the configuration space.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 0Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 1       | <b>Mfd: Multi-function Device</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0  | RO   | 00h     | <b>CfgLayout: Configuration Layout</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device default is 00h, indicating a conventional type 00h PCI header. |

### 4.16.6 SVID: Subsystem Vendor Identification Register (D16, F2)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identifies any PCI device.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 2Ch |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:0   | RWO  | 8086h   | <b>VIN: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

### 4.16.7 SID: Subsystem Identity (D16, F2)

This register identifies the system.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:0   | RWO  | 8086h   | <b>SID: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

## 4.16.8 GLOBAL\_FERR: Global First Error Register (D16, F2)

When the “local” FERRST register captures the error, it closes the log register and signals the recorded error to the GLOBAL\_FERR.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 40h - 43h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 31   | RWCST | 0       | <b>Global_FERR_31</b><br>Internal NB Fatal Error               |
| 30   | RV    | 0       | <b>Reserved</b>  |
| 29   | RWCST | 0       | <b>Global_FERR_29</b><br>FSB B Fatal Error                     |
| 28   | RWCST | 0       | <b>Global_FERR_28</b><br>FSB A Fatal Error                     |
| 27   | RWCST | 0       | <b>Global_FERR_27</b><br>IMI D Fatal Error                     |
| 26   | RWCST | 0       | <b>Global_FERR_26</b><br>IMI C Fatal Error                     |
| 25   | RWCST | 0       | <b>Global_FERR_25</b><br>IMI B Fatal Error                     |
| 24   | RWCST | 0       | <b>Global_FERR_24</b><br>IMI A Fatal Error                     |
| 23   | RWCST | 0       | <b>Global_FERR_23</b><br>PCI Express A1(Device 7) Fatal Error  |
| 22   | RWCST | 0       | <b>Global_FERR_22</b><br>PCI Express A0 (Device 6) Fatal Error |
| 21   | RWCST | 0       | <b>Global_FERR_21</b><br>PCI Express B1(Device 5) Fatal Error  |
| 20   | RWCST | 0       | <b>Global_FERR_20</b><br>PCI Express B0 (Device 4) Fatal Error |
| 19   | RWCST | 0       | <b>Global_FERR_19</b><br>PCI Express C1 (Device 3) Fatal Error |
| 18   | RWCST | 0       | <b>Global_FERR_18</b><br>PCI Express C0 (Device 2) Fatal Error |
| 17   | RWCST | 0       | <b>Global_FERR_17</b><br>PCI Express D (Device 1) Fatal Error  |
| 16   | RWCST | 0       | <b>Global_FERR_16</b><br>HI Fatal Error                        |
| 15   | RWCST | 0       | <b>Global_FERR_15</b><br>Internal NB Non-Fatal Error           |
| 14   | RV    | 0       | <b>Reserved</b>  |

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 40h - 43h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 13   | RWCST | 0       | <b>Global_FERR_13</b><br>FSB B Non-Fatal Error                     |
| 12   | RWCST | 0       | <b>Global_FERR_12</b><br>FSB A Non-Fatal Error                     |
| 11   | RWCST | 0       | <b>Global_FERR_11</b><br>IMI D Non-Fatal Error                     |
| 10   | RWCST | 0       | <b>Global_FERR_10</b><br>IMI C Non-Fatal Error                     |
| 9  | RWCST | 0       | <b>Global_FERR_09</b><br>IMI B Non-Fatal Error                     |
| 8  | RWCST | 0       | <b>Global_FERR_08</b><br>IMI A Non-Fatal Error                     |
| 7  | RWCST | 0       | <b>Global_FERR_07</b><br>PCI Express A1(Device 7) Non-Fatal Error  |
| 6  | RWCST | 0       | <b>Global_FERR_06</b><br>PCI Express A0 (Device 6) Non-Fatal Error |
| 5  | RWCST | 0       | <b>Global_FERR_05</b><br>PCI Express B1 (Device 5) Non-Fatal Error |
| 4  | RWCST | 0       | <b>Global_FERR_04</b><br>PCI Express B0 (Device 4) Non-Fatal Error |
| 3  | RWCST | 0       | <b>Global_FERR_03</b><br>PCI Express C1 (Device 3) Non-Fatal Error |
| 2  | RWCST | 0       | <b>Global_FERR_02</b><br>PCI Express C0 (Device 2) Non-Fatal Error |
| 1  | RWCST | 0       | <b>Global_FERR_01</b><br>PCI Express D (Device 1) Non-Fatal Error  |
| 0  | RWCST | 0       | <b>Global_FERR_00</b><br>HI Non-Fatal Error                        |

## 4.16.9 GLOBAL\_NERR: Global Next Error Register (D16, F2)

Once an error has been logged in the GLOBAL\_FERR, subsequent errors are logged in the GLOBAL\_NERR register.

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 44h - 47h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 31   | RWCST | 0       | <b>Global_NERR_31</b><br>Internal NB Fatal Error               |
| 30   | RV    | 0       | <b>Reserved</b>  |
| 29   | RWCST | 0       | <b>Global_NERR_29</b><br>FSB B Fatal Error                     |
| 28   | RWCST | 0       | <b>Global_NERR_28</b><br>FSB A Fatal Error                     |
| 27   | RWCST | 0       | <b>Global_NERR_27</b><br>IMI D Fatal Error                     |
| 26   | RWCST | 0       | <b>Global_NERR_26</b><br>IMI C Fatal Error                     |
| 25   | RWCST | 0       | <b>Global_NERR_25</b><br>IMI B Fatal Error                     |
| 24   | RWCST | 0       | <b>Global_NERR_24</b><br>IMI A Fatal Error                     |
| 23   | RWCST | 0       | <b>Global_NERR_23</b><br>PCI Express A1 (Device 7) Fatal Error |
| 22   | RWCST | 0       | <b>Global_NERR_22</b><br>PCI Express A0 (Device 6) Fatal Error |
| 21   | RWCST | 0       | <b>Global_NERR_21</b><br>PCI Express B1 (Device 5) Fatal Error |
| 20   | RWCST | 0       | <b>Global_NERR_20</b><br>PCI Express B0 (Device 4) Fatal Error |
| 19   | RWCST | 0       | <b>Global_NERR_19</b><br>PCI Express C1 (Device 3) Fatal Error |
| 18   | RWCST | 0       | <b>Global_NERR_18</b><br>PCI Express C0 (Device 2) Fatal Error |
| 17   | RWCST | 0       | <b>Global_NERR_17</b><br>PCI Express D (Device 1) Fatal Error  |
| 16   | RWCST | 0       | <b>Global_NERR_16</b><br>HI Fatal Error                        |
| 15   | RWCST | 0       | <b>Global_NERR_15</b><br>Internal NB Non-Fatal Error           |
| 14   | RV    | 0       | <b>Reserved</b>  |

| <b>Device</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 44h - 47h |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 13   | RWCST | 0       | <b>Global_NERR_13</b><br>FSB B Non-Fatal Error                     |
| 12   | RWCST | 0       | <b>Global_NERR_12</b><br>FSB A Non-Fatal Error                     |
| 11   | RWCST | 0       | <b>Global_NERR_11</b><br>IMI D Non-Fatal Error                     |
| 10   | RWCST | 0       | <b>Global_NERR_10</b><br>IMI C Non-Fatal Error                     |
| 9  | RWCST | 0       | <b>Global_NERR_09</b><br>IMI B Non-Fatal Error                     |
| 8  | RWCST | 0       | <b>Global_NERR_08</b><br>IMI A Non-Fatal Error                     |
| 7  | RWCST | 0       | <b>Global_NERR_07</b><br>PCI Express A1 (Device 7) Non-Fatal Error |
| 6  | RWCST | 0       | <b>Global_NERR_06</b><br>PCI Express A0 (Device 6) Non-Fatal Error |
| 5  | RWCST | 0       | <b>Global_NERR_05</b><br>PCI Express B1 (Device 5) Non-Fatal Error |
| 4  | RWCST | 0       | <b>Global_NERR_04</b><br>PCI Express B0 (Device 4) Non-Fatal Error |
| 3  | RWCST | 0       | <b>Global_NERR_03</b><br>PCI Express C1 (Device 3) Non-Fatal Error |
| 2  | RWCST | 0       | <b>Global_NERR_02</b><br>PCI Express C0 (Device 2) Non-Fatal Error |
| 1  | RWCST | 0       | <b>Global_NERR_01</b><br>PCI Express D (Device1) Non-Fatal Error   |
| 0  | RWCST | 0       | <b>Global_NERR_00</b><br>HI Non-Fatal Error                        |

#### 4.16.10 EXSMRAMC - Expansion System Management RAM Control (D16, F2)

This register indicates whether an invalid SMRAM access has taken place. It is located in a different function than the other SMM related registers because it needs to be written by software.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> 60h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWC  | 0       | <b>E_SMERR: Invalid SMRAM Access</b><br>This bit is set when CPU has accessed the defined memory ranges in Extended SMRAM (High Memory and T-segment) while not in SMM space and with the D-OPEN bit = 0. It is software's responsibility to clear this bit. The software must write a 1 to this bit to clear it. |
| 6:0   | RV   | 0h      | <b>Reserved</b>   |

#### 4.16.11 FSB{A/B}\_FERR: FSB First Error Register(D16, F2)

For a description of the Errors (Fxx) refer to [Table 6-39 “Errors Detected by the NB”](#) on page 328.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (80h - 81h), (A0h - A1h) |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 15:11  | RV    | 0h      | <b>Reserved</b>  |
| 10   | RWCST | 0       | <b>F10Err: FSB hang</b><br>Fatal   |
| 9  | RWCST | 0       | <b>F9Err: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RWCST | 0       | <b>F8Err: Unsupported Front Side Bus Transaction</b><br>Fatal  |
| 7  | RWCST | 0       | <b>F7Err: FSB Protocol Error</b><br>Fatal  |
| 6  | RWCST | 0       | <b>F6Err: Data Strobe Glitch</b><br>Fatal  |
| 5  | RWCST | 0       | <b>F5Err: Address Strobe Glitch</b><br>Fatal   |
| 4  | RWCST | 0       | <b>F4Err: Request/Address Parity Error</b><br>Fatal  |



| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (80h - 81h), (A0h - A1h) |       |         |   |
|--|-------|---------|---|
| Bit  | Attr  | Default | Description   |
| 3  | RWCST | 0       | <b>F3Err: Detected MCERR from a processor</b><br>Nonfatal |
| 2  | RWCST | 0       | <b>F2Err: Detected BINIT from a processor</b><br>Nonfatal |
| 1  | RWCST | 0       | <b>F1Err: Correctable ECC Error</b><br>Nonfatal           |
| 0  | RWCST | 0       | <b>F0Err: Multi-Bit ECC Error</b><br>Nonfatal             |

#### 4.16.12 FSB{A/B}\_NERR: FSB Next Fatal Error Register (D16, F2)

This register logs all FSB subsequent errors after the FERR\_FSB has logged the 1st fatal error.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (82h - 83h), (A2 h- A3h) |       |         |  |
|--|-------|---------|--|
| Bit  | Attr  | Default | Description  |
| 15:11  | RV    | 0       | <b>Reserved</b>  |
| 10   | RWCST | 0       | <b>F10Err:</b> FSB hang  |
| 9  | RWCST | 0       | <b>F9Err: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RWCST | 0       | <b>F8Err:</b> Unsupported Front Side Bus Transaction   |
| 7  | RWCST | 0       | <b>F7Err:</b> FSB Protocol Error   |
| 6  | RWCST | 0       | <b>F6Err:</b> Data Strobe Glitch   |
| 5  | RWCST | 0       | <b>F5Err:</b> Address Strobe Glitch  |
| 4  | RWCST | 0       | <b>F4Err:</b> Request/Address Parity Error   |
| 3  | RWCST | 0       | <b>F3NextErr:</b> Detected MCERR   |
| 2  | RWCST | 0       | <b>F2NextErr:</b> Detected BINIT   |
| 1  | RWCST | 0       | <b>F1NextErr:</b> Correctable ECC Error  |
| 0  | RWCST | 0       | <b>F0NextErr:</b> Multi-Bit ECC Error  |

### 4.16.13 RECFSB{A/B}\_LOG: Recoverable FSB Error Log Register (D16, F2)

The following error log registers captures the syndrome information of the 32 bytes containing the data in which the data error was detected when a non-Fatal error is logged in the FSB\_FERR register.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (84h - 87h), (A4h - A7h) |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:24  | ROST | 0h      | <b>SYNDROME1:</b> Syndrome bits of 3rd clock of data |
| 23:16  | ROST | 0h      | <b>SYNDROME3:</b> Syndrome bits of 4th clock of data |
| 15:8   | ROST | 0h      | <b>SYNDROME0:</b> Syndrome bits of 1st clock of data |
| 7:0  | ROST | 0h      | <b>SYNDROME2:</b> Syndrome bits of 2nd clock of data |

### 4.16.14 NRECFSB{A/B}\_LOG0: Non-recoverable FSB Error Log 0 Register (D16, F2)

FSB Log registers for non-recoverable errors when a fatal error is logged in its corresponding FSB\_FERR Register.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (88h - 8Bh), (A8h - ABh) |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description                                |
| 31:3   | ROST | 0h      | <b>ADDR:</b> ADDRa[31:3] fields of the FSB |
| 2  | ROST | 0h      | <b>ADS:</b> ADS field from the FSB         |
| 1:0  | ROST | 0h      | <b>RCV_PARITY:</b> Address parity received |

#### 4.16.15 NRECFSB{A/B}\_LOG1: Non-recoverable FSB Error Log 1 Register (D16, F2)

FSB Log registers for non-recoverable errors when a fatal error is logged in its corresponding FSB\_FERR Register.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (8Ch - 8Fh), (ACh - AFh) |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 31:15  | ROST | 0h      | <b>ADDRB:</b> ADDRb[19:3] fields of the FSB                      |
| 14   | ROST | 0       | <b>INFO</b>  |
| 13   | ROST | 0h      | <b>DROVE_ADS:</b> Indicates whether the <b>NB</b> drove this ADS |
| 12:8   | ROST | 0h      | <b>REQA:</b> REQa[4:0] fields of the FSB                         |
| 7:0  | ROST | 0h      | <b>ADDR:</b> ADDRa[39:32] fields of the FSB                      |

#### 4.16.16 NRECFSB{A/B}\_LOG2: Non-recoverable FSB Error Log 2 Register (D16, F2)

FSB Log registers for non-recoverable errors when a fatal error is logged in its corresponding FSB\_FERR Register.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (90h - 93h), (B0 - B3h) |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description                                  |
| 31:25   | RV   | 0h      | <i>Reserved</i>                              |
| 24:20   | ROST | 0h      | <b>REQB:</b> REQb[2:0] fields of the FSB     |
| 19:0  | ROST | 0h      | <b>ADDRB:</b> ADDRb[39:20] fields of the FSB |

#### 4.16.17 EMASK\_FSB{A/B}: FSB Error Mask Register (D16, F2)

A '0' in any field enables that error.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (94h - 95h), (B4 - B5h) |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:11   | RV   | 0h      | <b>Reserved</b>   |
| 10  | RW   | 1       | <b>F10Msk:</b> FSB hang   |
| 9   | RW   | 1       | <b>F9Msk: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & )Dual-Core Intel® Xeon® processor 7000 sequence |
| 8   | RW   | 1       | <b>F8Msk:</b> Unsupported Front Side Bus Transaction  |
| 7   | RW   | 1       | <b>F7Msk:</b> FSB Protocol Error  |
| 6   | RW   | 1       | <b>F6Msk:</b> Data Strobe Glitch  |
| 5   | RW   | 1       | <b>F5Msk:</b> Address Strobe Glitch   |
| 4   | RW   | 1       | <b>F4Msk:</b> Request/Address Parity Error  |
| 3   | RW   | 1       | <b>F3Msk:</b> Detected MCERR  |
| 2   | RW   | 1       | <b>F2Msk:</b> Detected BINIT#   |
| 1   | RW   | 1       | <b>F1Msk:</b> Correctable ECC Error   |
| 0   | RW   | 1       | <b>F0Msk:</b> Multi-Bit ECC Error   |

#### 4.16.18 ERR0\_FSB{A/B}: FSB Error 0 Mask Register (D16, F2)

This register enables the signaling of Err[0] when an error flag is set. Note that one and only one error signal should be enabled ERR0\_FSB, ERR1\_FSB, ERR2\_FSB, MCERR\_FSB, and ICHRST# for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (96h - 97h), (B6h - B7h) |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:11  | RV   | 0h      | <b>Reserved</b>   |
| 10   | RWST | 0       | <b>F10Err0:</b> FSB hang  |
| 9  | RWST | 0       | <b>F9Err0: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RWST | 0       | <b>F8Err0:</b> Unsupported Front Side Bus Transaction   |
| 7  | RWST | 0       | <b>F7Err0:</b> FSB Protocol Error   |
| 6  | RWST | 0       | <b>F6Err0:</b> Data Strobe Glitch   |
| 5  | RWST | 0       | <b>F5Err0:</b> Address Strobe Glitch  |
| 4  | RWST | 0       | <b>F4Err0:</b> Request/Address Parity Error   |

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (96h - 97h), (B6h - B7h) |      |         |                                      |
|--|------|---------|--------------------------------------|
| Bit  | Attr | Default | Description                          |
| 3  | RWST | 0       | <b>F3Err0:</b> Detected MCERR        |
| 2  | RWST | 0       | <b>F2Err0:</b> Detected BINIT#       |
| 1  | RWST | 0       | <b>F1Err0:</b> Correctable ECC Error |
| 0  | RWST | 0       | <b>F0Err0:</b> Multi-Bit ECC Error   |

#### 4.16.19 ERR1\_FSB{A/B}: FSB Error 1 Mask Register (D16, F2)

This register enables the signaling of Err[1] when an error flag is set. Note that one and only one error signal should be enabled ERR0\_FSB, ERR1\_FSB, ERR2\_FSB, MCERR\_FSB, and ICHRST# for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (98h - 99h), (B8 - B9) |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:11  | RV   | 0h      | <b>Reserved</b>   |
| 10   | RWST | 0       | <b>F10Err1:</b> FSB hang  |
| 9  | RWST | 0       | <b>F9Err1: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RWST | 0       | <b>F8Err1:</b> Unsupported Front Side Bus Transaction   |
| 7  | RWST | 0       | <b>F7Err1:</b> FSB Protocol Error   |
| 6  | RWST | 0       | <b>F6Err1:</b> Data Strobe Glitch   |
| 5  | RWST | 0       | <b>F5Err1:</b> Address Strobe Glitch  |
| 4  | RWST | 0       | <b>F4Err1:</b> Request/Address Parity Error   |
| 3  | RWST | 0       | <b>F3Err1:</b> Detected MCERR   |
| 2  | RWST | 0       | <b>F2Err1:</b> Detected BINIT#  |
| 1  | RWST | 0       | <b>F1Err1:</b> Correctable ECC Error  |
| 0  | RWST | 0       | <b>F0Err1:</b> Multi-Bit ECC Error  |

#### 4.16.20 ERR2\_FSB{A/B}: FSB Error 2 Mask Register (D16, F2)

This register enables the signaling of Err[2] when an error flag is set. Note that one and only one error signal should be enabled ERR0\_FSB, ERR1\_FSB, ERR2\_FSB, MCERR\_FSB, and ICHRST# for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (9Ah - 9Bh), (BAh - BBh) |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:11  | RV   | 0h      | <b>Reserved</b>   |
| 10   | RWST | 0       | <b>F10Err2:</b> FSB hang  |
| 9  | RWST | 0       | <b>F9Err2: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RWST | 0       | <b>F8Err2:</b> Unsupported Front Side Bus Transaction   |
| 7  | RWST | 0       | <b>F7Err2:</b> FSB Protocol Error   |
| 6  | RWST | 0       | <b>F6Err2:</b> Data Strobe Glitch   |
| 5  | RWST | 0       | <b>F5Err2:</b> Address Strobe Glitch  |
| 4  | RWST | 0       | <b>F4Err2:</b> Request/Address Parity Error   |
| 3  | RWST | 0       | <b>F3Err2:</b> Detected MCERR   |
| 2  | RWST | 0       | <b>F2Err2:</b> Detected BINIT#  |
| 1  | RWST | 0       | <b>F1Err2:</b> Correctable ECC Error  |
| 0  | RWST | 0       | <b>F0Err2:</b> Multi-Bit ECC Error  |

#### 4.16.21 MCERR\_FSB{A/B}: FSB MCERR Mask Register (D16, F2)

This register enables the signaling of MCERR when an error flag is set. Note that one and only one error signal should be enabled ERR0\_FSB, ERR1\_FSB, ERR2, MCERR\_FSB, and ICHRST# for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (9Ch - 9Dh), (BC - BDh) |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:11   | RV   | 0h      | <b>Reserved</b>  |
| 10  | RW   | 0       | <b>F10MCErr:</b> FSB hang  |
| 9   | RW   | 0       | <b>F9MCErr: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8   | RW   | 0       | <b>F8MCErr:</b> Unsupported Front Side Bus Transaction   |
| 7   | RW   | 0       | <b>F7MCErr:</b> FSB Protocol Error   |
| 6   | RW   | 0       | <b>F6MCErr:</b> Data Strobe Glitch   |
| 5   | RW   | 0       | <b>F5MCErr:</b> Address Strobe Glitch  |

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> (9Ch - 9Dh), (BC - BDh) |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 4   | RW   | 0       | <b>F4MCErr:</b> Request/Address Parity Error   |
| 3   | RW   | 0       | <b>F3MCErr:</b> Detected MCERR   |
| 2   | RW   | 0       | <b>F2MCErr:</b> Detected BINIT#  |
| 1   | RW   | 0       | <b>F1MCErr:</b> Correctable ECC Error  |
| 0   | RW   | 0       | <b>F0MCErr: Multi-Bit ECC Error.</b> Set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence . |

#### 4.16.22 ICHRST\_FSB{A/B}: FSB ICHRST Mask Register (D16, F2)

This register enables the signaling of ICHRST# when an error flag is set. Note that one and only one error signal should be enabled ERR0\_FSB, ERR1\_FSB, ERR2, MCERR\_FSB, and ICHRST# for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> BEh, 9Eh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:11  | RV   | 0h      | <b>Reserved</b>  |
| 10   | RW   | 0       | <b>F10Rst:</b> FSB hang  |
| 9  | RW   | 0       | <b>F9Rst: Data Parity Error</b> (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) |
| 8  | RW   | 0       | <b>F8Rst:</b> Unsupported Front Side Bus Transaction   |
| 7  | RW   | 0       | <b>F7Rst:</b> FSB Protocol Error   |
| 6  | RW   | 0       | <b>F6Rst:</b> Data Strobe Glitch   |
| 5  | RW   | 0       | <b>F5Rst:</b> Address Strobe Glitch  |
| 4  | RW   | 0       | <b>F4Rst:</b> Request/Address Parity Error   |
| 3  | RW   | 0       | <b>F3Rst:</b> Detected MCERR   |
| 2  | RW   | 0       | <b>F2Rst:</b> Detected BINIT#  |
| 1  | RW   | 0       | <b>F1Rst:</b> Correctable ECC Error  |
| 0  | RW   | 0       | <b>F0Rst:</b> Multi-Bit ECC Error  |

### 4.16.23 INT\_FERR: Internal First Fatal Error Register (D16, F2)

INT\_FERR latches the first NB internal error, whether fatal or non-fatal. All subsequent errors get logged in the INT\_NERR.

| <b>Device: 16</b><br><b>Function: 2</b><br><b>Offset: C1h</b> |       |         |   |
|---|-------|---------|---|
| Bit   | Attr  | Default | Description   |
| 7   | RWCST | 0       | <b>T2Err: Uncorrectable Memory Error</b><br>Non-fatal Error<br>Signaled by the NB after a request returns uncorrectable data at least 2 times from an IMI. This error is signaled only after any reconstruction efforts made by RAID or Mirroring logic (if enabled) have also attempted to reconstruct the data. Since poison is maintained, this error is considered non-fatal. |
| 6   | RWCST | 0       | <b>T4Err: Coherency Violation Error</b><br>Fatal  |
| 5   | RWCST | 0       | <b>T3Err: Multi-Tag Hit from CDC</b><br>Fatal. Not detected.  |
| 4   | RWCST | 0       | <b>T8Err: Poison leaving a poison domain</b><br>Fatal<br>An uncorrectable error marked as poison is leaving an error detection domain and no longer has an indication that the data is incorrect.   |
| 3   | RWCST | 0       | <b>T7Err: UnCorrectable Data Error during a Re-silvering Process</b><br>Non-fatal   |
| 2   | RWCST | 0       | <b>T6Err: Poison being passed on to another poison capable domain</b><br>Non-fatal  |
| 1   | RWCST | 0       | <b>T5Err: Address Map Error</b><br>Non-fatal  |
| 0   | RWCST | 0       | <b>T1Err: Correctable ECC Error</b><br>Non-fatal  |



#### 4.16.24 INT\_NERR: Internal Next Fatal Error Register (D16, F2)

For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on [page 328](#).

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> C3h |       |         |   |
|---|-------|---------|---|
| Bit   | Attr  | Default | Description   |
| 7   | RWCST | 0       | <b>T2Err: Uncorrectable Memory Error</b>  |
| 6   | RWCST | 0       | <b>T4NextErr: Coherency Violation Error</b><br>Fatal                                  |
| 5   | RWCST | 0       | <b>T3NextErr: Multi-Tag Hit from CDC</b><br>Fatal. Not detected.                      |
| 4   | RWCST | 0       | <b>T8NextErr: Poison leaving a poison domain</b>                                      |
| 3   | RWCST | 0       | <b>T7NextErr: UnCorrectable Data Error during a Re-silvering Process</b><br>Non-fatal |
| 2   | RWCST | 0       | <b>T6Err: Poison being passed on to another poison capable domain</b><br>Non-fatal    |
| 1   | RWCST | 0       | <b>T5NextErr: Address Map Error</b><br>Non-fatal                                      |
| 0   | RWCST | 0       | <b>T1NextErr: Correctable ECC Error</b><br>Non-fatal                                  |

#### 4.16.25 NRECNCB: Non-recoverable NB Error Log Register (D16, F2)

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> C4h - C7h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description                                      |
| 31:7  | RV   | 0000h   | <b>Reserved</b>                                  |
| 6:0   | ROST | 0h      | <b>FailedCdcId:</b> CDC Entry of Failed Location |

#### 4.16.26 RECNB: Recoverable NB Data Log Register (D16, F2)

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> C8h - CBh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description                                      |
| 31:7  | RV   | 0h      | <b>Reserved</b>                                  |
| 6:0   | ROST | 0h      | <b>FailedCdcld:</b> CDC Entry of Failed Location |

#### 4.16.27 EMASK\_INT: Internal Error Mask Register (D16, F2)

For details on errors listed on this table, refer to the [Table 6-39 “Errors Detected by the NB”](#) on [page 328](#). A ‘0’ in any field enables that error.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> CCh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 7   | RW   | 1       | <b>T2Msk: Uncorrectable Memory Error</b><br>Signaled by the NB after a request returns uncorrectable data at least 2 times from an IMI. This error is signaled only after any reconstruction efforts made by RAID or Mirroring logic (if enabled) have also attempted to reconstruct the data. Since poison is maintained, this error is considered non-fatal. |
| 6   | RW   | 1       | <b>T4Msk: Coherency Violation Error</b>  |
| 5   | RV   | 0       | <b>Reserved</b>  |
| 4   | RW   | 1       | <b>T8Msk: Poison leaving a poison domain</b><br>Must be set if ECC disabled. Set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence .   |
| 3   | RW   | 1       | <b>T7Msk: UnCorrectable Data Error during a Re-silvering Process</b>   |
| 2   | RW   | 1       | <b>T6Msk: Poison being passed on to another poison capable domain</b><br>Must be set if ECC disabled. Set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence .  |
| 1   | RW   | 1       | <b>T5Msk: Address Map Error</b>  |
| 0   | RW   | 1       | <b>T1Msk: Correctable ECC Error</b><br>Must be set if ECC disabled. Set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence .  |

#### 4.16.28 ERR0\_INT: Internal Error 0 Mask Register (D16, F2)

This register enables the signaling of Err[0] when an error flag is set. Note that one and only one error signal should be enabled. Note that one and only one error signal should be enabled in the ERR0\_INT, ERR1\_INT, ERR2\_INT, and MCERR\_INT for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> D0h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWST | 0       | <b>T2Err0:</b> Uncorrectable Memory Error                             |
| 6   | RWST | 0       | <b>T4Err0:</b> Coherency Violation Error                              |
| 5   | RV   | 0       | <b>Reserved</b>   |
| 4   | RWST | 0       | <b>T8Err0:</b> Poison leaving a poison domain                         |
| 3   | RWST | 0       | <b>T7Err0:</b> UnCorrectable Data Error during a Re-silvering Process |
| 2   | RWST | 0       | <b>T6Err:</b> Poison being passed on to another poison capable domain |
| 1   | RWST | 0       | <b>T5Err0:</b> Address Map Error                                      |
| 0   | RWST | 0       | <b>T1Err0:</b> Correctable ECC Error                                  |

#### 4.16.29 ERR1\_INT: Internal Error 1 Mask Register (D16, F2)

This register enables the signaling of Err[1] when an error flag is set. Note that one and only one error signal should be enabled. Note that one and only one error signal should be enabled in the ERR0\_INT, ERR1\_INT, ERR2\_INT, and MCERR\_INT for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> D1h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWST | 0       | <b>T2Err1:</b> Uncorrectable Memory Error                             |
| 6   | RWST | 0       | <b>T4Err1:</b> Coherency Violation Error                              |
| 5   | RWST | 0       | <b>T3Err1:</b> Multi-Tag Hit from CDC                                 |
| 4   | RWST | 0       | <b>T8Err1:</b> Poison leaving a poison domain                         |
| 3   | RWST | 0       | <b>T7Err1:</b> UnCorrectable Data Error during a Re-silvering Process |
| 2   | RWST | 0       | <b>T6Err:</b> Poison being passed on to another poison capable domain |
| 1   | RWST | 0       | <b>T5Err1:</b> Address Map Error                                      |
| 0   | RWST | 0       | <b>T1Err1:</b> Correctable ECC Error                                  |

### 4.16.30 ERR2\_INT: Internal Error 2 Mask Register (D16, F2)

This register enables the signaling of Err[2] when an error flag is set. Note that one and only one error signal should be enabled. Note that one and only one error signal should be enabled in the ERR0\_INT, ERR1\_INT, ERR2\_INT, and MCERR\_INT for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> D2h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWST | 0       | <b>T2Err2:</b> Uncorrectable Memory Error                             |
| 6   | RWST | 0       | <b>T4Err2:</b> Coherency Violation Error                              |
| 5   | RWST | 0       | <b>T3Err2:</b> Multi-Tag Hit from CDC                                 |
| 4   | RWST | 0       | <b>T8Err2:</b> Poison leaving a poison domain                         |
| 3   | RWST | 0       | <b>T7Err2:</b> UnCorrectable Data Error during a Re-silvering Process |
| 2   | RWST | 0       | <b>T6Err:</b> Poison being passed on to another poison capable domain |
| 1   | RWST | 0       | <b>T5Err2:</b> Address Map Error                                      |
| 0   | RWST | 0       | <b>T1Err2:</b> Correctable ECC Error                                  |

### 4.16.31 MCERR\_INT: Internal MCERR Mask Register (D16, F2)

This register enables the signaling of MCERR when an error flag is set. Note that one and only one error signal should be enabled. Note that one and only one error signal should be enabled in the ERR0\_INT, ERR1\_INT, ERR2\_INT, and MCERR\_INT for each of the corresponding bits.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> D3h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 7   | RWST | 0       | <b>T2MCErr:</b> Uncorrectable Memory Error                              |
| 6   | RWST | 0       | <b>T4MCErr:</b> Coherency Violation Error                               |
| 5   | RWST | 0       | <b>T3MCErr:</b> Multi-Tag Hit from CDC                                  |
| 4   | RWST | 0       | <b>T8MCErr:</b> Poison leaving a poison domain                          |
| 3   | RWST | 0       | <b>T7MCErr:</b> UnCorrectable Data Error during a Re-silvering Process  |
| 2   | RWST | 0       | <b>T6MCErr:</b> Poison being passed on to another poison capable domain |
| 1   | RWST | 0       | <b>T5MCErr:</b> Address Map Error                                       |
| 0   | RWST | 0       | <b>T1MCErr:</b> Correctable ECC Error                                   |

### 4.16.32 RECINT\_LOG0: Recoverable Internal Error Log 0 Register (D16, F2)

The following error log registers capture information about the transaction or access that encountered an internal NB error when a non-Fatal or a Fatal error is logged in the INT\_FERR or when certain errors are logged in the IMI\_FERR or IMI\_NERR registers.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> D8h - DBh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description                                   |
| 31:6  | RWST | 0h      | <b>ADDR31T6:</b> Bits [31:6] of the address   |
| 5:2   | RWST | 0h      | <b>ADDR5T2:</b> Bits [5:2] of the address     |
| 1   | RWST | 0       | <b>WRITE:</b> '1' if the access was a write   |
| 0   | RWST | 0       | <b>DRAM:</b> '1' if the access mapped to DRAM |

### 4.16.33 RECINT\_LOG1: Recoverable Internal Error Log 1 Register (D16, F2)

The following error log registers captures information about the transaction or access that encountered an internal NB error when a non-Fatal or a Fatal error is logged in the INT\_FERR.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> DCh - DFh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:24   | RWST | 0h      | <b>TAGRAM</b><br>Zero padded, cpip_rq4_readinfo_ff[top:96]                             |
| 23  | RWST | 0       | <b>GOTDATA</b><br>Internal indication of the status of the line in the internal cache. |
| 22  | RWST | 0       | <b>NP: Non-Posted</b><br>'1' if non-posted.  |
| 21  | RWST | 0       | <b>BURN:</b><br>'1' if the entry was bypassed from an FSB but not used.                |
| 20  | RV   | 0       | <b>Reserved</b>  |
| 19:16   | RWST | 0h      | <b>IWB_CNT:</b><br>How many IWB's were still needed.                                   |
| 15  | RV   | 0       | <b>Reserved</b>  |
| 14:8  | RWST | 0h      | <b>CDCID</b>   |
| 7:0   | RWST | 0       | <b>ADDR39T32:</b> Bits [39:32] of the address  |

#### 4.16.34 RECINT\_LOG2: Recoverable Internal Error Log 2 Register (D16, F2)

The following error log registers captures information about the transaction or access that encountered an internal NB error when a non-Fatal or a Fatal error is logged in the INT\_FERR.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> E0h - E3h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description                                 |
| 31:0  | RWST | 0000h   | <b>TAGRAM</b><br>cpip_rq4_readinfo_ff[31:0] |

#### 4.16.35 RECINT\_LOG3: Recoverable Internal Error Log 3 Register (D16, F2)

The following error log registers captures information about the transaction or access that encountered an internal NB error when a non-Fatal or a Fatal error is logged in the INT\_FERR.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> E4h - E7h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description                                  |
| 31:0  | RWST | 0000h   | <b>TAGRAM</b><br>cpip_rq4_readinfo_ff[63:32] |

#### 4.16.36 RECINT\_LOG4: Recoverable Internal Error Log 4 Register (D16, F2)

The following error log registers captures information about the transaction or access that encountered an internal NB error when a non-Fatal or a Fatal error is logged in the INT\_FERR.

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> E8h - EBh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description                                  |
| 31:0  | RWST | 0000h   | <b>TAGRAM</b><br>cpip_rq4_readinfo_ff[95:64] |

### 4.16.37 INTLOGC: Internal Error Log Control (D16, F2)

The following error log registers controls error logging of the internal error log registers RECINT\_LOG[4:0].

| <b>Device:</b> 16<br><b>Function:</b> 2<br><b>Offset:</b> ECh - EFh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31  | RWST | 0       | <b>Valid:</b><br>'1' if the error logs are valid   |
| 30:24   | RV   | 0       | <b>Reserved</b>  |
| 23  | RO   | 0       | <b>TRIG:</b><br>Set if a log is currently being made. (Logs are expected to change in a few clocks.)   |
| 22:16   | RO   | 0       | <b>TRIG_CDCID:</b><br>If set, the bit indicates the CDCID that will be logged. Could be inaccurate if a previously logged recoverable error exists, but the current logging is being done for a non-recoverable error. |
| 15  | RWST | 0       | <b>NREC:</b> Enables non-recoverable error logging. Cleared by hardware after logging a non-recoverable error and REARM is clear.  |
| 14  | RWST | 0       | <b>REC:</b> Enables recoverable error logging. Cleared by hardware after logging a recoverable error and REARM is clear.   |
| 13  | RWST | 0       | <b>DIAG:</b> Enables diagnostic logging. Cleared by hardware when logging finished.  |
| 12  | RWST | 0       | <b>REARM:</b> When clear, hardware will log one error of one type, then clear the appropriate enable bit and not log further errors of the same severity.  |
| 11:8  | RWST | 0       | <b>GLOB_EV:</b> Set to enable logging on a global event. Hardware clears on any of global event, recoverable, or non-recoverable error logged unless <b>REARM</b> set.   |
| 7   | RWST | 0       | <b>DEBUG:</b> Set to cause information from the DEBUG_CDCID from CCAM to be logged instead information from the INTLOGC.CDCIC.   |
| 6:0   | RWST | 0       | <b>CDCID:</b> CDCID to log information for when DEBUG field clear.   |

## 4.17 Miscellaneous (Device 17, Function 0)

### 4.17.1 VID: Vendor Identification Register (D17, F0)

This register identifies Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 00 - 01h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.17.2 DID: Device Identification Register (D17, F0)

This register combined with the Vendor Identification register uniquely identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 02 - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2613h   | <b>Device Identification Number</b><br>Identifies each function of the NB. |

### 4.17.3 RID: Revision Identification Register (D17, F0)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br><br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br><br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |



#### 4.17.4 CCR: Class Code Register (D17, F0)

This register contains the Class Code for the device.

| <b>Device</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 09 - 0Bh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class.</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class.</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For this device default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface.</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

#### 4.17.5 HDR: Header Type Register (D17, F0)

This register identifies the header layout of the configuration space.

| <b>Device</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 0Eh |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 7  | RO   | 1       | <b>Mfd: Multi-function Device.</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0  | RO   | 00h     | <b>CfgLayout: Configuration Layout.</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device default is 00h, indicating a conventional type 00h PCI header. |

#### 4.17.6 SVID: Subsystem Vendor Identification Register (D17, F0)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identifies any PCI device.

| <b>Device:</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 2Ch |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RWO  | 8086h   | <b>VIN: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.17.7 SID: Subsystem Identity (D17, F0)

This register identifies the system.

| <b>Device:</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RWO  | 8086h   | <b>SID: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.17.8 FSBDC[A]: Front Side Bus Data Control (D17, F0)

This register controls the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device:</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> A4h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:5  | RV   | XX      | <b>Reserved.</b>  |
| 4   | RW   | 0       | <b>POISONON: Enable poison generation.</b> Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache |

| <b>Device:</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> A4h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 3   | RW   | 0       | <b>PARCHKEN:</b><br>1: Enable DP[3:0] checking. Must be set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence support.          |
| 2   | RW   | 0       | <b>ECCCHKEN:</b><br>1: Enable ECC check and correct. Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.  |
| 1   | RW   | 1       | <b>DRVECC:</b><br>1: Drive DEP[7:0] onto FSB. Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.   |
| 0   | RW   | 0       | <b>DRVPAR:</b><br>1: Drive DP[3:0] parity bits onto FSB. Must be set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence support. |

#### 4.17.9 FSB[A]AC2: Front Side Bus Control2 (D17,F0)

This is the second register for controlling the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device:</b> 17<br><b>Function:</b> 0<br><b>Offset:</b> B0h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:24   | RV   | xxx     | <b>Reserved</b>   |
| 23:20   | RW   | 6h      | <b>CMPL_LIMIT: CMPLQ high water mark</b><br>Suggested Value: 5h |
| 19:0  | RV   | xxx     | <b>Reserved</b>   |

#### 4.17.10 FSB[A]AC: Front Side Bus Control (D17, F0)

This register controls the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device: 17</b><br><b>Function: 0</b><br><b>Offset: B8h</b> |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:27   | RV   | XX      | <b>Reserved.</b>  |
| 26  | RW   | 0       | <b>CPUREQ_EXT: BPRI Optimization Enable</b><br>1: Enables CPU to get another transaction onto the bus if a BREQ change occurred. Helps get more BWL/BWL back to back cases possible.<br>Suggested Value: 1 for 64-bit Intel® Xeon® processor MP. 0 for Dual-Core Intel® Xeon® processor 7000 sequence   |
| 25:15   | RV   | XX      | <b>Reserved.</b>  |
| 14  | RW   | 0       | <b>ARB_ADS: ADS Arbitration Optimization Enable</b><br>0: The NB doesn't look at ADS to BPRI the bus faster.<br>1: The NB can take ADS into account to BPRI the bus faster.<br>Suggested Value: 1   |
| 13  | RW   | 0       | <b>ARB_BREQ: Arbitration Streaming Optimization Enable</b><br>0: The NB will not use the BREQ# pins to drive ADS# early.<br>1: The NB will observe BREQ# to determine when the processor is requesting the bus. When no processor is requesting the bus, the NB (priority agent) may drive ADS# one cycle after it drives BPRI#.<br>Suggested Value: 1 for 64-bit Intel® Xeon® processor MP, 0 for Dual-Core Intel® Xeon® processor 7000 sequence |
| 12:8  | RV   | XX      | <b>Reserved.</b>  |
| 7   | RW   | 0       | <b>DPSDIS: Disable Enhanced Defer</b><br>0: The NB will listen to DPS# and can complete transactions with IDS#. Only if strapped for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache<br>1: The NB will complete deferred transactions with Deferred Reply rather than IDS#.  |
| 6   | RW   | 0       | <b>MEDEN: Modified Enhanced Defer Enable</b><br>0: The NB will assert OOD# at the same time as IDS#.<br>1: The NB may assert OOD# later than IDS#. Should be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache   |
| 5:0   | RW   | 2Dh     | <b>CRQDEPTH: Snoop Request Queue Depth</b><br>The NB will assert flow control when the CRQ reaches this threshold.<br>Suggested Value: 1Dh  |

## 4.18 Miscellaneous (Device 17, Function 1)

### 4.18.1 VID: Vendor Identification Register (D17, F1)

This register identifies Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 00 - 01h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.18.2 DID: Device Identification Register (D17, F1)

This register combined with the Vendor Identification register uniquely identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 02 - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2614h   | <b>Device Identification Number</b><br>Identifies each function of the NB. |

### 4.18.3 RID: Revision Identification Register (D17, F1)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br><br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br><br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

#### 4.18.4 CCR: Class Code Register (D17, F1)

This register contains the Class Code for the device.

| <b>Device</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 09 - 0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For this device default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

#### 4.18.5 HDR: Header Type Register (D17, F1)

This register identifies the header layout of the configuration space.

| <b>Device</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 0Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 1       | <b>Mfd: Multi-function Device</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0  | RO   | 00h     | <b>CfgLayout: Configuration Layout</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device default is 00h, indicating a conventional type 00h PCI header. |

#### 4.18.6 SVID: Subsystem Vendor Identification Register (D17, F1)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identifies any PCI device.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 2Ch |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RWO  | 8086h   | <b>VIN: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.18.7 SID: Subsystem Identity (D17, F1)

This register identifies the system.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RWO  | 8086h   | <b>SID: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.18.8 FSBDC[B]: Front Side Bus Data Control (D17, F1)

This register controls the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> A4h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 31:5  | RV   | XX      | <b>Reserved.</b>  |
| 4   | RW   | 0       | <b>POISONON: Enable poison generation.</b> Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.  |
| 3   | RW   | 0       | <b>PARCHKEN:</b><br>1: Enable DP[3:0] checking. Must be set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence support.          |
| 2   | RW   | 0       | <b>ECCCHKEN:</b><br>1: Enable ECC check and correct. Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.  |
| 1   | RW   | 1       | <b>DRVECC:</b><br>1: Drive DEP[7:0] onto FSB. Must be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.   |
| 0   | RW   | 0       | <b>DRVPAR:</b><br>1: Drive DP[3:0] parity bits onto FSB. Must be set for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence support. |

### 4.18.9 FSB[B]AC2: Front Side Bus Control2 (D17, F1)

This is the second register for controlling the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> B0h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:24   | RV   | xxx     | <b>Reserved</b>  |
| 23:20   | RW   | 6h      | <b>CMPL_LIMIT: CMPLQ high water mark.</b><br>Suggested Value: 5h |
| 19:0  | RV   | xxx     | <b>Reserved</b>  |

### 4.18.10 FSB[B]AC: Front Side Bus Control (D17, F1)

This register controls the Front Side Buses. There is one register for each bus and they must be programmed identically.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> B8h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:27   | RV   | XX      | <b>Reserved.</b>   |
| 26  | RW   | 0       | <b>CPUREQ_EXT: BPRI Optimization Enable</b><br>1: Enables CPU to get another transaction onto the bus if a BREQ change occurred. Helps get more BWL/BWL back to back cases possible.<br>Suggested Value: 1   |
| 25:15   | RV   | XX      | <b>Reserved.</b>   |
| 14  | RW   | 0       | <b>ARB_ADS: ADS Arbitration Optimization Enable</b><br>0: The NB doesn't look at ADS to BPRI the bus faster.<br>1: The NB can take ADS into account to BPRI the bus faster.<br>Suggested Value: 1  |
| 13  | RW   | 0       | <b>ARB_BREQ: Arbitration Streaming Optimization Enable</b><br>0: The NB will not use the BREQ# pins to drive ADS# early.<br>1: The NB will observe BREQ# to determine when the processor is requesting the bus. When no processor is requesting the bus, the NB (priority agent) may drive ADS# one cycle after it drives BPRI#.<br>Suggested Value: 1 |



| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> B8h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 12:8  | RV   | XX      | <b>Reserved.</b>  |
| 7   | RW   | 0       | <b>DPSDIS: Disable Enhanced Defer</b><br>0: The NB will listen to DPS# and can complete transactions with IDS#. Only if strapped for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.<br>1: The NB will complete deferred transactions with Deferred Reply rather than IDS#. |
| 6   | RW   | 0       | <b>MEDEN: Modified Enhanced Defer Enable</b><br>0: The NB will assert OOD# at the same time as IDS#.<br>1: The NB may assert OOD# later than IDS#. Should be set for 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache.  |
| 5:0   | RW   | 2Dh     | <b>CRQDEPTH: Snoop Request Queue Depth</b><br>The NB will assert flow control when the CRQ reaches this threshold.<br>Suggested Value: 1Dh  |

#### 4.18.11 EXP\_GCTRL: PCI Express Global Control Register

This 32-bit global register in the NB implements chipset specific operations for generalized control of all PCI Express events and activity such as Power Management. There is only one register for all PCI Express ports.

| <b>Device:</b> 17<br><b>Function:</b> 1<br><b>Offset:</b> DCh |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:16   | RV   | 0       | <b>Reserved.</b>   |
| 15:2  | RV   | 3FFFh   | <b>Reserved.</b>   |
| 1   | RWST | 0       | <b>PME_TURN_OFF: Send PME Turn Off Message<sup>a</sup></b><br>When set, the NB will issue a PME Turn Off Message to all enabled PCI Express ports. The NB will clear this bit once the Message is sent.                                  |
| 0   | RWC  | 0       | <b>PME_TO_ACK: Received PME Time Out Acknowledge Message<sup>a</sup></b><br>The NB sets this bit when it receives a PME TO_ACK Message from all enabled PCI Express ports. Software will clear this bit when it handles the Acknowledge. |

##### NOTES:

- a. Note that PME\_TURN\_OFF and PME\_TO\_ACK bits are defined in the EXP\_GCTRL register (global) since the intent was to have one and only one of these status bits unique for all the seven PCI Express ports in the NB.

## 4.19 Miscellaneous (Device 17, Function 2)

### 4.19.1 VID: Vendor Identification Register (D17, F2)

This register identifies Intel as the manufacturer of the NB. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 00 - 01h |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 15:0  | RO   | 8086h   | <b>Vendor Identification Number</b><br>The value assigned to Intel. |

### 4.19.2 DID: Device Identification Register (D17, F2)

This register combined with the Vendor Identification register uniquely identifies the NB Function in the event that a driver is required. Writes to this register have no effect.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 02 - 03h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 15:0  | RO   | 2615h   | <b>Device Identification Number</b><br>Identifies each function of the NB. |

### 4.19.3 RID: Revision Identification Register (D17, F2)

This register contains the revision number of the Intel® E8501 chipset North Bridge (NB).

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 08h |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7:4  | RO   | 0h      | <b>Major_rev: Major Revision</b><br>Steppings which require all masks to be regenerated.<br><br>1: B stepping   |
| 3:0  | RO   | 0h      | <b>Minor_rev: Minor Revision</b><br>Incremented for each stepping which does not modify all masks. Reset for each major revision.<br><br>0: x0 stepping<br>1: x1 stepping<br>2: x2 stepping |

#### 4.19.4 CCR: Class Code Register (D17, F2)

This register contains the Class Code for the device.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 09 - 0Bh |      |         |   |
|---|------|---------|---|
| Bit   | Attr | Default | Description   |
| 23:16   | RO   | 06h     | <b>BaseClass: Base Class</b><br>This field indicates the general device category. For the NB, this field is hardwired to 06h, indicating it is a "Bridge Device".   |
| 15:8  | RO   | 00h     | <b>SubClass: Sub-Class</b><br>This field qualifies the Base Class, providing a more detailed specification of the device function.<br>For this device default is 00h, indicating "Host Bridge".   |
| 7:0   | RO   | 00h     | <b>RLPI: Register-Level Programming Interface</b><br>This field identifies a specific programming interface (if any), that device independent software can use to interact with the device. There are no such interfaces defined for "Host Bridge" types, and this field is hardwired to 00h. |

#### 4.19.5 HDR: Header Type Register (D17, F2)

This register identifies the header layout of the configuration space.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 0Eh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 7  | RO   | 1       | <b>Mfd: Multi-function Device</b><br>Selects whether this is a multi-function device, that may have alternative configuration layouts.  |
| 6:0  | RO   | 00h     | <b>CfgLayout: Configuration Layout</b><br>This field identifies the format of the configuration header layout for a PCI-to-PCI bridge from bytes 10h through 3Fh.<br>For this device default is 00h, indicating a conventional type 00h PCI header. |

#### 4.19.6 SVID: Subsystem Vendor Identification Register (D17, F2)

This register identifies the manufacturer of the system. This 16-bit register combined with the Device Identification Register uniquely identifies any PCI device.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 2Ch |      |         |  |
|--|------|---------|--|
| Bit  | Attr | Default | Description  |
| 15:0   | RWO  | 8086h   | <b>VIN: Vendor Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

#### 4.19.7 SID: Subsystem Identity (D17, F2)

This register identifies the system.

| <b>Device</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> 2Eh - 2Fh |      |         |   |
|--|------|---------|---|
| Bit  | Attr | Default | Description   |
| 15:0   | RWO  | 8086h   | <b>SID: Subsystem Identification Number</b><br>The default value specifies Intel. Each byte of this register will be writable once. Second and successive writes to a byte will have no effect. |

## 4.19.8 IMI\_HPTIM: Independent Memory Interface Hot Plug Timer (D17, F2)

This register is reserved for IMI Hot Plug and Redundancy Recovery Software. The timings produced by this register are based on a 166 MHz FSB clock rate. The values must be scaled appropriately for other frequencies. As opposed to the other Hot Plug Registers, there is only one of these registers.

| <b>Device: 17</b><br><b>Function: 2</b><br><b>Offset: B0h</b> |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:17   | RV   | 0h      | <b>Reserved.</b>   |
| 16  | RWC  | 0       | <b>TIMER: Timer Interrupt</b><br>This bit is set whenever IMI_HPINT is asserted due to this register. This bit should be inspected by software whenever it handles an MP Hot-Plug Interrupt. Software must clear this bit by writing a 1 to it.                    |
| 15  | RW   | 0       | <b>ENABLE: Interrupt Enable</b><br>When set, IMI_HPINT is asserted when the count elapses.   |
| 14:5  | RW   | 000h    | <b>COUNT:</b><br>The maximum number of 12.5 ms intervals that will elapse between setting the ENABLE bit and IMI_HPINT is asserted. The delay will be between $12.582912 * (\text{COUNT} - 1)$ and $12.582912 * \text{COUNT}$ . The maximum delay is 12.8 seconds. |
| 4:0   | RW   | 0h      | <b>PRESCALE:</b><br>This field defines the number of FSB clocks before the COUNT field is decremented. COUNT is decremented every $2^{\text{PRESCALE}}$ clocks. Values other than 21 (15h) should be used for validation purposes only.                            |

### 4.19.9 REDUN: Memory Redundancy Control (D17, F2)

This register enables RAID and Mirroring as described in [Section 6.3.5.1, “Memory Mirroring”](#) and [Section 6.3.5.2, “Memory RAID”](#).

| <b>Device:</b> 17<br><b>Function:</b> 2<br><b>Offset:</b> B4h |      |         |  |
|---|------|---------|--|
| Bit   | Attr | Default | Description  |
| 31:19   | RV   | 0       | <b>Reserved</b>  |
| 18  | RW   | 0       | <b>HCP: HardCode Poison</b><br>When set by software, overwrite uncorrectable memory data with hardcoded value for poison. Reduces debug visibility.<br>Must be set: 1h   |
| 17  | RW   | 0       | <b>SD: Scrub Disable</b><br>When set, disables raid/mirror scrub operation when memory returns uncorrectable data.   |
| 16  | RW   | 0       | <b>RF: Retry Forever</b><br>When set, the NB will not time out due to retries to the IMI links.  |
| 15:2  | RV   | 0       | <b>Reserved</b>  |
| 1   | RW   | 0       | <b>RAID: RAID Mode Enabled</b><br>When this bit is set, parity is calculated across sets of 3 cache lines that appear on different IMIs and stored in the fourth IMI. If any IMI fails, the NB will reconstruct the data from the other 3 IMIs.  |
| 0   | RW   | 0       | <b>MIRROR: Mirroring Enabled</b><br>The IMIR registers change how memory reads and writes are performed in mirroring mode, but this bit is set by software to enable secondary aspects of mirroring (such as error detection). Software must set this bit before the NB can handle any memory accesses to mirrored memory.<br>When this bit is set, every IMI is paired with another and data is written to both. If one IMI fails, the NB will deliver data from the other. This bit must be set whenever firmware allows memory accesses and $IMIR[j].IMG0WAY[i] \neq IMIR[j].IMG1WAY[i]$ for all $i=0-3$ and $j=0-5$ . If this bit is not set, proper error sequencing is not guaranteed. |

§

## 5 System Address Map

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This chapter describes the system address maps in memory space, I/O space, and PCI configuration register map.

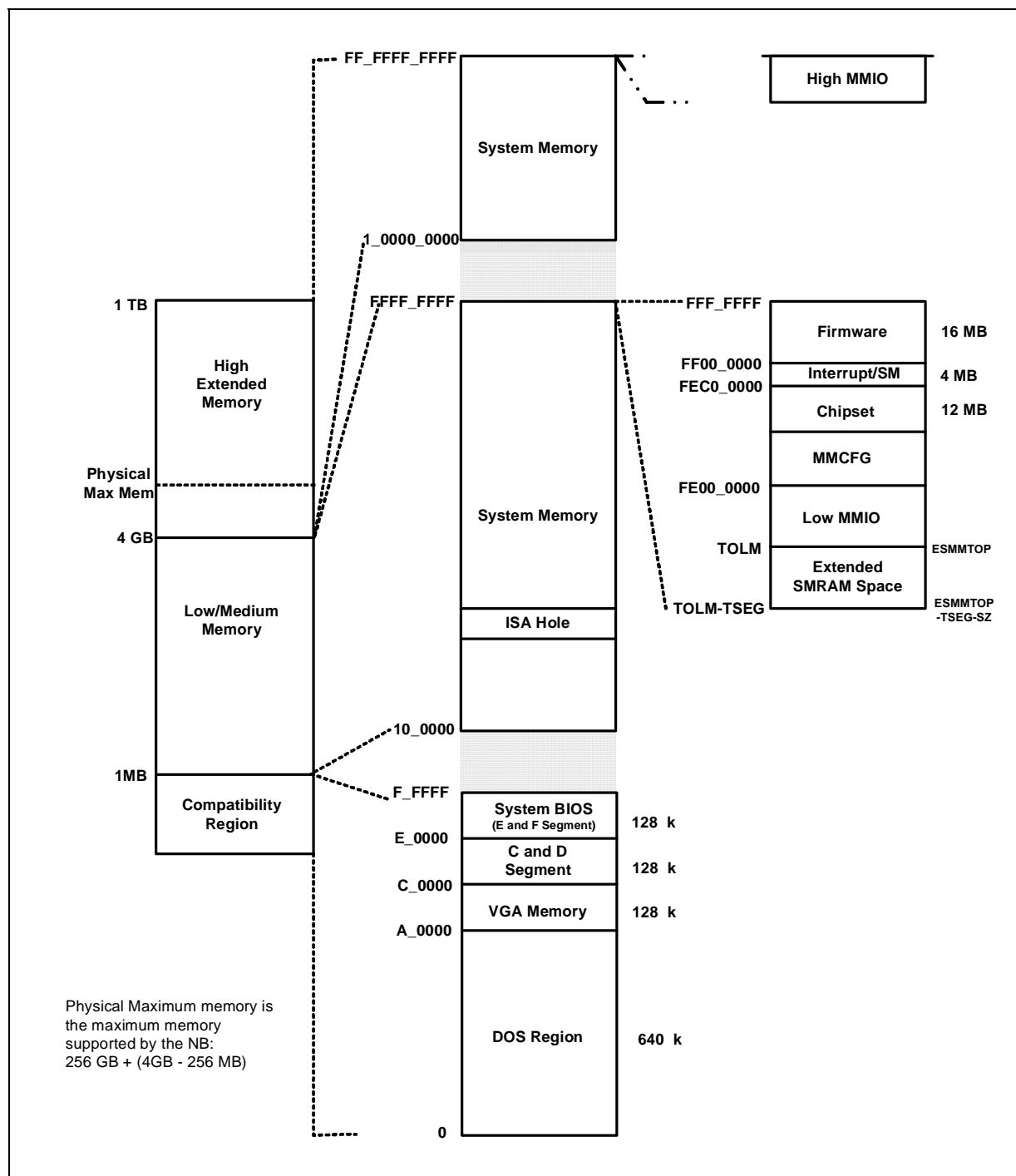
### 5.1 Memory Map

The Intel® E8501 chipset platform supports 40 bits of memory address space. All key components and interfaces also support the 40-bit address space.

- The 64-bit Intel® Xeon® processor MP provides address bits for a 40-bit address space.
- 40-bit local address supported over the Independent Memory Interface (IMI) for the memory space.
- 32- and 64-bit address bit formats supported for PCI Express interface.

The chipset treats accesses to various address ranges in different ways. There are fixed ranges like the compatibility region below 1 MB, interrupt delivery range, and the system region located in the 32 MB directly below 4 GB. In addition, there is a variable region for Memory Mapped I/O. The locations of these ranges in the memory map are illustrated in [Figure 5-1](#).

Figure 5-1. System Memory Address Space





## 5.1.1 Compatibility Region

This is the range from 0-1 MB (0\_0000 to F\_FFFF). Requests to the Compatibility region are directed to main memory, the Compatibility Bus, or the VGA device. Any physical DRAM that would be addressed by requests in this region that are mapped to the Compatibility Bus is not recovered. This region is divided into four ranges. Regions below 1M that are mapped to memory are accessible by the processors and by any I/O bus.

**Note:** The DRAM that has a physical address between 0-1 MB must not be recovered or relocated or reflected. This range must always be available to the OS as DRAM, even if at times addresses in this range are sent to the Compatibility Bus, VGA or other non-DRAM areas.

### 5.1.1.1 Microsoft MS-DOS\* Region

Microsoft MS-DOS applications execute in the lowest 640 KB, in the address range 0h to 9\_FFFFh. This range is always mapped to main memory.

### 5.1.1.2 VGA Memory Range

The 128 KB Video Graphics Adapter Memory range (A\_0000h to B\_FFFFh) can be mapped to the VGA device which may be on any PCI Express or Hub Interface or it can be mapped to main memory (if it is mapped to SMM space). At power-on this space is mapped to the HI port.

Note that the NB chipset does not support the historical MDA (Monochrome Display Adapter) space which would have appeared in the VGA region.

This region can be redirected by BIOS to point to any bus which has a VGA card. If the VGAEN bit is set in one of the NB.BCTRL configuration registers associated with the PCI Express port, then transactions in this space are sent to that PCI Express port. Note that the VGAEN bit can only be set in one and only one of the NB.BCTRL registers. For more information on the BCTRL registers, refer to [Section 4.11.27, “BCTRL\[7:1\]: Bridge Control Register \(D1-7, F0\)” on page 4-100](#).

If any VGAEN bits are set, all the ISAEN bits must be set.

This 128 KB region may also be used for mapping SMM space. The SMM range can overlay the VGA range in the A and B segments. If the SMM range overlaps an enabled VGA range then the state of the SMMEM# signal determines where accesses to the SMM Range are directed. SMMEM# asserted directs the accesses to the memory and SMMEM# deasserted directs the access to the PCI Express bus where VGA has been mapped.

**This region cannot be cached.**

### 5.1.1.3 C and D Segments

Writes and reads may be directed to different destinations in the range C\_0000 to D\_FFFF. Typically, these blocks were used to shadow ISA device BIOS code. For the NB these regions are used to provide address space to PCI devices requiring memory space below 1 MB. The range is divided into 8 sub-ranges. These ranges are defined by NB.PAM registers (similar to MAR registers in the 870 chipset). There is one PAM register for each sub-range that defines the routing of reads and writes (Section 4.15.8, “PAM[6:0]: Programmable Attribute MAP (D16, F1)” on page 4-177).

**Table 5-1. PAM Settings**

| PAM value[5:4] | writes go to | reads go to | Result                          |
|----------------|--------------|-------------|---------------------------------|
| 00             | HI1.5        | HI1.5       | Mapped to the compatibility PCI |
| 01             | HI1.5        | Main Memory | Memory Write Protect            |
| 10             | Main Memory  | HI1.5       | In-line Shadowed                |
| 11             | Main Memory  | Main Memory | Mapped to main memory           |

The power-on default for these segments is mapped read/write to the HI1.5 (ICH5) which forwards the access to the Compatibility Bus. Software should not set cacheable memory attributes for any of these ranges unless both reads and writes are mapped to main memory. Chipset functionality is not guaranteed if this region is cached in any mode other than both reads and writes being mapped to main memory.

For locks to this region, the NB will complete, but does not guarantee the atomicity of locked-access to this range when writes and reads are mapped to separate destinations.

If inbound accesses are expected, the C and D segments MUST be programmed to send accesses to DRAM.

### 5.1.1.4 System BIOS (E and F Segments)

The 128 KB region from E0000h to F\_FFFFh is divided into 5 sub-ranges. Read/write attributes defined in the NB.PAM registers may be used to direct accesses to the HI1.5 (which will access the FWH) or main memory. At power-on, this area is mapped read/write to the HI1.5. The PAM settings for accesses in this region are defined in Table 5-1, “PAM Settings”.

For locks to this region, the NB will complete, but does not guarantee the atomicity of locked access to this range when writes and reads are mapped to separate destinations.

If inbound accesses are expected, the E and F segments MUST be programmed to send accesses to DRAM.

## 5.1.2 Low/Medium Memory

The low/medium memory regions range from 1 MB to 4 GB. It consists of sub-regions for Firmware, Processor memory mapped functions, and NB chipset specific registers.

### 5.1.2.1 System Memory

See [Section 5.1.4, “Main Memory Region”](#).

### 5.1.2.2 ISA Hole

An ISA “window” can be optionally opened up between 15 MB and 16 MB by setting the NB.FDHC.HEN bit. If this bit is set, accesses to this region will be sent to the ICH5 via the HI1.5. Otherwise, it is decoded as a system memory access. The memory behind this hole cannot be reclaimed.

### 5.1.2.3 Extended SMRAM Space (TSEG)

SMM space allows system management software to partition a region in main memory that is only accessible by system management software. When the SMM range is enabled, memory in this range is not exposed to the Operating System. The SMM range is accessed only when the processor is in SMM-mode. This is an extended SMM range that is different than the SMM space that may reside that overlaps VGA space. The register fields that define the NB.EXSMRC.TSEG\_SZ and NB.EXSMRTOP.ESMMTOP. The TSEG SMM space starts at ESMMTOP-TSEG\_SZ and ends at ESMMTOP. This region may be 128KB, 256KB, or 1MB in size, depending on the TSEG\_SZ field. ESMMTOP is relocatable to accommodate software that wishes to configure the TSEG SMM space before MMIO space is known. The ESMMTOP will default to the same value as TOLM.

If SMM is enabled, the chipset allows accesses to this range only when the SMMEM# signal on the FSB is asserted with the request.

If SMMEM# is deasserted, accesses to the SMM Range are master aborted. If SMMEM# is asserted the access is routed to main memory. The NB will use the SMM enable and range registers to determine where to route the access.

The NB will not support a locked-access that crosses an SMM boundary. Firmware should not create data structures that span this boundary.

SMM main memory is protected from Inbound accesses.

**Note:** In order to make cacheable SMM possible, the chipset must accept EWB's (BWL's) and must absorb IWB (HITM) data regardless of the condition of the SMMEM# pin. Because of this, care must be used when attempting to cache SMM space. The chipset/platform cannot protect against processor which attempts to illegally access SMM space that is modified in another processor's cache. Any software that creates such a condition (for example, by corrupting the page table) will jeopardize the protective properties of SMM.

See [Table 5-9 “Decoding Processor Requests to SMM and VGA Spaces”](#) on page 5-257 for details on SMM decoding.

### 5.1.2.4 Memory Mapped Configuration Region

There is one relocatable memory mapped configuration regions on the NB. The FSB address defines the configuration register to be accessed and the FSB data either returns or provides register contents. As opposed to CF8/CFC-based configuration accesses, this mechanism is atomic. The memory mapped configuration region is compatible with the PCI Express enhanced configuration mechanism. It is a 256MB window that maps to PCI Express registers. (Both in the chipset and south of the chipset.) The location of this MMCFG window is defined by the NB.EXP\_ECBASE register ([Section 4.15.13](#)).

The default value of NB.EXP\_ECBASE maps these regions into a region where there will be no wasted memory that is lost behind it. The default value for the PCI Express registers is 0100\_0000. If this range is moved, the following recommendations will enable reclaiming the memory that is lost to MMCFG accesses.

1. MMCFG range is mapped to a legal location within the range between TOLM and 4GB. Since ranges must not overlap other legal ranges, it is safest to put this range between TOLM and the lowest real MMIO range (The current default is in these ranges).

OR

2. Put the regions above 4GB (above the top of memory and not overlapping above 4GB MMIO space).

This space is also accessible inbound. To protect the chipset under normal operation, inbound accesses can be protected by the NB.EXP\_CTRL.DIS\_INB\_CFG bit ([Section 4.11.28](#)).

BIOS/software must ensure there are no outstanding configuration accesses or memory accesses to the old and new MMCFG range addresses when relocating this range.

### 5.1.2.5 Low Memory Mapped I/O (MMIO)

This is the first of the two NB memory mapped I/O ranges. The low memory mapped I/O range is defined to be between TOLM and FE00\_0000h. This low MMIO region is further subdivided between the PCI Express and HI1.5 (ICH5) ports. The following table shows the registers used to define the MMIO ranges for each PCI Express/HI device. These registers are compatible with PCI Express and the PCI-to-PCI bridge specifications. Note that all subranges must be contained in the low memory mapped I/O range (between TOLM and FE00\_0000h). In other words, the lowest base address must be above TOLM and the highest LIMIT register must be below FE00\_0000h. Subranges must also not overlap each other.

**Table 5-2. Low Memory Mapped I/O<sup>a</sup> (Sheet 1 of 2)**

| I/O Port                           | NB Base                     | NB Limit                      |
|------------------------------------|-----------------------------|-------------------------------|
| HI (ICH5)                          | N/A <sup>b</sup>            |                               |
| PCI Express D Memory               | MBASE1 (MBASE in device 1)  | MLIMIT1 (MLIMIT in device 1)  |
| PCI Express D Prefetchable Memory  | PMBASE1 (MBASE in device 1) | PMLIMIT1 (MLIMIT in device 1) |
| PCI Express C0 Memory              | MBASE2                      | MLIMIT2                       |
| PCI Express C0 Prefetchable Memory | PMBASE2                     | PMLIMIT2                      |
| PCI Express C1 Memory              | MBASE3                      | MLIMIT3                       |

**Table 5-2. Low Memory Mapped I/O<sup>a</sup> (Sheet 2 of 2)**

| I/O Port                           | NB Base | NB Limit |
|------------------------------------|---------|----------|
| PCI Express C1 Prefetchable Memory | PMBASE3 | PMLIMIT3 |
| PCI Express B0 Memory              | MBASE4  | MLIMIT4  |
| PCI Express B0 Prefetchable Memory | PMBASE4 | PMLIMIT4 |
| PCI Express B1 Memory              | MBASE5  | MLIMIT5  |
| PCI Express B1 Prefetchable Memory | PMBASE5 | PMLIMIT5 |
| PCI Express A0 Memory              | MBASE6  | MLIMIT6  |
| PCI Express A0 Prefetchable Memory | PMBASE6 | PMLIMIT6 |
| PCI Express A1 Memory              | MBASE7  | MLIMIT7  |
| PCI Express A1 Prefetchable Memory | PMBASE7 | PMLIMIT7 |

**NOTES:**

- This table assumes NB.PMLU and NB.PMBU are 0's. Otherwise, the prefetchable memory space will be located in high MMIO space.
- NB does not need base/limit for ICH5 because subtractive decoding will send the accesses to the ICH5. This is OK for software also, since the ICH5 is considered part of the same bus as the NB.

The NB will decode addresses in this range and route them to the appropriate HI1.5 or PCI Express port. If the address is in the low MMIO range, but is not contained in any of the PCI Express base and limit ranges, it will be routed to the HI1.5.

If the NB.PMLU and NB.PMBU registers are greater than 0, than the corresponding prefetchable region will be located in the high MMIO range instead.

### 5.1.2.6 Chipset Specific Range

The address range FE00\_0000h - FEBF\_FFFFh region is reserved for chipset specific functions.

- FE60\_C000h - FE6F\_FFFFh: This range is used for memory mapped NB registers. They are accessible only from the FSB. These registers are fixed since they are needed early during the boot process. The registers include:
  - 4 Scratch Pad Registers
  - 4 Sticky Scratch Pad Registers
  - 4 Boot flag registers
  - 4 Repeatability registers

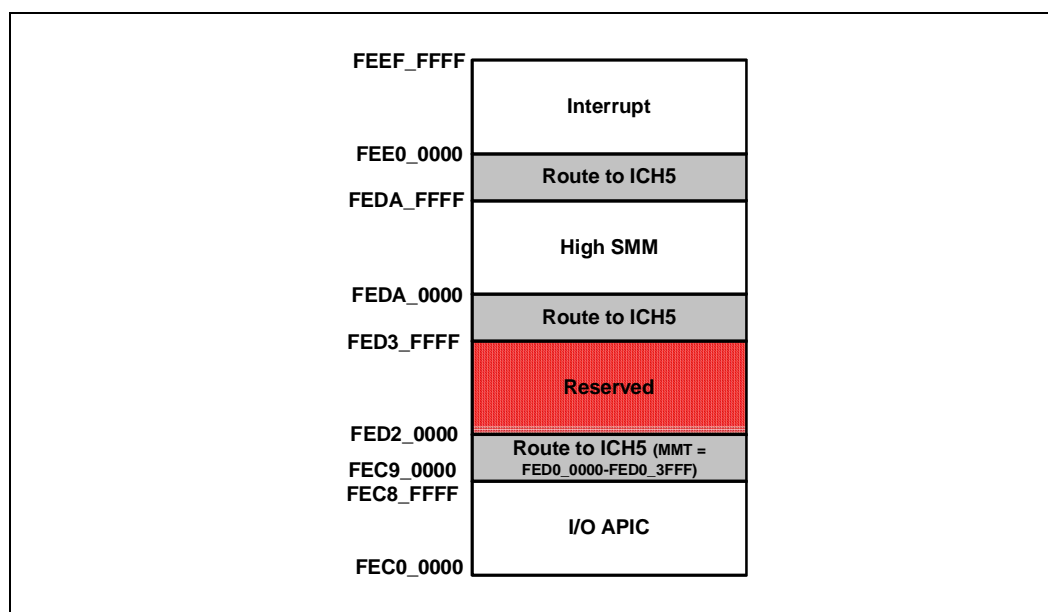
These registers are described in the NB Configuration Register Chapter.

Only the first 4 bytes of each 1 K block in this 16 K range is accepted by the NB. The NB will issue requests to the remainder of this region to the ICH unless they map into one of the relocatable regions such as MMCFG. The mechanism for this range can be the same as it is for the memory mapped configuration accesses.

### 5.1.2.7 Interrupt/LT Region

This 4 MB range is used for processor specific applications. It lies between FEC0\_0000h and FEEF\_FFFFh and is split into four 1 MB segments.

Figure 5-2. Interrupt Region



#### 5.1.2.7.1 I/O APIC Controller Range

This address range FEC0\_0000 to FEC8\_FFFF is used to communicate with the IOAPIC controllers in the Intel 6700PXH/6702PXH 64-bit PCI Hub, or ICH5.

The APIC ranges are hard coded. Reads and writes to each IOAPIC region should be sent to the appropriate HI1.5 or PCI Express as indicated below.

Table 5-3. IOAPIC Address Mapping

|                          |   |
|--------------------------|---|
| IOAPIC0 (HI1.5)          | 0_FEC0_0000 to 0_FEC7_FFFF <sup>a</sup> |
| IOAPIC1 (PCI Express D)  | 0_FEC8_0000 to 0_FEC8_0FFF              |
| IOAPIC2 (PCI Express C0) | 0_FEC8_1000 to 0_FEC8_1FFF              |
| IOAPIC3 (PCI Express C1) | 0_FEC8_2000 to 0_FEC8_2FFF              |
| IOAPIC4 (PCI Express B0) | 0_FEC8_3000 to 0_FEC8_3FFF              |
| IOAPIC5 (PCI Express B1) | 0_FEC8_4000 to 0_FEC8_4FFF              |
| IOAPIC6 (PCI Express A0) | 0_FEC8_5000 to 0_FEC8_5FFF              |
| IOAPIC7 (PCI Express A1) | 0_FEC8_6000 to 0_FEC8_6FFF              |
| Reserved                 | 0_FEC8_7000 to 0_FEC8_FFFF              |

**NOTES:**

a. IOAPIC range is hard coded on the ICH5

For hot-plug IOAPIC support, it is recommended that software use the standard MMIO range to communicate to the Intel 6700PXH 64-bit PCI Hub. To accomplish this, the PXH.MBAR must be programmed within the PCI Express device MMIO region.

Inbound accesses to this memory range should also be routed to the I/O APIC controllers. This could happen if software configures MSI devices to send MSI's to an I/O APIC controller.

#### 5.1.2.7.2 High SMM Range

If high SMM space is enabled by EXSMRC.H\_SMRAME, then requests to the address range from FEDA\_0000 to FEDB\_FFFF will be aliased down to the physical address of A\_0000 to B\_FFFF. The HIGHSMM space allows cacheable accesses to the compatible (legacy) SMM space. In this range, the chipset will accept EWB's (BWL's) regardless of the SMMEM# pin. Also, if there is an implicit writeback (HITM with data), the chipset will update memory with the new data (regardless of the SMMEM# pin). Note that if the HIGHSMM space is enabled, the aliased SMM space of A\_0000-B\_FFFF will be disabled.

**Note:** In order to make cacheable SMM possible, the chipset must accept EWB's (BWL's) and must absorb IWB (HITM) data regardless of the condition of the SMMEM# pin. Because of this, care must be used when attempting to cache SMM space. The chipset/platform cannot protect against processors who attempt to illegally access SMM space that is modified in another processor's cache. Any software that creates such a condition (for example, by corrupting the page table) will jeopardize the protective properties of SMM.

#### 5.1.2.7.3 Interrupt Range

Requests to the address range FEE0\_0000 to FEEF\_FFFF are used to deliver interrupts. Memory reads or write transactions to this range are illegal from the processor. The processor issues interrupt transactions to this range. Inbound interrupts from the PCI Express devices in the form of memory writes to this range are converted by the NB to FSB interrupt requests.

#### 5.1.2.7.4 Reserved Ranges

The NB will master abort requests to the remaining addresses in the interrupt range. This is the FEF0\_0000h - FEFf\_FFFFh or FED4\_0000h - FEDf\_FFFFh ranges. This can be done by sending the request to the compatibility bus (Hub Interface) to be master aborted. In the event the ICH5 adds new registers or functionality in this range in the future, this provides the most likely chance that it will work.

#### 5.1.2.8 Firmware Range

The Intel® E8501 chipset platform allocates 16MB of firmware space from FF00\_0000h to FFFF\_FFFFh. Requests in this range are directed to the Compatibility Bus. The ICH5 will route these to its FWH interface. This range is accessible from any FSB.

### 5.1.3 High Extended Memory

This is the range above 4 GB. The range from 4 GB to NB.IMIR5.LIMIT is mapped to system memory. There can also be a memory mapped I/O region is located at the top of the address space. (Just below 1TB). This is described in [Section 5.1.3.2](#).

#### 5.1.3.1 System Memory

See [Section 5.1.4, "Main Memory Region"](#).

### 5.1.3.2 High MMIO

The high memory mapped I/O region is located above the top of memory as defined by NB.IMIR5.LIMIT. These NB.PMBU and NB.PMLU registers in each PCI Express configuration device determine whether there is memory mapped I/O space above the top of memory. If an access is above IMIR5.LIMIT and it falls within the NB.PMBU+PMBASE/ NB.PMLU+PMLIMIT range, it should be routed to the appropriate PCI Express port. For accesses above IMIR5.LIMIT (and above 4GB) that are not in a high MMIO region, they should be master aborted.

### 5.1.3.3 Extended Memory (not applicable)

The range of memory just below 4 GB from TOLM to 4 GB (Low MMIO, Chipset, Interrupt) do not map to memory. If nothing is done, the DRAM memory behind the TOLM to 4 GB range will be unused.

On NB Chipset, the extended memory does not have any meaning because reclamation mechanism is handled by hardware and NB will use IMIR5.LIMIT to indicate the top of usable memory.

## 5.1.4 Main Memory Region

### 5.1.4.1 Application of Coherency Protocol

The NB applies the coherency protocol to any accesses to main memory. [Table 5-8](#) defines the conditions under which processor transactions are routed to main memory. [Table 5-11](#) defines the conditions under which inbound transactions are routed to main memory. Application of the coherency protocol includes snooping the other FSB.

Two exceptions are the C\_0000 - F\_FFFFh and the legacy SMM ranges. (C\_0000h-F\_FFFFh may not necessarily route both reads and writes to memory, legacy SMM range may target non-memory when not in SMM mode.) These exceptions will not apply the coherency protocol. The NB may malfunction if processors issue coherent transactions such as BRIL's, IWB's, and EWB's to ranges that do not call for application of the coherency protocol to both reads and writes. In addition, the chipset can not guarantee coherency for these ranges regardless of the types of transactions that are issued. Software must not set cacheable attributes for these areas (Only UC and WC attributes are not cacheable).

### 5.1.4.2 Routing Memory Requests

When a request appears on the FSB, PCI Express link, or Hub Interface, and it does not fall in any of the previously mentioned regions, it is compared against the IMIR.LIMIT registers on the NB and XMB.

The NB.IMIR.LIMIT registers will decode an access into a specific interleaving range. Within the interleaving range, the NB.IMIR.LIMIT register indicates which IMI the address is associated with. In the event that a mirroring event is occurring, memory writes may be associated with 2 IMI's.

The XMB will further decode the address to determine which rank the access is targeted for. The XMB contains the same XMB.IMIR.LIMIT registers as the NB, which helps it identify if the access belongs to that XMB. It also helps with converting the memory (compressing gaps due to



MMIO or IMI interleaving policies). The XMB.DMIR.LIMIT registers also decode the access into a specific interleaving range, which helps decode which rank the access will be directed to. The XMB will also convert the address into the appropriate DDR address, RAS, and CAS signals.

### 5.1.5 Main Memory interleaving

Memory interleaving can be described at two levels. The lowest level of memory interleaving is at the XMB level where DIMMs/Ranks are interleaved. The highest level of memory interleaving is between IMI ports. Interleaving can be at a fine or coarse granularity. Fine granularity interleaves at the cacheline boundary and provides optimal performance by evenly distributing memory accesses when addresses are accessed somewhat linearly. It helps eliminate hot spots. Coarse granularity interleaves on a boundary that is much coarser than a cacheline, for example, a different address range for each IMI (which some may call 1:1 interleaving). Coarse interleaving enables certain RAS features. A combination of fine and coarse interleaving will probably achieve the optimal mix of performance and RAS.

The NB supports 6 interleave ranges to interleave across the IMI's. Each range supports 4 way (4:1), 2 way (2:1), or 1 way (1:1) interleaving. The NB.IMIR registers contain the address of the top of the interleave range, the primary and secondary IMI ports (for mirroring) for each way.

The XMB tracks the same 6 interleave ranges. In addition, the XMB supports 5 interleave ranges to interleave across the 8 DIMM ranks. The XMB also comprehends gaps in the address to do MMIO space and IMI interleaving. The MMIO gap is accounted for using the TOLM register and is described in detail in [Section 5.1.5.4, "Recovering Main Memory Behind Other Regions"](#). The other gaps due to IMI interleaving are handled by setting the interleave range associated with that address range to not point to any ranks on the XMB.

The interleaving scheme also comprehends mirroring across IMI's, RAID, and DIMM pair sparing. For mirroring, each way of each NB.IMIR register contains a primary and secondary port. Writes are sent to both ports. Reads are sent to one port depending. For RAID, interleaving must use 4 interleaving ranges to enable RAID striping. For sparing (on the XMB), the XMB.DIMIRs reflect the live DIMM ranks. If a sparing event occurs, the DMIR will be automatically updated with the spare DIMM rank.

#### 5.1.5.1 Interleaving Registers

The NB and XMB contain the following registers to support the ranges to do IMI and DIMM rank interleaving.

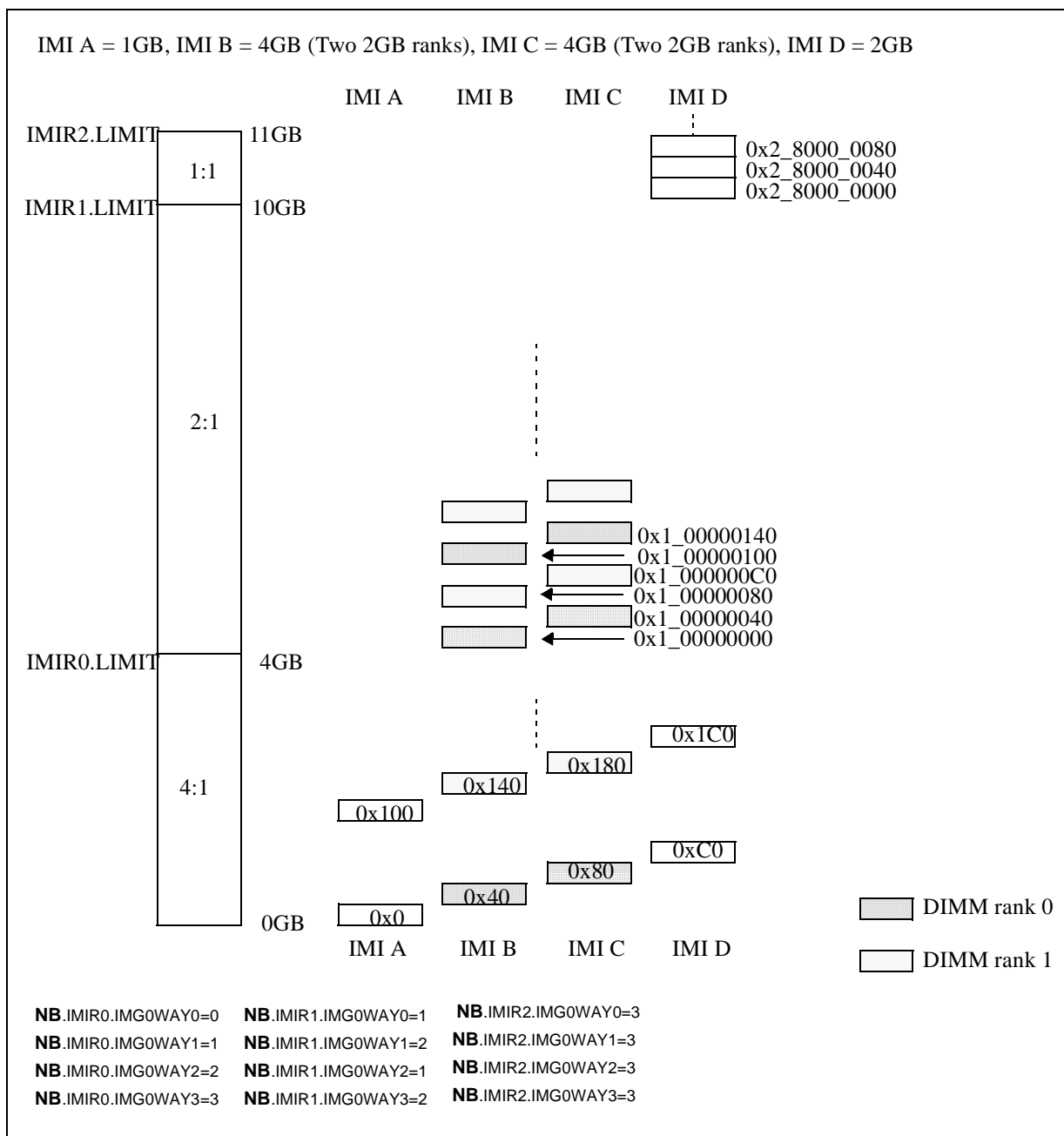
Table 5-4. Interleaving Registers

| Register Name        | Field   | Description   |
|----------------------|---|---|
| <b>NB.IMIR[5:0]</b>  | LIMIT<br>RFBI (Read From Both Images)<br>IMG1WAY3<br>IMG1WAY2<br>IMG1WAY1<br>IMG1WAY0<br>IMG0WAY3<br>IMG0WAY2<br>IMG0WAY1<br>IMG0WAY0 | IMIR0 Defines the interleave policy for the range from 0 to IMIR0.LIMIT.<br>IMIR[5:1] Defines the interleave policy for the range from IMIR[N-1].LIMIT to IMIR[N].LIMIT.  |
| <b>NB.AIMIR[5:0]</b> | ADJLIMIT  | Scratch pad registers reserved for BIOS to use to store interleave information.   |
| <b>XMB.IMIR[5:0]</b> | LIMIT<br>WAY[3:0]   | IMIR0 Defines the interleave policy for the range from 0 to IMIR0.LIMIT.<br>IMIR[5:1] Defines the interleave policy for the range from IMIR[N-1].LIMIT to IMIR[N].LIMIT.  |
| <b>XMB.DMIR[6:0]</b> | LIMIT<br>ENABLE<br>RANK[3:0]  | DIMIR0 Defines the interleave policy for the range from 0 to DIMIR0.LIMIT.<br>DMIR[5:1] Defines the interleave policy for the range from DMIR[N-1].LIMIT to DMIR[N].LIMIT.<br>WAY defines whether a memory request participates in this IMIR range.<br>RANK defines which rank is set to which WAY. |

### 5.1.5.2 Fine grain Interleave Example

This example shows how interleaving can be a fine granularity (per cacheline). Cacheline interleaving provides optimal performance by evenly distributing memory accesses. This example is not meant to be an extensive definition of interleaving, but is more to illustrate the mechanism. For example, this example does not show memory reclamation of space behind MMIO. For details on memory reclamation, please see [Section 5.1.5.4, “Recovering Main Memory Behind Other Regions”](#).

For this example, BIOS has chosen to first interleave across all 4 IMI's until the smallest IMI has no more memory. The second range is 2:1 interleaved across IMI1 and IMI2 until these IMI's have no more memory. The third range is 1-way interleaved because only IMI3 has any memory left. Each rectangle constitutes a cacheline. In the case of IMI1 and IMI2 where there are multiple ranks (smallest granularity that the XMB will interleave), different shadings indicate which rank is being accessed.

**Figure 5-3. Simple Example of Fine Grained Interleave**


### 5.1.5.3 Coarse Interleave Example

This example shows how a coarse grain granularity works. It uses the same mechanism as fine grained granularity, except all regions are 1-way interleaved. As in the previous example, each rectangle constitutes a cacheline. In the case of IMI B and IMI C where there are multiple ranks (smallest granularity that the XMB will interleave), different shadings indicate which rank is being accessed.

The map on the left shows the NB interleaving ranges. Each range sends all accesses to a given IMI A. For example, the first range which is bounded by address 0 and NB.IMIR0.LIMIT will send all accesses to IMI B. The next level of interleaving is at the XMB. XMB can also support limited coarse grained interleaving. Since the XMB is limited to 5 DIMM rank interleave ranges, coarse interleaving must be limited to 5 ranges for all DIMM ranks. In this example, XMB B (IMI B) coarsely interleaves between the 2 DIMM ranks. The light dotted line in the address map indicates additional XMB boundaries to differentiated between rank 0 and rank 1. XMB C (IMI C) is still cacheline interleaved.

### Figure 5-4. Example of Coarse Grained Interleave



#### 5.1.5.4 Recovering Main Memory Behind Other Regions

The NB will reclaim memory that is lost behind the region between TOLM and 4 GB. To do this, the NB and XMB will automatically adjust the internal LIMIT values (referred to as the adjusted limit ADJLIMIT). The ADJLIMIT value that is used in the range comparators will be:

```
IF (IMIR.LIMIT > TOLM, THEN ADJLIMIT = IMIR.LIMIT + MMIO_size
ELSE ADJLIMIT = IMIR.LIMIT
```

Note: TOLM will always be below 4 GB.

$MMIO\_size = 4\text{ GB} - TOLM[15:12]$  (corresponds to  $A[31:28]$ )

In addition, the XMB will logically perform an address conversion (subtraction) for addresses above the MMIO or other gap. For example, addresses above MMIO will be converted to Address minus the size of the MMIO gap (MMIO\_size). Accesses above MMIO and a gap due to global IMI interleaving policies would be converted to Address minus MMIO\_size minus size of the interleave range. The following is a logical description of the same XMB conversion.

```
IMIR_Size = LIMIT[N] - LIMIT[N-1]
IF System_addr > Any unmapped IMIR range
OtherGaps = Sum of Unmapped IMIR_Size below System_addr
IF (System_Addr > 4GB, THEN AdjustedAddr = SystemAddr - MMIO_size - OtherGaps
ELSE AdjustedAddr = System_Addr - OtherGaps
```

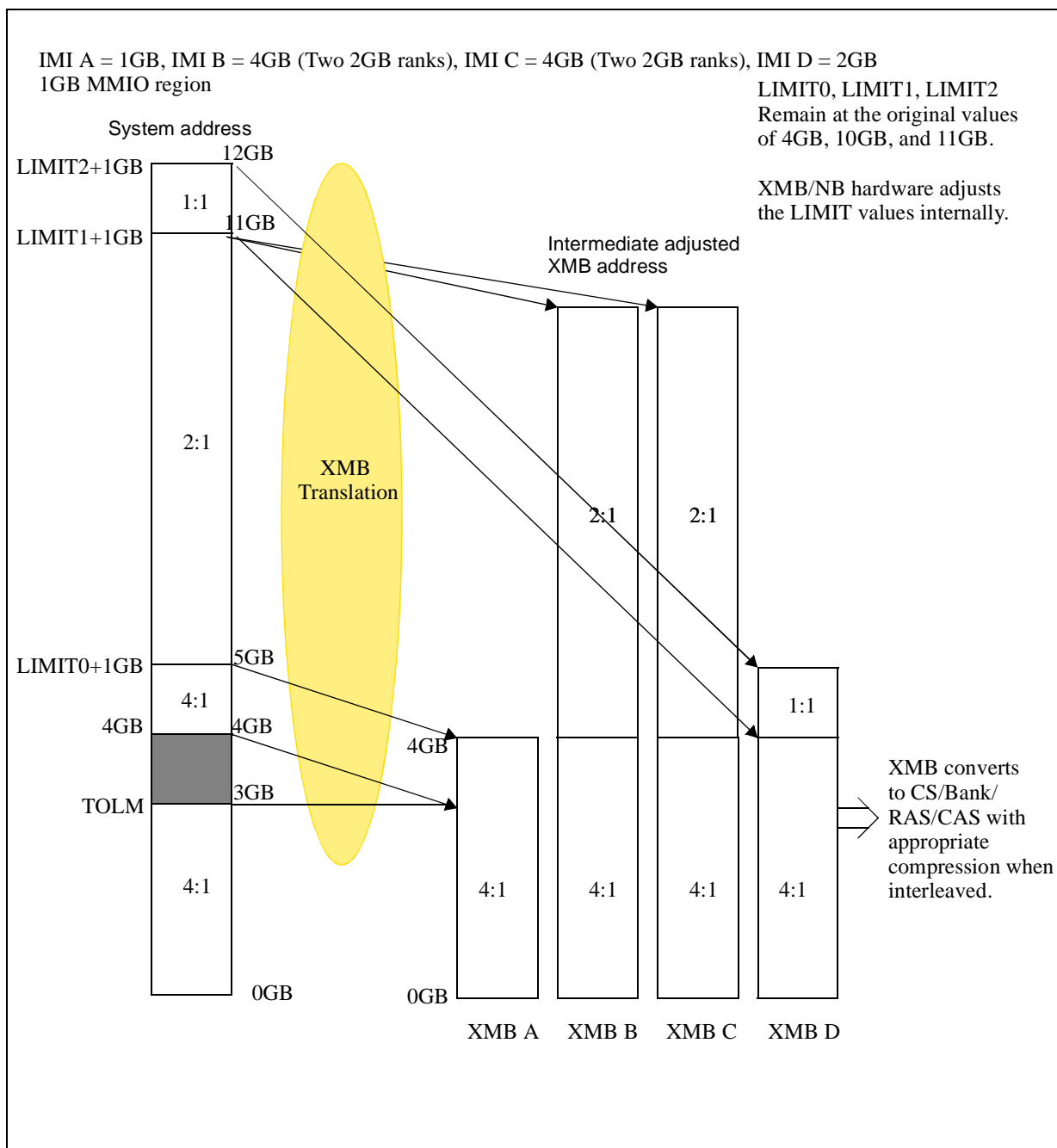
Software only needs to program the TOLM register in the NB and XMB. It does not need to adjust the LIMIT registers. In addition, there is a scratch pad register NB.AIMIR that software can use to store pertinent interleave information.

##### Example of reclaiming MMIO space:

The following example shows how a 1 GB MMIO (TOLM to 4 GB) range would be reclaimed. For this example, the NB/XMB internally adjusts the LIMIT values above 4 GB to  $IMIR.LIMIT + MMIO\_size = IMIR.LIMIT + 1\text{ GB}$  (1 GB is the MMIO\_size). If there were IMIR.LIMIT's below TOLM, they would not have needed any adjustments. In addition, the XMB converts the addresses above 4 GB to  $System\_Address - 1\text{ GB}$  (1 GB is the MMIO\_size). Addresses below 4 GB do not need to be adjusted. For addresses above 11 GB, the XMB also subtracts the size of the unmapped IMIR range, which is 6 GB in this example. (Size of the range limited by LIMIT1). Note that the example shows conceptually how the address is processed, but does not necessarily correspond to the exact implementation.

For this picture, LIMIT0 is the same as IMIR0.LIMIT, LIMIT1 is IMIR1.LIMIT, etc.

**Figure 5-5. Example of Reclaiming MMIO Memory**



### 5.1.5.5 Interleaving

A number of memory RAS features involve removing or adding memory to the system. Care must be exercised in the interleaving definition to balance RAS robustness with optimal interleaving for performance. For example, the interleaving shouldn't be set up so that removing a DIMM rank results in removing all system memory.

#### 5.1.5.5.1 Interleaving with sparing

If DIMM sparing (without graceful degradation) is desired, at configuration time, a DIMM rank must be set aside to replace a defective DIMM rank. This spare DIMM must not be included in the IMIR and DMIR settings.

#### 5.1.5.5.2 The Effects of Graceful Degradation & Sparing on Interleaving

Graceful degradation is when the memory associated with a bad DIMM rank is removed by software deallocating the memory. If memory is in a region that is pinned (i.e. cannot be removed), an unrelated DIMM pair can be chosen to be deallocated. Once it is deallocated, it can be converted into a spare DIMM.

This feature relies on restrictions to hardware configurations and interleaving policies to be robust. For example, If the DIMMs are interleaved so that none are a good candidate for being a spare, then a spare cannot be made. Software can follow the [suggestions](#) below to increase the chance that there will be a good candidate for a spare.

Interleaving restrictions (SW):

1. For each XMB, select a rank that can become a spare. This rank must be the largest of all populated ranks.
  - a. If there are any split DIMM's, then the spare must be a split DIMM.
  - b. Since all DIMM's will meet minimum DIMM size restriction, any DIMM can be selected to be predestined to be a spare.
2. Interleave the remaining DIMMs. The amount of memory allowable below 4 GB depends on the size of the spare rank. The memory below 4 GB must be able to fit into the spare. For example, if the spare DIMM pair holds 1 GB, then the remaining DIMM's must only have 1 GB of memory below 4 GB.

Put the spare rank above 4 GB. It must be non-interleaved (i.e. 1:1). Restrictions on hardware include:

1. If there are any double sided DIMM's, then there needs to be at least 2 double-sided DIMMs.
2. Minimum memory capacity must be larger than 4 GB.
3. Each XMB must have at least 2 DIMM pairs.
4. Restrict the use of small DIMM's. The DIMM size restrictions are dependent the number of XMB's and the IMI interleaving. The following table shows the smallest DIMM size allowable for different configurations. These restrictions are to guarantee that even with limited interleaving to allow for this functionality, there will be full memory.



**Table 5-5. Minimum DIMM Size Restriction**

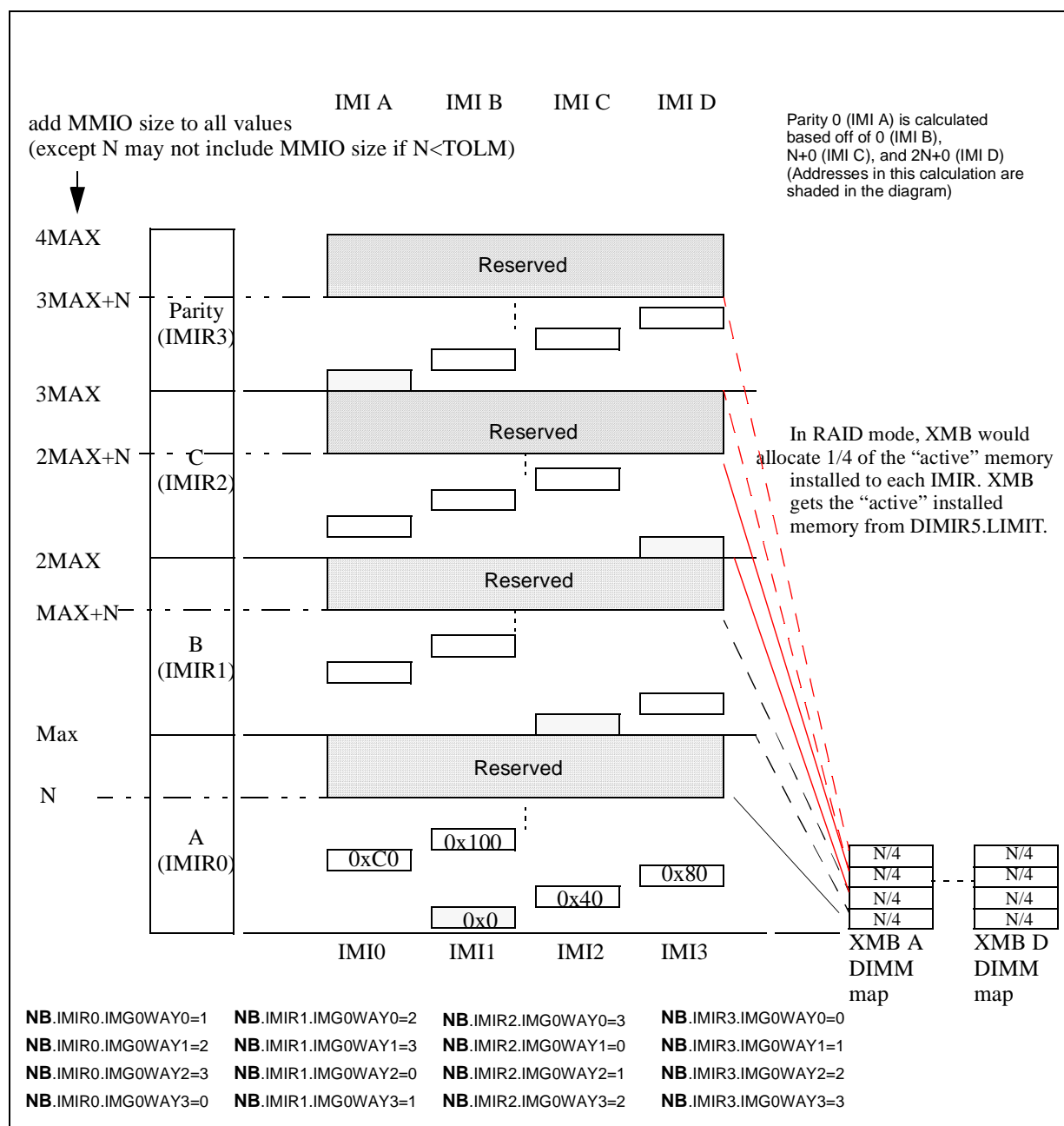
| Number of XMBs | IMI Interleaving | Smallest DIMM Allowed |
|----------------|------------------|-----------------------|
| 4              | 4:1              | 1GB                   |
| 2/4            | 2:1              | 2GB                   |
| 1/2/4          | 1:1              | 4GB                   |

### 5.1.5.5.3 Interleaving with RAID

When Intel® E8501 chipset is in RAID mode, all 4 IMI's must be populated symmetrically. Therefore, all IMI's can be 4:1 interleaved. The reason for 4 IMIR ranges is because the starting point of each range is shifted to enable the RAID striping.

The following diagram shows how memory should be interleaved in RAID mode. This scheme includes space that is reserved in each range to accommodate capacity upgrades. A capacity upgrade with RAID would include replacing memory cards one by one with larger cards while still assuming the original smaller size. Once all 4 cards have been upgraded, a memory hot add is performed to bring the extra memory online. For systems that are not planning to be upgraded, the reserved space is not necessary. In this diagram, "N" is equal to the amount of memory per XMB that is currently installed. "MAX" represents the maximum amount of memory that is allowed per XMB after an upgrade.

Figure 5-6. Address Mapping for RAID



#### 5.1.5.5.4 Interleaving with Mirroring

Only the NB is aware of mirroring. The NB.IMIR registers have WAY fields defined for both image 0 and image 1 (IMG{1/0}WAY[3:0]). The memory on both IMI's that are being mirrored should be the same size, so the IMI interleaving algorithm will result in the same settings for both IMI's. The only difference is that one of the IMI's is image 0 and the other is image 1. For example, if IMI A and IMI B are mirrored images and IMI C and IMI D are mirrored images, software could cacheline interleave between IMI A/B and IMI C/D by setting the IMIR register as follows:

```
IMIR.IMG0WAY0 = IMI A
IMIR.IMG1WAY0 = IMI B
IMIR.IMG0WAY1 = IMI C
IMIR.IMG1WAY1 = IMI D
IMIR.IMG0WAY2 = IMI A
IMIR.IMG1WAY2 = IMI B
IMIR.IMG0WAY3 = IMI C
IMIR.IMG1WAY3 = IMI D
```

### 5.1.6 General Interleaving Guidelines

1. There can be no enabled XMB.DMIRs above a disabled DMIR. For example, if DMIR[3] is disabled, DMIR[5:4] must be disabled.
2. All memory mapped I/O above 4GB (PMBASE/PMLIMIT/PMLU/PMBU) must be higher than the highest IMIR.LIMIT value plus the MMIO hole.
3. For IMIR.LIMIT values above 4GB, the value in IMIR.LIMIT cannot exceed IMIR.LIMIT minus the size of the MMIO hole, since the NB will internally adjust the LIMIT value to IMIR.LIMIT+MMIO hole.
4. Unused NB.IMIR registers should have their IMIR.LIMIT programmed to the same as the LIMIT of the highest functional IMIR. Similarly, unused XMB.DMIR and XMB.IMIR registers should have their LIMIT set to the same as the highest function IMIR/DMIR.
5. For optimal performance when doing 2-way interleaving only on the XMB, the XMB DMIR ways (called RANK[3:0]) should be programmed so that consecutive ways do not go to the same rank.

For example, if you have two ranks “m” and “n”, the four ways should be programmed as follows:

| Way 0 | Way 1 | Way 2 | Way 3 | OR | Way 0 | Way 1 | Way 2 | Way 3 |
|-------|-------|-------|-------|----|-------|-------|-------|-------|
| n     | m     | n     | m     |    | m     | n     | m     | n     |

Similarly, if a NB is doing 2:1 interleaving (2 IMI's in the IMIR range), the ways (NB.IMIR.IMG\*WAY\*) should be programmed so consecutive ways do not go to the same rank.

## 5.2 Memory Address Disposition

### 5.2.1 Registers Used for Address Routing

#### 5.2.1.1 Intel® E8501 Chipset North Bridge (NB) Registers

**Table 5-6. Intel® E8501 Chipset North Bridge (NB) Memory Mapping Registers**

| Name                       | Function  |
|----------------------------|---|
| IMIR[5:0]                  | Memory Interleaving Registers (IMI interleaving)  |
| AIMIR[5:0]                 | Scratch pad register for software to use related to memory interleaving. For example, software can write MMIO gap adjusted limits here to aid in subsequent memory RAS operations.                |
| PAM[6:0]                   | Defines attributes for ranges in the C and D segments. Supports shadowing by routing reads and writes to memory of I/O.   |
| FDHC                       | Contains HEN which enables the ISA hold.  |
| SMRAM                      | SMM Control.  |
| EXSMRC, EXSMRTOP, EXSMRAMC | Extended SMM Control.   |
| BCTRL                      | Contains VGAEN and ISAEN for each PCI Express.  |
| TOLM                       | Top of low memory. Everything between TOLM and 4GB will not be sent to memory.  |
| EXP_ECBASE                 | Base of the memory mapped configuration region that maps to all PCI Express registers.  |
| MBASE (Dev 1-7)            | Base address for memory mapped I/O to PCI Express ports 1-7.  |
| IMILIMIT (Dev 1-7)         | Limit address for memory mapped I/O to PCI Express ports 1-7.   |
| PMBASE (Dev 1-7)           | Base address for memory mapped I/O to prefetchable memory of PCI Express ports 1-7 <sup>a</sup> .   |
| PMLIMIT (Dev 1-7)          | Limit address for memory mapped I/O to prefetchable memory of PCI Express ports 1-7.  |
| PMBU (Dev 1-7)             | Prefetchable Memory Base (Upper 32 bits) - Upper address bits to the base address of prefetchable memory space. If the prefetchable memory is below 4 GB, this register will be set to all 0's.   |
| PMLU (Dev 1-7)             | Prefetchable Memory Limit (Upper 32 bits) - Upper address bits to the limit address of prefetchable memory space. If the prefetchable memory is below 4 GB, this register will be set to all 0's. |
| PCICMD (Dev 1-7)           | MAE (Memory Access Enable) bit enables the memory and pre-fetchable ranges.   |

**NOTES:**

- a. The chipset treats memory and prefetchable memory the same. These are just considered 2 apertures to the PCI Express port.

## 5.2.1.2 XMB Registers

**Table 5-7. XMB Memory Mapping Registers**

| Name      | Function   |
|-----------|--|
| IMIR[5:0] | Memory Interleaving Registers (IMI interleaving).                |
| TOLM      | Top of low memory. Used in aiding in the XMB address conversion. |
| DMIR[4:0] | Memory Interleaving Registers (DIMM interleaving).               |
| MTR       | Memory Technology Register.                                      |

## 5.2.2 Address Disposition for Processor

The following tables define the address disposition for the NB. [Table 5-8](#) defines the disposition of outbound requests entering the NB on the FSB. For address dispositions of PCI Express/HI devices, please refer to the specifications for the Intel 6700PXH/6702PXH 64-bit PCI Hub and Intel ICH5. [Table 5-8](#) defines how the NB completes outbound requests. [Table 5-11](#) defines the disposition of inbound requests entering the NB on I/O bus. In these tables, an address listed as “A to B” can be interpreted as A <= Address <= B

**Table 5-8. Address Disposition for Processor (Sheet 1 of 4)**

| Address Range | Conditions  | NB Behavior   | XMB Behavior   |
|---------------|---|---|--|
| DOS           | 0 to 09FFFFh  | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
| SMM/VGA       | 0A0000h to 0BFFFFh, SMM not enabled, and VGAEN=0                                | Send to HI to be master aborted.  | N/A  |
|               | 0A0000h to 0BFFFFh, SMM not enabled, and VGAEN=1                                | <b>VGA:</b><br>Non-coherent request to PCI Express or Hub Interface based on BCTRL and various SMM registers.   | N/A  |
|               | 0A0000h to 0BFFFFh, SMM enabled and valid access to SMM space. <sup>a</sup>     | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register.  |
|               | (0A0000h to 0BFFFFh and SMM enabled, and denied access to SMM space and VGAEN=0 | Send to HI to be master aborted.  | N/A  |
|               | (0A0000h to 0BFFFFh and SMM enabled, and denied access to SMM space and VGAEN=1 | <b>VGA:</b><br>Non-coherent request to PCI Express or Hub Interface based on BCTRL registers.   | N/A  |

**Table 5-8. Address Disposition for Processor (Sheet 2 of 4)**

| Address Range  | Conditions                             | NB Behavior   | XMB Behavior  |
|--|--|---|---|
| C and D BIOS segments<br>(see Table 5-1 for a definition of PAM encodings) | 0C0000h to 0DFFFFh and PAM=11          | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Write to 0C0000h to 0DFFFFh and PAM=10 | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Read to 0C0000h to 0DFFFFh and PAM=01  | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Read to 0C0000h to 0DFFFFh and PAM=10  | Issue request to Hub Interface.   |   |
|  | Write to 0C0000h to 0DFFFFh and PAM=01 |   |   |
|  | 0C0000h to 0DFFFFh and PAM=00          |   |   |

**Table 5-8. Address Disposition for Processor (Sheet 3 of 4)**

| Address Range  | Conditions   | NB Behavior   | XMB Behavior  |
|--|--|---|---|
| E and F BIOS segments<br>(see Table 5-1 for a definition of PAM encodings) | 0E0000h to 0FFFFFFh and PAM=11   | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Write to 0E0000h to 0FFFFFFh and PAM=10  | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Read to 0E0000h to 0FFFFFFh and PAM=01   | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation). Route to appropriate XMB according to NB.IMIR registers. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | Read to 0E0000h to 0FFFFFFh and PAM=10   | Issue request to Hub Interface  |   |
|  | Write to 0E0000h to 0FFFFFFh and PAM=01  |   |   |
|  | 0E0000h to 0FFFFFFh and PAM=00   |   |   |
| Low/Medium Memory  | 10_0000 to EF_FFFF   | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
| ISA Hole   | F0_0000 to FF_FFFF and FDHC.HEN = 0  | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | F0_0000 to FF_FFFF and FDHC.HEN = 1  | Issue request to Hub Interface  |   |
| Low/Medium Memory (cont)   | 100_0000 <= Addr < ESMMTOP-TSEG_SZ<br>OR<br>ESMMTOP <= Addr < TOLM             | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
| Extended SMRAM Space   | ESMMTOP-TSEG_SZ <= Addr < ESMMTOP and (valid SMM access or SMM range disabled) | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|  | ESMMTOP-TSEG_SZ <= Addr < ESMMTOP and denied access to SMM space               | Master Abort.   |   |
| Low MMIO   | TOLM <= Addr < FE00_0000 and falls into a legal BASE/LIMIT range               | Request to PCI Express based on <MBASE/IMILIMIT and PMBASE/PMLIMIT> registers.  |   |
|  | TOLM <= Addr < FE00_0000 and not in a legal BASE/LIMIT range                   | Send to HI to be master aborted.  |   |

**Table 5-8. Address Disposition for Processor (Sheet 4 of 4)**

| Address Range      | Conditions  | NB Behavior   | XMB Behavior  |
|--------------------|---|---|---|
| PCI Express MMCFG  | HECBASE <= Addr < HECBASE+256MB   | Convert to a configuration access and route according to the Configuration Access Disposition.                  |   |
| NB specific        | FE00_0000h to FEBF_FFFFh AND valid NB memory mapped register address        | Issue configuration access to memory mapped register inside NB.   |   |
|                    | FE00_0000h to FEBF_FFFFh AND NOT a valid NB memory mapped register address  | Send to HI to be master aborted.  |   |
| I/O APIC registers | FEC0_0000 to FEC8_FFFFh   | Non-coherent request to PCI Express or HI based on <a href="#">Table 5-3, "IOAPIC Address Mapping"</a> .        |   |
| ICH/ICH timers     | FEC9_0000h to FED1_FFFF   | Issue request to Hub Interface.   |   |
| High SMM           | FEDA_0000h to FEDB_FFFF and (valid SMM access or SMM range disabled)        | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
|                    | FEDA_0000h to FEDB_FFFF and access denied to SMM space                      | Master Abort.   |   |
| Interrupt          | interrupt transaction to FEE0_0000h to FEEF_FFFFh (not really memory space) | Route to appropriate FSB(s). See Interrupt Chapter for details on interrupt routing.                            |   |
|                    | memory transaction to FEE0_0000h to FEEF_FFFFh                              | Send to HI to be master aborted.  |   |
| Firmware           | FF00_0000h to FFFF_FFFFh  | Issue request to Hub Interface.   |   |
| High Memory        | 1_0000_0000 to MIR5.LIMIT <sup>b</sup> (max FF_FFFF_FFFF)                   | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol. | Route the memory request to the correct rank based on the XMB.IMIR and XMB.DMIR register. |
| High MMIO          | PMBU+PMBASE <= Addr <= PMLU+PMLIMIT   | Route request to appropriate PCI Express port.  |   |
| All others         | All Others (subtractive decoding)   | Issue request to Hub Interface.   |   |

**NOTES:**

- Access is in SMM space, SMMEM# pin is asserted, and D\_OPEN, D\_CLS, D\_LCK permit access type (code or data). See [Table 5-9 "Decoding Processor Requests to SMM and VGA Spaces" on page 5-257](#)
- This is the top of legal memory. Even if IMIR5 is not a valid IMIR range, it will still be the top of memory because unused IMIR's should have the LIMIT's set to match the highest functional IMIR.



### 5.2.2.1 Processor Access to SMM Space

The FSB has a SMMEM# signal that qualifies the request asserted as having access to a system management memory. The SMM register defines SMM space that may fall in one of three ranges: A0000-BFFFFh, Extended SMRAM Space, or High SMRAM Space. The NB prevents illegal processor access to SMM memory. This is accomplished by routing memory requests from processors as a function of request address, code or data access, the SMMEM# signal accompanying request and the settings of the NB.SMRAM, NB.EXSMRC, and NB.BCTRL registers. Table 5-9 defines request type and Attribute field for each case. Illegal accesses are routed to the Compatibility Bus where they are Master Aborted. SMMEM# only affects NB behavior if it falls in an enabled SMM space. Note that the D\_CLS only applies to the Legacy (A0000-BFFFFh) SMM space. The bold values indicate the reason SMM access was denied.

D\_CLS closes off the SMM space to all accesses, except for code reads with SMMEM# asserted. EWB/IWB's will also be accepted.

**Table 5-9. Decoding Processor Requests to SMM and VGA Spaces**

| SMM region                  | Address                       | BRLC? | EWB/IWB | SMMEM# | D_OPEN | D_CLS | VGAEN | Enabled? <sup>a</sup> | Access Granted to SMM Space?            |
|-----------------------------|-------------------------------|-------|---------|--------|--------|-------|-------|-----------------------|---|
| Legacy VGA/SMM              | A_0000h <= A <= B_FFFFh       | X     | X       | X      | X      | X     | 0     | N                     | Master abort                            |
|                             |                               | X     | X       | X      | X      | X     | 1     | N                     | To VGA                                  |
|                             |                               | N     | N       | 0      | 0      | X     | N     | Y                     | Denied - HI                             |
|                             |                               | N     | N       | 0      | 0      | X     | Y     | Y                     | Denied - VGA port                       |
|                             |                               | X     | X       | X      | 1      | 0     | X     | Y                     | Yes                                     |
|                             |                               | X     | X       | X      | 1      | 1     | X     | Y                     | Illegal programming - HI (master abort) |
|                             |                               | X     | X       | 1      | 0      | 0     | X     | Y                     | Yes                                     |
|                             |                               | N     | N       | 1      | 0      | 1     | N     | Y                     | Denied - HI                             |
|                             |                               | N     | N       | 1      | 0      | 1     | Y     | Y                     | Denied - VGA port                       |
|                             |                               | X     | Y       | X      | X      | X     | X     | X                     | N/A <sup>b</sup>                        |
|                             |                               | Y     | N       | 1      | 0      | 1     | X     | Y                     | Yes                                     |
| Extended SMRAM Space (TSEG) | (TOLM-TSEG <= A <= TOLM)      | X     | X       | X      | X      | X     | X     | N                     | Access to DRAM                          |
|                             |                               | X     | N       | 0      | 0      | X     | X     | Y                     | Denied                                  |
|                             |                               | X     | N       | 0      | 1      | X     | X     | Y                     | Yes                                     |
|                             |                               | X     | N       | 1      | 0      | X     | X     | Y                     | Yes                                     |
|                             |                               | X     | Y       | X      | X      | X     | X     | X                     | Yes                                     |
| HIGHSMM                     | FEDA_0000h <= A <= FEDB_7FFFh | X     | X       | X      | X      | X     | 0     | N                     | Master abort                            |
|                             |                               | X     | N       | 0      | 0      | X     | X     | Y                     | Denied                                  |
|                             |                               | X     | N       | 0      | 1      | X     | X     | Y                     | Yes                                     |
|                             |                               | X     | N       | 1      | 0      | X     | X     | Y                     | Yes                                     |
|                             |                               | X     | Y       | X      | X      | X     | X     | X                     | Yes                                     |

**NOTES:**

- See Table 5-10, "Enabled SMM Ranges" for the definition of an enabled space
- Software must not cache this region.

Table 5-10 defines when an SMM range is enabled. All the enable bits G\_SMFRAME, H\_SMRAM\_EN, and TSEG\_EN are located in the NB.EXSMRC register.

**Table 5-10. Enabled SMM Ranges**

| Global Enable<br>G_SMFRAME | High Enable<br>H_SMRAM_EN | TSEG Enable<br>TSEG_EN | Legacy SMM<br>Enabled? | HIGHSMM<br>Enabled | Extended SMRAM<br>Space (TSEG)<br>Enabled? |
|----------------------------|---------------------------|------------------------|------------------------|--------------------|--|
| 0                          | X                         | X                      | No                     | No                 | No   |
| 1                          | 0                         | 0                      | Yes                    | No                 | No   |
| 1                          | 0                         | 1                      | Yes                    | No                 | Yes  |
| 1                          | 1                         | 0                      | No                     | Yes                | No   |
| 1                          | 1                         | 1                      | No                     | Yes                | Yes  |

## 5.2.3 Inbound Transactions

In general, inbound I/O transactions are decoded and dispositioned similarly to processor transactions. The key differences are in SMM space, memory mapped configuration space and interrupt policies.

For all table entries where an access is forwarded to HI to be master aborted, if an access comes from HI, the NB may master abort a transaction without forwarding it back to the HI.

**Table 5-11. Address Disposition for Inbound Transactions (Sheet 1 of 3)**

| Address<br>Range  | Conditions                                       | NB Behavior   | XMB Behavior   |
|---|--|---|--|
| DOS   | 0 to 09FFFFh                                     | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
| SMM/VGA   | 0A0000h to 0BFFFFh, SMM not enabled, and VGAEN=0 | Send to HI to be master aborted.  | N/A  |
|   | (0A0000h to 0BFFFFh and SMM enabled and VGASE=0  | Send to HI to be master aborted.  | N/A  |
|   | 0A0000h to 0BFFFFh and VGAEN=1                   | VGA:<br>Non-coherent request to PCI Express or Hub Interface based on BCTRL and various SMM registers.  | N/A  |
| C, D, E, and F BIOS segments<br>(see Table 5-1 for a definition of PAM encodings) | 0C0000h to 0FFFFFFh and PAM = 11 <sup>a</sup>    | Non-coherent request to main memory. (Coherency does not need to be guaranteed. Coherency protocol can be followed if it simplifies implementation.) Route to appropriate XMB according to NB.IMIR registers. | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
| Low/Medium Memory   | 10_0000 to EF_FFFF                               | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.   | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |

**Table 5-11. Address Disposition for Inbound Transactions (Sheet 2 of 3)**

| Address Range            | Conditions   | NB Behavior  | XMB Behavior   |
|--------------------------|--|--|--|
| ISA Hole                 | F0_0000 to FF_FFFF and FDHC.HEN = 0  | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.  | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
|                          | F0_0000 to FF_FFFF and FDHC.HEN = 1  | Issue request to Hub Interface.  |  |
| Low/Medium Memory (cont) | 100_0000 <= Addr < TOLM-TSEG_SZ  | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol.  | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
| Extended SMRAM Space     | ESMMTOP-TSEG_SZ <= Addr < ESMMTOP  | TSEG SMM enabled: Master Abort.<br>TSEG SMM disabled: Issue request to main memory.  |  |
| Low MMIO                 | TOLM <= Addr < FE00_0000 and falls into a legal BASE/LIMIT range           | Request to PCI Express based on <IMIBASE/IMILIMIT and PMBASE/PMLIMIT> registers.   |  |
|                          | TOLM <= Addr < FE00_0000 and not in a legal BASE/LIMIT range               | Send to HI to be master aborted.   |  |
| PCI Express MMCFG        | HECBASE <= Addr < HECBASE+256MB  | Inbound MMCFG is allowed when dis_inb_cfg configuration bit is cleared, and, the NB does not modify addresses of peer-to-peer transactions.<br><br>Inbound MMCFG is not allowed when dis_inb_cfg configuration bit is set. This access should be routed as a general memory mapped I/O access, which should ultimately master abort, since it should not hit any legal MMIO range. |  |
| NB specific              | FE00_0000h to FEBF_FFFFh AND valid NB memory mapped register address       | Inbound MMCFG is not allowed. This access should be routed as a general memory mapped I/O access, which should ultimately master abort, since it should not hit any legal MMIO range.  |  |
|                          | FE00_0000h to FEBF_FFFFh AND NOT a valid NB memory mapped register address | Send to HI to be master aborted.   |  |
| I/O APIC registers       | FEC0_0000 to FEC8_FFFFh  | Non-coherent request to PCI Express or HI based on <a href="#">Table 5-3, "IOAPIC Address Mapping"</a>   |  |
| ICH/ICH timers           | FEC9_0000h to FED1_FFFF  | Issue request to Hub Interface.  |  |
| High SMM                 | FEDA_0000h to FEDB_FFFF  | Master Abort.  |  |
| Interrupt                | Inbound write to FEE0_0000h - FEEF_FFFFh                                   | Route to appropriate FSB(s). See Interrupt Chapter for details on interrupt routing.   |  |
|                          | memory transaction to FEE0_0000h to FEEF_FFFFh                             | Send to HI to be master aborted.   |  |

**Table 5-11. Address Disposition for Inbound Transactions (Sheet 3 of 3)**

| Address Range | Conditions                                   | NB Behavior   | XMB Behavior   |
|---------------|--|---|--|
| Firmware      | FF00_0000h to FFFF_FFFFh                     | Master abort.   |  |
| High Memory   | 1_0000_0000 to MIR5.LIMIT (max FF_FFFF_FFFF) | Coherent Request to Main Memory. Route to main memory according to NB.IMIR registers. Apply Coherence Protocol. | Route the coherent request to the correct rank based on the XMB.IMIR and XMB.DMIR registers. |
| High MMIO     | PMBU+PMBASE <= Addr <= PMLU+PMLIMIT          | Route request to appropriate PCI Express port.  |  |
| All others    | All Others (subtractive decoding)            | Issue request to Hub Interface.   |  |

**NOTES:**

- a. Other combinations of PAM's are not allowed if inbound accesses to this region can occur. Just like Cayuse, chipset functionality is not guaranteed.

## 5.3 I/O Address Map

The I/O address map is separate from the memory map and is primarily used to support legacy code/drivers that use I/O mapped accesses rather than memory mapped I/O accesses. Except for the special addresses listed in [Section 5.3.1, “Special I/O Addresses”](#), I/O accesses are decoded by range and sent to the appropriate HI/PCI Express port, which will route the I/O access to the appropriate device.

### 5.3.1 Special I/O Addresses

There are two classes of I/O addresses that are specifically decoded by the NB:

- I/O addresses used for VGA controllers.
- I/O addresses used for the PCI Configuration Space Enable (CSE) protocol. The I/O addresses 0CF8h and 0CFCh are specifically decoded as part of the CSE protocol.

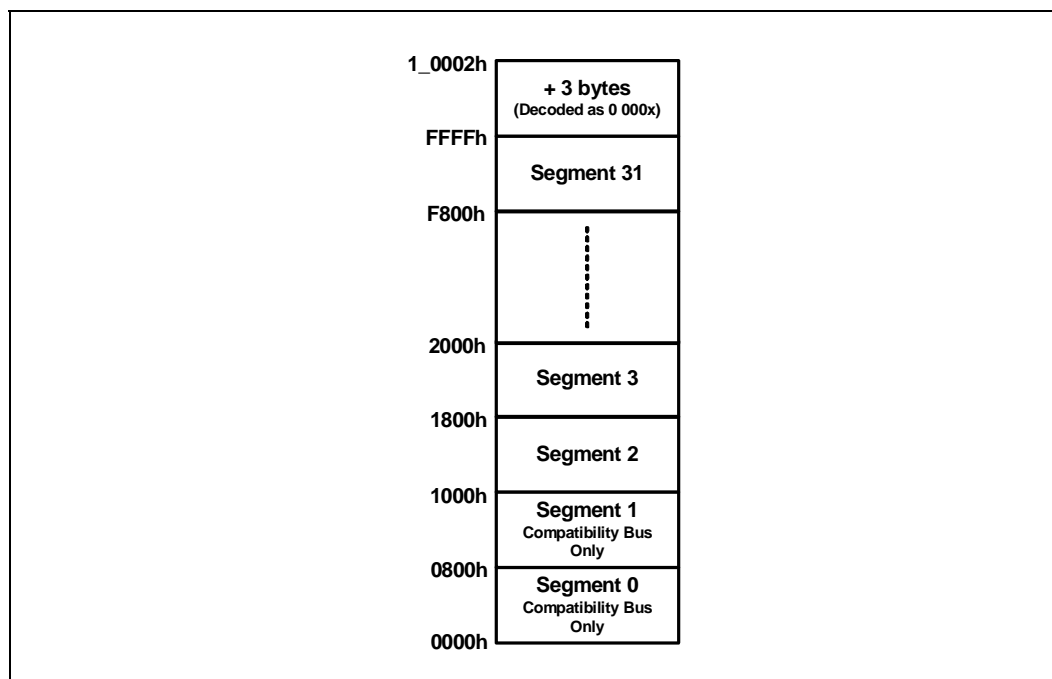
Historically, the 64 KB I/O space actually was 64 K+3 bytes. For the extra 3 bytes, A#[16] is asserted. The NB decodes only A#[15:3] when the request encoding indicates an I/O cycle. Therefore accesses with A#[16] asserted are decoded as if they were accesses to address 0 and be forwarded to the Compatibility Bus.

At power-on, all I/O accesses are mapped to the Compatibility Bus.

### 5.3.2 Outbound I/O Access

The NB chipset allows I/O addresses to be mapped to resources supported on the I/O buses underneath the NB. This I/O space is partitioned into 32 x 2KB segments. Each of the I/O buses can have from 0 to 32 segments mapped to it. Each PCI bus gets contiguous blocks. All PCI busses must be assigned contiguous blocks. The lowest block, from 0 to 0FFFh, is always sent to the Compatibility Bus. For further details on the legacy I/O ranges that the ICH decodes in the lowest block, please refer to *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 (ICH5R) Datasheet*. The ICH5 Datasheet is available at: <http://developer.intel.com/design/chipsets/datashts>.

Figure 5-7. System I/O Address Space



### 5.3.2.1 Outbound I/O Transaction Routing

The NB applies these routing rules in order:

(A[2:0] for the following is not physically present on the FSB, but are calculated from BE[7:0]).

1. **I/O addresses used for VGA controllers on PCI Express:**

If one of the BCTRL.VGAEN bit is set, and each addressed byte is in the following range:

A[9:0] = 3B0h-3BBh, 3C0h-3DFh. (A[15:10] are ignored for this decode.)

The access is sent to the PCI Express port that VGAEN is set for. Note that only one VGAEN bit can be set.

For example, a 2 byte read starting at X3BBh includes X3BB-X3BCh (X can be any number since A[15:10] are ignored).

Since A[9:0] = 3BCh which is not one of the VGA bytes, the access is not routed to VGA.

2. **Configuration accesses:** If a request is a DW accesses to 0CF8h (See CFGDAT register) or 1-4 B accesses to 0CFCh with configuration space is enabled (See bit 31 of CFGADR register), the request is considered a configuration access. Configuration accesses are routed based on the bus and device numbers.

3. **ISA Aliases:** If the BCTRL.ISAEN is set, addresses X100-X3FFh, X500-X7FFh, X900-XBFF, and XD00-XFFFh will result in the access being sent out to the Hub Interface (ICH5). This is the top 768B in each 1KB block. 100 = 256B 3FF = 1K-1

4. **I/O defined by IOBASE/IOLIMIT:** If PCICMD.IOAE is set in any of the NB PCI Express devices and the I/O address falls in this range: (IOBASE <= address <= IOLIMIT), then the access will be sent to the PCI Express port that is defined by the correct IOBASE/IOLIMIT registers.

5. **Otherwise:** the I/O Read/Write is sent to HI (ICH5).

### 5.3.3 Inbound I/O Accesses

Inbound I/O's are supported only for peer-to-peer accesses and are decoded the same as processor initiated I/O's. Inbound I/O accesses to the NB (i.e. CF8/CFC) are not supported and will receive a Master Abort response.

§

## 6 Functional Description

This chapter will cover the Intel® E8501 chipset north bridge (NB) functionality and its interface components, including Front Side Bus, IMI, PCI Express and Hi1.5. The *Intel® E8501 Chipset North Bridge (NB) Datasheet* shall only cover the NB component. Details on the rest of the platform components can be found in each component's respective documentation.

### 6.1 Processor Support

The NB is the priority agent for the two FSB's and is optimized for two 64-bit Intel® Xeon® Processor MP on each bus. The Intel® E8501 chipset does not allow mixing of 64-bit Intel® Xeon® processor MP with up to 8MB L3 cache, 64-bit Intel® Xeon® processor MP with 1MB L2 cache or Dual-Core Intel® Xeon® processor 7000 sequence within the same platform.

**Table 6-1. FSB Feature Summary**

| Feature   | Description  |
|---|--|
| Cache Line Size                                       | 64B  |
| Clock Rate  | Control@166 MT/s, Address@333 MT/s, Data@667 MT/s.<br>Control@200 MT/s, Address@400 MT/s, Data@800 MT/s  |
| Addresses   | NB supports 40 address bits.   |
| Enhanced Defer  | NB responds using Defer phase when DPS is asserted.  |
| Modified Enhanced Defer                               | NB typically drives IDS# 5 clocks before OOD#.   |
| Maximum Deferred Transactions                         | 32   |
| Maximum In-Order Transactions                         | 12   |
| ECC/Parity  | NB supports both DEP[7:0]# and DP[3:0]# but not at the same time.  |
| BRIL.OWN  | NB ignores the OWN bit.  |
| BWLD  | 64-bit Intel® Xeon® processor MP processors do not issue this transaction.   |
| BWL.INVLD   | Disabled and treated as a BWL.   |
| Threads/cores   | NB fully supports 4 logical agents per FSB.  |
| Modified response following clean snoop (buried HITM) | NB supports this for debug, but not for production. The solution will not be performance optimized. Buried HITM is inconsistent with enhanced defer. |
| Processor Tristate                                    | A[39:36] at reset (see <a href="#">Section 4.14.12, "POC_FSB{A/B}: Power-on Configuration (D16, F0)"</a> on page 168).                               |

## 6.1.1 Clock Phasing

The FSB clocks run in phase.

## 6.1.2 Arbitration Phase

The following table shows the arbitration phase signals and the NB usage.

**Table 6-2. Arbitration Signals**

| Signal     | Usage  |
|------------|--|
| BPRI#      | NB asserts this signal when it will drive requests that require a snoop or when it wants to stall the FSB, or to avoid oversubscription of certain internal resources. Processors do not drive this signal.  |
| BNR#       | NB may assert this signal for debug.   |
| BREQ[3:0]# | The NB never drives these signals, except for BREQ[0]# at reset. These pins are connected to the processor BR# pins in a rotating order.<br>The NB uses an active BREQ# from a processor to determine if it should release BPRI# and return the bus to the processors. |
| LOCK#      | The NB never asserts LOCK#. The NB observes LOCK# and will do all transactions with LOCK# asserted atomically. LOCK# on I/O reads or writes is an illegal transaction.   |

## 6.1.3 Symmetric/Priority Agent Arbitration Policy

NB asserts BPRI# as necessary for flow control, and this overrides any arbitration policy on BPRI#.

NB asserts BPRI# for NB transactions only when it has transactions to drive to the bus, and it's not giving priority to CPU agents. NB limits the length of time it will assert BPRI by FSB[1:0]AC.TNBREQ[2:0]. When a CPU asserts a BREQ# signal on the bus, NB will give the bus to the CPUs as long as NB has no transactions to do. Otherwise, NB ensures BPRI stays deasserted for a period of time controlled by FSB[1:0]AC.CPUREQ[1:0]. If NB sees a BREQ change while BPRI is released, FSB[1:0]AC.CPUREQ\_EXT controls whether NB allows an extra transaction to occur from the CPUs, to try to make back-to-back BWL's more likely.

NB's arbitration policy is such that as long as CPUs drive their BREQ signals efficiently (releasing it if they have no transactions to perform) and drive ADS as soon as possible when the protocol allows, that NB and the CPUs can share the bus with no dead cycles under any traffic pattern.

## 6.2 Request Phase

Table 6-3 defines how NB decodes transactions initiated by processors and Table 6-5 defines how NB drives transactions. NB self-samples the common-clock signals. NB does not sample the address or data signals but instead tracks what it has driven internally.

Reserved Read and Write transactions are not issued by 64-bit Intel® Xeon® processor MP. NB will complete these transactions as the most similar well defined transactions in order to enable subsequent transactions to complete. NB will respond to Reserved Read (ReqA[0]=0) as a NOP, returning data from the addressed memory. NB will respond to Reserved Write (ReqA[0]=1) as a BTM.



BWL with DEN is not issued by 64-bit Intel® Xeon® processor MP. The NB will not defer any BWL.

If a Deferred Reply is decoded, but the NB has not issued it, the NB will treat it as NOP and set FSB\_FERR.F8 (refer to [Table 6-39 “Errors Detected by the NB” on page 6-328](#)).

If DEN is not asserted when it is shown to be 1 in [Table 6-3](#), the NB will defer anyway. The “Unsupported FSB Transaction” bit will be set in the FERRST or SERRST register if these are decoded.

If an address/request parity error is detected, the NB will attempt to complete the decoded bus transaction on a best effort basis as if no error has been detected and at the same time log an F4 error. The NB will remain operational after such an error.

NB does require ASZ# (ReqA#[4:3] for memory transactions) to be correct for correct operation.

DSZ# (ReqB#[4:3] for most transactions) has no effect on NB operation.

In the following table “x” indicates that the NB will treat either 0 or 1 the same way; the bit is ignored. “0/1” indicates that the NB will treat 0 different from 1. Both 0 and 1 should be validated for both “x” and “0/1” entries.

**Table 6-3. Processor Initiated Transactions Supported by Intel® E8501 Chipset North Bridge (NB) (Sheet 1 of 2)**

| Transaction | Variant        | Support | Ab combinations decoded |       |      |      |           |           |              |
|-------------|----------------|---------|-------------------------|-------|------|------|-----------|-----------|--------------|
|             |                |         | BE#[7:0]                | LOCK# | DEN# | DPS# | Ab[5]     | Ab[6]     | Ab[7] SMMEN# |
| BRIL        | BRIL           | yes     | FFh                     | 0     | 1    | 0/1  | 0/1 (OWN) |           | 0/1          |
|             | BRIL.OWN       | yes     | FFh                     | 0     | 1    | 0/1  | 0/1 (OWN) |           | 0/1          |
|             | BIL            | yes     | 0                       | 0     | 1    | 0/1  | x (OWN)   |           | 0/1          |
| BRLC        | BRLC           | yes     | contiguous              | 0     | 1    | 0/1  | x (OWN)   |           | 0/1          |
| BRLD        | BRLD           | yes     | contiguous              | 0     | 1    | 0/1  | x (OWN)   |           | 0/1          |
|             | BLR            | yes     | contiguous              | 1     | 1    | x    | x         | x         | 0/1          |
| BWL         | INVLD#=0, NZ   | yes     | FFh                     | 0     | 0    | 0    | x         | 0 (INVLD) | 0/1          |
|             | INVLD#=0, Z    | yes     | 00h                     | 0     | 0    | 0    | x         | 0 (INVLD) | 0/1          |
|             | BWL.INVLD NZ   | yes     | FFh                     | 0     | 0    | 0    | x         | 1 (INVLD) | 0/1          |
|             | BWL.INVLD Z    | yes     | 00h                     | 0     | 0    | 0    | x         | 1 (INVLD) | 0/1          |
|             | DEN#           | no      | any                     | 0     | 1    | 1    | x         | x         | 0            |
| BWIL        | BLW            | yes     | ?                       | 1     | 0    | 0    | x         | 0         | 0/1          |
|             | BWIL           | yes     | any                     | 0     | 0/1  | 1    | x         | 0         | 0/1          |
| IACK        | IACK           | yes     | 1h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
| SPEC        | NOP            | yes     | 0h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | Shut Down      | yes     | 1h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | Flush          | yes     | 2h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | Halt           | yes     | 3h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | SYNC           | yes     | 4h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | Stop Clock     | yes     | 5h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | Stop Grant Ack | yes     | 6h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | SMIACK         | yes     | 7h                      | 0     | 1    | 0/1  | 0         | 0         | x            |
|             | XTPR Update    | yes     | 8h                      | 0     | 0    | 0    | 0         | 0         | x            |
| BTM         | BTM            | yes     | FFh                     | ?     | 0    | 0    | 0         | 0         | x            |

**Table 6-3. Processor Initiated Transactions Supported by Intel® E8501 Chipset North Bridge (NB) (Sheet 2 of 2)**

|          |                |     | Ab combinations decoded |   |   |   |   |     |   |
|----------|----------------|-----|-------------------------|---|---|---|---|-----|---|
| INT/EOI  | INT            | yes | "3h,Fh"                 | 0 | 0 | 0 | 0 | 0/1 | x |
|          | EOI            | yes | 1h                      | 0 | 0 | 0 | 1 | 1   | x |
| IOR      | IOR            | yes | contiguous              | 0 | 1 | 1 | x | x   | x |
| IOW      | IOW            | yes | 4B boundary             | 0 | 1 | 1 | x | x   | x |
| Reserved | Reserved Read  | no  |                         |   |   |   |   |     |   |
|          | Reserved Write | no  |                         |   |   |   |   |     |   |

The following tables show how the NB decodes the 2nd phase of the address.

**Table 6-4. Intel® E8501 Chipset North Bridge (NB) Decoding of 2nd Phase of Address**

| Ab    | Signal     | Definition               | NB Usage  |
|-------|------------|--------------------------|---|
| 39:36 | reserved   | Reserved                 | Does not affect NB operation.   |
| 35:32 | reserved   | Snoop Count              | Does not affect NB operation.   |
| 31    | ATTR[7]#   | XTPR Disable             | Redirection Disable for XTPR update transaction, ignored otherwise  |
| 30:29 | ATTR[6:5]# | Logical ID               | NB uses this field to differentiate transactions from different logical processors (threads or cores) within a CPU package.   |
| 28    | ATTR[4]#   | Undefined                | Does not affect NB operation  |
| 27:24 | ATTR[3:0]# | Task Priority            | Interrupt Redirection Task Priority for XTPR update transaction   |
|       |            | Caching Attributes       | NB ignores.   |
| 23    | DID[7]#    | Priority/Symmetric Agent | 0 since processors are symmetric agent  |
| 22:21 | DID[6:5]#  | Agent ID                 | Returned on defer Reply Or IDS#   |
| 20:16 | DID[4:0]#  | Transaction ID           | Returned on defer reply or IDS#.  |
| 15:8  | BE[7:0]#   | byte enables             | Indicates which bytes are valid in a data transfer.   |
| 7     | EXF[4]#    | SMMEM#                   | The NB will generally disallow access to SMM memory unless this bit is set. However, when SMM memory is made cacheable, writes may be evicted without this bit set. |
| 6     | EXF[3]#    | SPLCK#                   | If LOCK# is asserted, the NB ignores this signal. It uses LOCK# to decode locked reads and writes.  |
|       |            | INVLD#                   | If the transaction is a BWL, INVLD#=1 indicates that the processor will invalidate the line   |
|       |            | INT[1]#                  | If the transaction is a Interrupt or EOI, differentiates different interrupt types  |
| 5     | EXF[2]#    | OWN#                     | NB ignores.   |
|       |            | INT[0]#                  | If the transaction is a Interrupt or EOI, differentiates different interrupt types  |
| 4     | EXF[1]#    | DEN#                     | The NB needs to defer a transactions to ensure coherency, and the DEN is not set, the NB will defer anyway and will detect error F8.                                |
| 3     | EXF[0]#    | DPS#                     | If set, the NB may complete the transaction with a deferred phase (IDS# assertion).   |

## 6.2.1 16-Thread Support

The NB supports up to 16 total threads automatically, in case of 2 dual-core CPUs per FSB of 2 threads each.

## 6.2.2 Intel® E8501 Chipset North Bridge (NB) Requests

Table 6-5 and Table 6-6 show what the NB drives on the FSB. Table 6-5 shows REQ and address driven for the first cycle. Table 6-6 shows the 2nd phase of the address. Any bits not specifically mentioned are driven to 0.

**Table 6-5. Encoding of Transactions Initiated by the Intel® E8501 Chipset North Bridge (NB)**

| Common Bus Transaction          | NB Transaction | REQa               | REQb <sup>a</sup>  | Aa[39:3]   |
|---------------------------------|----------------|--------------------|--------------------|--|
| Deferred Reply                  | Deferred Reply | 00000              | 11011 <sup>b</sup> | A[39:24]=0   |
|                                 |                |                    | 11000 <sup>c</sup> | A[23:16] = DID[7:0] of original transaction<br>A[15] = Early indication of HIT#<br>A[13] = Debug information (DBGMATCH)<br>A[12:8] = Debug information (PTQID[4:0])<br>A[3] = A[3] of original request |
| Zero Length Bus Read Invalidate | BIL            | zz010 <sup>d</sup> | 11000              | Address from other FSB, PCI Express, or Hub Interface  |
| Bus Read Line Code              | BRLC           | zz100              | 11000              | Address from other FSB, PCI Express, or Hub Interface  |
| Bus Read Line Data              | BRLD           | zz110              | 11000              | Address from other FSB   |
| Interrupt                       | INT            | 01001              | 11100              | 0_FEEy_yyy0  |

**NOTES:**

- RCNT[3:2] are driven on REQb[4:3] if FSB[1:0]AC.DRVCNT is set
- 64B of data will follow
- Less than 64B of data will follow.
- zz = ASZ[1:0]

**Table 6-6. Encoding 2nd Phase of Address for Transactions Initiated by Intel® E8501 Chipset North Bridge (NB) (Sheet 1 of 2)**

| Ab    | Signal     | Definition         | NB Drives   |
|-------|------------|--------------------|---|
| 39:36 | Reserved   | Reserved           | Debug information:<br>SRCINFO[3:0] if FSB[1:0]AC.DRVCNT = 1, else 0000. |
| 35:32 | Reserved   | Snoop Count        | Debug information:<br>SCNT[3:0] if FSB[1:0]AC.DRVCNT = 1, else 0000.    |
| 31    | ATTR[7]#   | XTPR Disable       | 0   |
| 30:29 | ATTR[6:5]# | Logical ID         | 0   |
| 28:27 | ATTR[4]#   | Undefined          | RCNT[1:0] is driven when the FSB[1:0]AC.DRVCNT bit is set.              |
| 26:24 | ATTR[2:0]# | Caching Attributes | 111 (writeback)   |
| 23    | DID[7]#    | Agent ID           | 1   |

**Table 6-6. Encoding 2nd Phase of Address for Transactions Initiated by Intel® E8501 Chipset North Bridge (NB) (Sheet 2 of 2)**

| Ab    | Signal    | Definition               | NB Drives  |
|-------|-----------|--------------------------|--|
| 22:16 | DID[6:0]# | Agent ID, Transaction ID | Debug information:<br>CDCID[6:0]                   |
| 15:8  | BE[7:0]#  | Byte Enables             | 11111111 Data present<br>00000000 No data          |
| 7     | EXF[4]#   | SMMEN#                   | 0  |
| 6     | EXF[3]#   | INT1                     | 0  |
| 5     | EXF[2]#   | INT0                     | A[5] on IPI for redirected interrupt, otherwise 0. |
| 4     | EXF[1]#   | DEN#                     | 0  |
| 3     | EXF[0]#   | DPS#                     | 0  |

## 6.2.3 Snoop Phase

The snoop phase consists of the following signals: HIT#, HITM#, DEFER#.

The NB can retry a deferred reply that it initiated in order to cause the processor to retry it to fix some BIL conflict cases and buried HITM cases.

The NB requires that any agent that asserts HITM# on a transaction must drive data. It may not drive HITM# and then respond with no data when given a TRDY#. If it does not provide data, the NB cannot guarantee correct operation.

**Table 6-7. Snoop Phase Signals**

| Signal      | Usage   |
|-------------|---|
| HIT#, HITM# | For a deferred BRCL and BRLD, if HIT# is asserted on the local FSB or the remote FSB (if snooped), the shared status will be driven during the deferred completion. Either DHIT# will be driven active during defer phase, or HIT# will be driven during snoop phase of the deferred reply.<br>NB only snoop stalls as a debug function.<br>If HITM# is asserted (and HIT# de-asserted) on a processor transaction, NB will response with an implicit-write back. |
| DEFER#      | The NB will assert DEFER# followed by a DEFER or RETRY response. The NB never gives a DEFER response to requests that it initiates.   |

## 6.2.4 Response Phase

Table 6-3 defines the responses that the NB gives to each FSB transaction. Table 6-5 defines the responses the NB gives to each NB transaction. The conditions are evaluated in the order given, that is the higher condition has priority.

When a request decode is in doubt, the NB will respond in the way that is most likely to keep these processors running. For example, the NB will respond to the transaction it decodes whether an Address/Request Parity error is detected or not. When a transaction is decoded that is not supported by the NB, the NB will treat them as the closest transaction it has been designed to support.

If a coherency violation occurs, the NB will complete the transaction as best it can (e.g deferring memory reads even if DEN=0, giving IWB response to illegal HITM's), but any data delivered after the violation may not be correct.

**Table 6-8. Intel® E8501 Chipset North Bridge (NB) Responses to Processor Transactions**

| Transaction Type                                   | Conditions  | Response    |
|--|---|-------------|
| BIL  | IF modified snoop response<br>(Coherency Protocol Violation: set Unsupported Bus transaction bit in FERRST or SERRST)<br>(can't have illegal data size; is defined to be zero length) | IWB         |
|  | ELSEIF NB has established a system lock   | Retry       |
|  | ELSEIF BIL Conflict   | Defer       |
|  | ELSE  | Defer       |
| BRIL,<br>BRLC,<br>BRLD                             | IF modified snoop response  | lwb         |
|  | ELSEIF NB has established a system lock   | Retry       |
|  | ELSE  | Defer       |
| BLR  | IF modified snoop response  | lwb         |
|  | ELSEIF<br>(NB has not yet established a system lock) OR<br>(NB has ordered another BLR from either bus first, and that BLR is not yet complete)                                       | Retry       |
|  | ELSE  | Normal Data |
| BWL  | All   | No Data     |
| BWIL   | IF modified snoop response  | lwb         |
|  | ELSEIF NB has established a system lock   | Retry       |
|  | ELSE  | Defer       |
| BLW  | All   | No Data     |
| IOR, IOW   | IF NB has established a system lock.  | Retry       |
|  | ELSE  | Defer       |
| Reserved Ignore                                    | All   | No Data     |
| Reserved Write                                     | IF REQa[2:0] == 011 (treat as BWL)  | No Data     |
|  | ELSE (treat as BTM)   | No Data     |
| Reserved Read                                      | all (treat as NOP)  | No Data     |
| IACK, HALT<br>Shut Down,<br>Stop Grant Ack,        | The NB has established a system lock.   | Retry       |
|  | ELSE  | Defer       |
| NOP,FLUSH,<br>SYNCH,SMIACK,<br>XTPR Update,<br>BTM | All   | No Data     |
| INT  | IF NB has established a system lock and interrupt is redirectable   | Retry       |
|  | ELSE  | No Data     |
| EOI  | IF NB has established a system lock   | Retry       |
|  | ELSE  | No Data     |
| Deferred Reply                                     | If the NB did not issue. The processor may not issue this transaction.  | No Data     |

Table 6-4 defines the various outcomes of the defer response.

**Table 6-9. Defer Response Outcomes**

| Conditions  | Response  |
|---|---|
| If buried HITM#.)   | Deferred Reply with Retry response  |
| Elseif BIL conflict   | Deferred reply with retry response  |
| Elseif DPS was asserted with transaction and FSB[1:0]AC.MEDEN=0 and not a BIL | Deferred Phase with IDS# and OOD# always asserted together (Enhanced Defer)               |
| Elseif DPS was asserted with transaction and FSB[1:0]AC.MEDEN=1 and not a BIL | Deferred Phase with IDS# and OOD# sometimes asserted separately (Modified Enhanced Defer) |
| Elseif NB will transfer data to processor                                     | Deferred Reply with Normal Data response  |
| Elseif  | Deferred Reply with No Data response  |

**Table 6-10. Intel® E8501 Chipset North Bridge (NB) Responses to Intel® E8501 Chipset North Bridge (NB) Transactions**

| Transaction Type | Conditions   | Response    |
|------------------|--|-------------|
| Deferred Reply   | If Buried HITM# or BIL conflict is detected                                  | Retry       |
|                  | Elseif original transaction requires that NB transfer data to the processor. | Normal Data |
|                  | Else   | No Data     |
| BIL, BRLD, BRLC  | HITM# asserted   | IWB         |
|                  | Else   | No Data     |
| INT              | always   | No Data     |

## 6.2.5 Defer Phase

**Table 6-11. Defer Phase Signals**

| Signal   | Intel® E8501 Chipset North Bridge (NB) Usage   |
|----------|--|
| IDS#     | A strobe that indicates the NB is completing a deferred transaction. The chipset returns ownership to the requesting processor when IDS# is asserted. That is, the NB no longer has snoop responsibility for an ADS asserted subsequent to an IDS# assertion. When IDS# is active, ID[7:0] is valid. If the NB will not return data for the transaction, the transaction is completed. If the NB will return data, it will come with the concurrent or next OOD# assertion. Only the NB drives IDS#, so it may be asserted once every two clocks.  |
| ID[7:0]# | Valid while IDS# is asserted. The first phase carries the transaction ID sent in the request phase of the deferred transaction. The second phase of ID carries information about the snoop results of the transaction. The NB asserts DHIT# for BRLD's if the address potentially remains shared in another agent. That is, when HIT# was asserted in the snoop phase for the original transaction or when it was snooped on the other bus.<br>If FSB[1:0]AC.DRVDCNT is set, the NB will drive DCNT on ID[7:5]#. DCNT is defined to be (number of DDEL# assertions - number of OOD# assertions) on the cycle before IDS#.<br>If FSB[1:0]AC.DRVCDBD is set, the NB will drive debug information onto the ID[7:0]# signals such that:<br>IDa[7] = CDCID[6]<br>IDb[7:5] = CDCID[5:3]<br>IDb[2:0] = CDCID[2:0]<br>NB never asserts DHITM# in response to a BRIL.OWN. |
| OOD#     | This is a data phase signal. See <a href="#">Table 6-13</a> .  |

### 6.2.5.1 Modified Enhanced Defer

The NB has an OOD# pin that enables IDS# assertion to give advance notice that a data transfer will occur. IDS# commits the order of deferred phase data transfers, but OOD# indicates when data will be driven.

After reset, the NB will drive OOD# coincident with IDS#. The bus protocol is defined such that this is equivalent to enhanced defer with no early data indication. The processor can sample IDS# but not OOD#. Once the processor is configured to sample both IDS# and OOD#, the FSB{A/B}\_AC.MEDEN bit will be set to enable the NB to drive IDS# before OOD#.

When data is returned from the other FSB (Remote HITM#/IWB), the NB will not drive IDS until after TRDY# has been asserted on the remote FSB. If NB asserted IDS# before TRDY# on the remote bus, IDS# might be asserted on both FSB's for a remote HITM, but TRDY# could not enable the IWB transfer on either bus due to the deadlock rule.

When data is returned from memory, the NB will drive IDS# as soon as it can after getting a read return header on an IMI (assuming coherency has already been completed) or after sampling TRDY# for an IWB from the other FSB.

## 6.2.6 Data Phase

### 6.2.6.1 Data Transfer Sizes

Table 6-12 defines limitations on the transfer sizes and alignments supported by the Intel® E8501 chipset north bridge (NB). The NB does not support all possible transfer sizes defined by Intel® Xeon® processor family. The NB supports all alignments generated by the 64-bit Intel® Xeon® processor MP profile. When the NB cannot support a length, the length is aliased to a supported length and no error is logged.

Address alignment does not affect which bytes are transferred, but only their order.

**Table 6-12. Processor Transfer Sizes and Alignment limitations of the Intel® E8501 Chipset North Bridge (NB) (Sheet 1 of 2)**

| Transaction Type | LEN#,BE# | Alignment | Comment   |
|------------------|----------|-----------|---|
| BRLC             | 64       | Any 8B    | Data is returned in critical word first order.  |
|                  | 1-8      |           | Not needed for 64-bit Intel® Xeon® processor MP.  |
|                  | 0        |           |   |
| BRLD             | 64       | Any 8B    | Data is returned in critical word first order.  |
|                  | 1-8      |           |   |
|                  | 0        |           |   |
| BRIL             | 64       | Any 8B    | Only 64B for 64-bit Intel® Xeon® processor MP.  |
| BIL              | 0        | Any 8B    |   |
| BLR,BLW          | 1-8      | Any 8B    | Validation must cover cases where the sum of the BE in the BLR's or BWL's total up to 16 bytes. |

**Table 6-12. Processor Transfer Sizes and Alignment limitations of the Intel® E8501 Chipset North Bridge (NB) (Sheet 2 of 2)**

| Transaction Type | LEN#,BE# | Alignment | Comment  |
|------------------|----------|-----------|--|
| BWIL             | 64       | Any 8B    | Data is received in critical word first order  |
|                  | 1-8      |           | Any combination of byte enables are legal. The BE do not need to be contiguous and any number from 0-8 may be asserted. For example, patterns such as 0001_1111, 0001_0101, 0101_0101 or 1010_1111 are allowed.<br><b>Note:</b> Downstream devices may not be able to support these unrestricted patterns of BE if the address maps to a MMCFG region. |
|                  | 0        |           | NB will assert TRDY for memory writes with zero data length but the processor will not assert any data transfer signals.   |
| BWL              | 64B      | Any 8B    | NB will assert TRDY for memory writes with zero data length but the processor will not assert any data transfer signals.   |
|                  | 0        |           |  |
| I/O read         | 1-4 byte | Any 8B    | the NB ignores the LEN field. Therefore, if LEN is other than "8 bytes or less" the transaction will be handled as usual and no error will be detected.  |
| I/O write        | 1-4 byte | Any 8B    | the NB ignores the LEN field. Therefore, if LEN is other than "8 bytes or less" the transaction will be handled as usual and no error will be detected. BE may NOT cross 4B boundary.  |
| IACK             | n/a      | n/a       | Reqb[2:0] =000, Address ignored.   |
| SPEC             | n/a      | n/a       | Reqb[2:0] =001, Address ignored.   |
| BTM              | n/a      | n/a       | Reqb[2:0] =000, Address ignored.   |
| INT              | 2B or 4B | n/a       | Address field holds other information.   |
| EOI              | 1B       | n/a       | Address is meaningless.  |
| XTPR_UPDATE      | ?        | n/a       | Address is meaningless.  |

### 6.2.6.2 Data Transfer Signals

Table 6-13 shows the signals used for data transfers.

**Table 6-13. Data Transfer Signals (Sheet 1 of 2)**

| Signal            | NB Usage  |
|-------------------|---|
| H_{A/B}_TRDY#     | Signals that a symmetric agent may transfer either Write or Implicit-Writeback data.                                  |
| H_{A/B}_DBSY#     | The data bus is owned by some agent that cycle. Does not imply that data is necessarily being transferred that cycle. |
| H_{A/B}_DRDY#     | data is valid. NB asserts for read data.  |
| H_{A/B}_D[63:0]#  | 64 bits of data transferred at 4x the bus clock frequency.  |
| H_{A/B}_DEP[7:0]# | ECC coverage over D[63:0].<br>Transferred at 4x the bus clock frequency.  |
| H_{A/B}_DP[3:0]#  | Odd parity over DBI and D[63:0].<br>DP must be disabled if DEP is used.   |



**Table 6-13. Data Transfer Signals (Sheet 2 of 2)**

| Signal                                      | NB Usage   |
|---|--|
| H_{A/B}_DBI[3:0]#                           | Each DBI bit is associated with 16 data lines and 2 ECC lines. If most of any of the 18 bits in a group are active, the NB inverts the group and the corresponding DBI bit is set. Note that DBI will cover all quad pumped signals including DEP.<br>Transferred at 4x the bus clock frequency. |
| H_{A/B}_OOD#                                | Indicates that the next or concurrent data transfer will be for deferred phase data delivery.  |
| H_{A/B}_DSTBp#[3:0],<br>H_{A/B}_DSTBn#[3:0] | Strobes for D[63:0]#, DEP[7:0]# and DBI[3:0]#.   |

## 6.2.7 Error Signals

The NB observes BINIT# and can be configured to drive BINIT# in certain error situations, including propagating BINIT# to the other FSB.

The “observed BINIT#” bit will be set in the FERR register and this may be configured to reset the system via ICHRST#.

The NB can be configured to assert MCERR# on the other bus when a processor asserts MCERR# (see [Section 4.16.21](#)).

## 6.2.8 Bus Assumptions

- BRLC's and BRLD's from the processor that have no BE asserted will get a No-Data Response. A PCI Express or Hub Interface request will be issued, but there are configuration bits to drop these zero length transactions in the I/O subsystem of NB.
- A locked request that is retried by the NB must be reissued unless a fatal processor error occurs.

## 6.2.9 FSB Coherency Assumptions

The following line state assumptions can be made following the snoop phase of a given transaction on a FSB populated with fully enabled 64-bit Intel® Xeon® processor MP.

**Table 6-14. 64-bit Intel® Xeon® Processor MP FSB Coherency Assumptions (Sheet 1 of 2)**

| Transaction type         | Possible Bus States after Snoop      |                                    |                                   |
|--------------------------|--------------------------------------|------------------------------------|-----------------------------------|
|                          | Snoop Result = Modified <sup>a</sup> | Snoop Result = Shared <sup>b</sup> | Snoop Result = Clean <sup>c</sup> |
| Processor Initiated BRLC | SI                                   | SI                                 | MESI                              |
| NB initiated BRLC        | I                                    | SI                                 | SI <sup>d</sup>                   |
| Processor Initiated BRLD | MESI                                 | SI                                 | MESI                              |
| NB initiated BRLD        | I                                    | SI                                 | I                                 |
| BRIL.OWN                 | M                                    | Can't Happen <sup>e</sup>          | MESI                              |
| BRIL                     | MESI                                 | Can't Happen                       | MESI                              |
| Processor Initiated BIL  | Can't Happen <sup>f</sup>            |                                    |                                   |

**Table 6-14. 64-bit Intel® Xeon® Processor MP FSB Coherency Assumptions (Sheet 2 of 2)**

|                  | Possible Bus States after Snoop |              |                   |
|------------------|---------------------------------|--------------|-------------------|
| NB initiated BIL | I                               | Can't Happen | I                 |
| BWL INVLD=0      | Can't Happen, not snooped       |              | MESI <sup>9</sup> |
| BWL INVLD=1      | Can't Happen, not snooped       |              | I                 |
| BWIL             | I                               | Can't Happen | I                 |
| BLR              | SI                              | SI           | SI                |
| BLW              | Can't happen <sup>h</sup>       | I            | I                 |

**NOTES:**

- HIT# = 0, HITM# = 1. Some agent currently has the line in modified state, but will reduce to shared or invalid
- HIT# = 1, HITM# = 0. Some agent intends to keep the line in shared state
- HIT# = 0, HITM# = 0. The line is invalid in all processor caches
- The shared result is only possible when 64-bit Intel® Xeon® processor MP L2 is disabled. The NB will assume I when the CDCC.BRLCI bit is set. This should typically be set.
- A shared response indicates the agent intends to keep the line in shared state which is illegal for an Invalidating transaction
- The 64-bit Intel® Xeon® processor MP does not issue BIL, even when L2 is disabled. It will back invalidate BIL's from Prescott on the FSB
- If attribute was WC, NB could assume I, but NB does not use attributes for coherency assumptions
- Must be preceded by a BLR that would invalidate

## 6.2.10 Power-on Configuration

### 6.2.10.1 POC Register

If a bit is set in the POC register, it will drive the corresponding address line during reset. See [Section 4.14.12, “POC\\_FSB{A/B}: Power-on Configuration \(D16, F0\)” on page 168](#) and [Section 4.14.13, “POC\\_AUX{A/B}: CPU Tristate Control \(D16, F0\)” on page 170](#) for the register definition. This includes processor tristate on A[39:36].

### 6.2.10.2 BREQ0

The NB asserts BREQ[0]# during RESET# on each bus to enable processors to determine their AgentID. In a configuration with 2 processor sockets on each bus, BREQ[0]# should be routed to BREQ[0]# on the first socket (end agent) and BREQ[1]# of the second socket (Middle agent) of each bus so that they use AgentID 0 and 1 on each FSB.

### 6.2.10.3 Pins that Do Not Connect to NB

The NB does not connect to A20M#, PMI#, SLPCK#, IGNNE#, IERR#, SMI# or STPCLK#.

## 6.3 Independent Memory Interface (IMI)

### 6.3.1 Topology

The NB masters 1 to 4 Independent Memory Interface (IMI) Ports, each of which is connects to one XMB. The IMI's are half-width (one byte of payload/transfer) outbound and full-width (2 Bytes of payload/transfer) inbound. Each IMI supports up to 1 Terabyte (2<sup>40</sup> Bytes) of addressability. The IMI's are operated independently, that is a given cache line request is serviced by 1 IMI. The NB does not support cascaded, or lock-stepped IMI's.

### 6.3.2 Physical Layer

The physical layer will be based on Scalable Differential electricals. As mentioned above, the NB issues half-width packets outbound and full-width packets inbound. The returning inbound link must be the same frequency and generated from the same clock buffer. This allows NB to perform bit de-skewing once at reset rather than periodically.

The NB drives the IMI outbound at 2.67 GHz or 3.2 GHz (16 times the front side bus clock rate). Since an outbound packet takes 8 transfers, commands can be issued at 333 MHz or 400 MHz. A single Write command transfer takes 9 packets, so writes can be issued at 167 MHz or 200 MHz.

The NB can accept responses inbound at the same rate as the outbound (2.67 GHz or 3.2 GHz). Since the inbound data packet is 4 transfers, the NB can accept one-read returns from each IMI at 667 MHz or 800 MHz. Write acknowledges are accepted at 333 MHz or 400 MHz.

### 6.3.3 Memory Space

MemRds and MemWrs are issued to memory space. The IMI has more address bits than the FSB's, so NB IMI addresses will be the same as FSB, PCI Express or HII.5 addresses. NB will always drive Mem\_Address[41:40] to zero in IMI packets.

The NB has a set of IMI Interleave Range (IMIR) registers which define the IMI to which a memory request should be issued ([Section 4.15.15, "IMIR\[5:0\]: IMI Interleave Range, \(D16, F1\)" on page 188](#)). The IMIR registers partition the memory address space at 256 MB boundaries. Within each IMI Interleave Range, cache lines may be interleaved in different ways to support optimum interleaving of arbitrary (non-symmetrical) memory populations.

### 6.3.4 Configuration Space

NB issues ConfigWrs and ConfigRds to Configuration space. Only one Configuration Space access can be outstanding on the IMI at a time. Configuration accesses are limited to 1, 2 or 4 bytes in size. Any combination of contiguous Byte enables is supported.

#### 6.3.4.1 Device Assignment

The NB assigns device numbers to the 4 IMI's and their corresponding XMBs as described in [Table 4-8 on page 60](#). These all appear on Bus 0.

The XMBDEV register defines the XMB device used for each IMI. They will default to the correct fixed values for the attached XMBs so that BIOS need not perform any enumeration. NB BIOS should not modify these registers, and does not need to read them. The only usage of these registers is for non-NB specific software (e.g. Hot-Plug driver) to determine the device number of an XMB attached to a IMI.

The NB does not support cascaded XMBs, which would require multiple devices.

The IMI requires that the NB toggle a bit in the header for each configuration access so that the NB can distinguish a new command from a retry. The IMI allows only one configuration command outstanding at a time.

Normally, the NB responds to XMB configuration requests for register offsets < 40h whether the XMB is present or not. Most of these registers are read-only so any IMI function can be accessed to provide the data. The NB will return the XMB value for the DID register. The SVID registers are writable once, so it is possible that software could write these registers. The NB maintains separate SID and SVID registers for the XMB functions. When the IMIHPC.XMBHDR bit is set, the NB forwards the accesses to the XMB to allow examination of the revision ID of the XMB.

The NB will master-abort any configuration requests to the XMB when the corresponding IMI is in a state that does not support XMB configuration accesses.

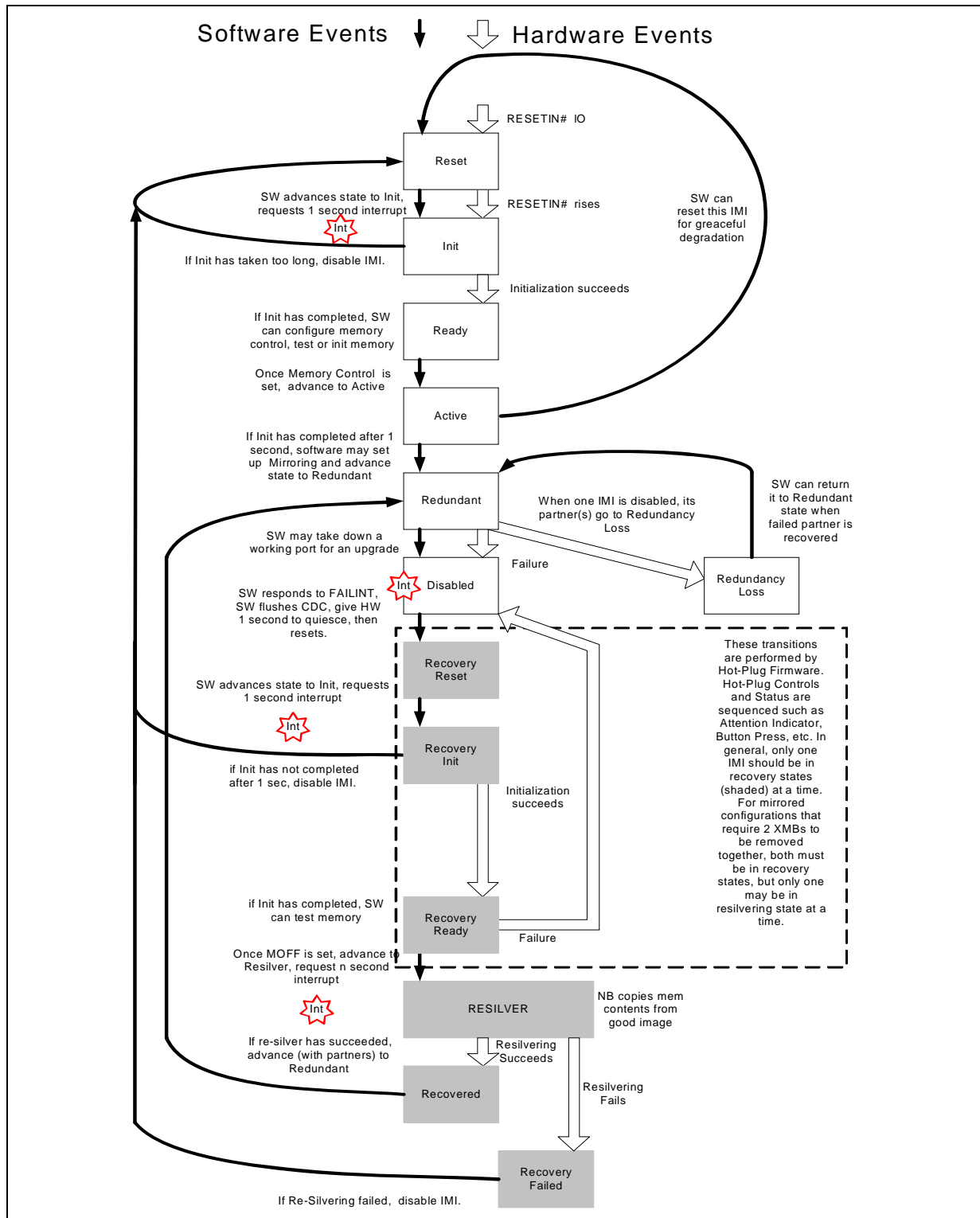
**Figure 6-1. Software Visible IMI States**


Table 6-15. Software Visible IMI State (Sheet 1 of 2)

| State           | NB Behavior  | Supported IMI activity   | SW Usage  |
|-----------------|--|--|---|
| Reset           | Outputs are disabled. Link, Physical, and Transaction Layers are reset. Configuration reads and writes to this IMI are still supported, but configuration writes to the associated XMB will be Master Aborted. IMI_{A,B,C,D}_RST# is asserted.   | None   | Software writes this state to force an IMI into reset. Software should place any IMI that is not operational, and which is not currently being considered for recovery in this state.<br><br>When in this state, IMIHPC.PWRCTL Section 4.13.10, "IMIHP: IMI Hot-Plug Control (D{8,10,12,14}, F0)" on page 150 can be set so that cards may be added or removed. |
| Init            | NB performs the initialization steps. Configuration reads and writes to this IMI are still supported, but configuration writes to the associated XMB will be Master Aborted.   | HW controlled init ops. No system accesses.  | Software writes this state to start IMI initialization. Software may not access physical memory behind the XMB nor XMB configuration.   |
| Ready           | The IMI sets this state when packet framing is completed, indicating that information can be sent and received on this IMI. Offset must be set before memory configuration accesses will work.   | Configuration accesses to XMB.   | Software may not write this value, but checks it to determine that the IMI is operational. Software may transition from this state to Reset.  |
| Active          | Link is fully configured and operational.  | All  | Software sets this state when the NB and XMB have been configured to support memory accesses.<br><br>First, the memory on this link must be de-allocated so that no new memory requests are issued.   |
| Redundant       | This implies that the NB is performing Mirroring. The data on this port is duplicated on others either by Mirroring and no error has been detected on this IMI that causes the NB to ignore its contents. The NB can still continue operation if this IMI is taken out of service. Failures that would otherwise be logged as uncorrectable or fatal are now logged as correctable. Inband Fatal or Uncorrectable Signals from the XMB produce the effect of the Correctable Error signal. | All  | Software writes this state to indicate that the contents behind an IMI can be reconstructed from the data on other IMI's.   |
| Disabled        | A Retry time-out or Fatal Error inband signal from XMB has occurred. This IMI is disabled. The NB is still operational. The NB is directing memory accesses to other IMI's, but it may take some time before this IMI reaches a quiescent state. Configuration accesses to this IMI are still supported, but configuration accesses to the associated XMB will master-abort. The NB will transition to this state from the redundant state when this IMI fails.                            | Transactions enqueued in the IMI may or may not be initiated. Any outstanding transactions complete. No new transactions from other ports are initiated. | Software may also write this value to take down a working redundant port for an upgrade. Software may not access physical memory behind the XMB nor XMB configuration.  |
| Redundancy Loss | This IMI is no longer redundant. One of the IMI's with which this IMI was redundant is now disabled.   | All  | Software can return this IMI to redundant state when the all the other IMI's are recovered.   |

**Table 6-15. Software Visible IMI State (Sheet 2 of 2)**

| State           | NB Behavior  | Supported IMI activity                      | SW Usage   |
|-----------------|--|---|--|
| Recovery Reset  | Same as Reset State.   | None  | Software writes this value to clear the IMI in preparation for recovery. Software can force entry to this state whenever there are partners for this IMI.<br><br>Once in this state, IMIHPC.PWRCTL can be set so that cards may be added or removed. |
| Recovery Init   | Same as Initialization State.  | HW controlled init ops. No system accesses. | Software writes this value to release the IMI reset and initiate recovery.   |
| Recovery Ready  | Similar to Ready State, but memory accesses are still being directed to/from other IMI's. Config accesses are enabled to IMI and to XMB.   | Config Accesses, but not memory operations. | Software may not write this value. It checks this state to determine whether the NB has completed Recovery Init. SPD reads, XMB Address configuration, Calibration and Memory Test Engine.   |
| Resilver        | The NB is reconstructing the memory image on this IMI from its partners in Redundancy Loss State.  | Re-silvering writes, System writes.         | Software may set this state when the NB and XMB have been configured to support memory accesses.<br><br>Software writes this value to initiate re-construction of the memory contents for this IMI.  |
| Recovered       | The images in the NB are consistent and ready to be put in redundant state. New reads and writes are already being processed the same as in the Redundant State. Any partners of this IMI in Redundancy Loss state should be returned at the same time.  | All   | Software may not write this value. It checks it to determine whether re-silvering succeeded.   |
| Recovery Failed | An uncorrectable error occurred while re-silvering. The image on this IMI is not consistent with images on others and this IMI should not be advanced to Redundant state. Configuration reads and writes to this IMI are still supported, but configuration writes to the associated XMB will be master aborted. | None  | Software may not write this value. It checks it to determine whether re-silvering succeeded.<br><br>Software may attempt another recovery attempt or force this IMI into Reset State.  |

## 6.3.5 Memory RAS

### 6.3.5.1 Memory Mirroring

In the mirrored configuration, one of the IMI ports will be designated the primary image and the other the secondary (for an overview on mirroring, refer to [Section 2.6.3](#)). Both ports will be issued the same write request and both ports will respond to the request (in a ping-pong fashion). The primary designation will toggle between the two IMI ports on detected correctable memory responses. The primary designation will become fixed on a specific port on an uncorrectable error.

**Memory Mirroring Write Operation-** For the case of memory writes, the write request is issued to both IMI ports. The NB must successfully collect both responses before considering the write completion. If the write request fails on an IMI port, the write will be re-issued to both ports with exactly the same transaction ID. If the retried write is acknowledged by only one port, switch to the single image (no mirror available).

**Memory Mirroring Read Operation-** For the case of memory reads, the read request does not go to both mirrors. At the successful completion of the read response, the read response is allowed to complete on the front side bus, PCI Express or H11.5 interface.

In the case of a detected error, the action of the NB is as follows:

- In the case of a detected Correctable Error, the definition of the Primary image will toggle and the read will be issued on the “new” primary image.
- In the case of a detected Uncorrectable Error, the definition of the Primary image will “hard fail” to the other image. In this case, the “failed” image will never become primary until service has replaced the FRU (Field Replaceable Units) and “re-silvered” the images.

In the event of a switch between the primary and secondary port designations, the NB will ensure that the IMI ports are idle at the time of the switch.

**Copy Engine (re-silvering the images)** - In the event that the memory configuration has changed (as when a failed memory FRU has been replaced), the NB uses a copy engine to walk memory from the primary image and write it back to both ports. When the copy engine is enabled, all writes are issued to both ports.

The steps to copy (or re-silver two memory images) are as follows:

1. IMI Link goes through a training and initialization process.
2. XMB registers are initialized.
3. Memory behind the XMB is tested and initialized (“0” is written with valid ECC).
4. NB copy engine is enabled. At this time writes start being issued to both images.
5. When copy is completed, re-enable mirroring. (i.e. Failures of the primary memory image are no longer FATAL errors).



**Correctable Errors** - The NB will just correct the data and provide to the requester. The XMB will also correct the data and write back into memory.

**Reasons to degrade to one memory image:**

- Receiving two uncorrectable errors (not including poisoned data) for the same access.
- Receiving Fatal Error Signal from an XMB.
- Software disabling an IMI interface.

**Re-enabling of memory mirroring:**

- Replacement of a Failed Memory FRU via the Hot-Plug procedure.
- Software/Firmware will configure and test a memory card FRU. If the memory card matches in size with the current image, the re-silvering process can be enabled. Upon successful completion of the copying process, the two images can be re-enabled.

## 6.3.5.2 Memory RAID

### Memory RAID Read Operation

**Normal Case** - Read Requests for a given Cache Line can be issued just as in the normal memory configuration to a given address with the following changes:

- RAID Address decoding must be done to route to the appropriate IMI Port.
- Address conflict check logic must take into account not only an address match for a write in progress, but also an address match of the Memory RAID associative lines. As indicated in [Table 6-16](#), a read of “Cache Line 0” must be delayed to occur after any of the following writes of Cache Line 0.

**Reconstructive Case** - In the case of a failed IMI port, there are two cases for reading a cache line (for this discussion, we assume that IMI Port D has failed):

- To read Cache Line 0, the NB performs a normal read.
- To read Cache Line 2n (for example when IMI Port D is failed), is to read checkline(2n, n, 0), cache line n and cache line 0 and re-construct cache line 2n, as in the following equation:

$$cacheline(2n) = checkline \oplus cacheline(n) \oplus cacheline(0)$$

### Memory RAID Write Operation

**Normal Case** - Write Request for a given cache line requires the cache line to be written and the check line to be updated accordingly. The steps of the write of cache line 0 are as follows:

1. Read Cache Line 2n and n.
2. Calculate Checkline, which is the exclusive OR of cache line 0, n, 2n.
3. Write Cache Line 0 and Check Line (2n,n,0).

**Reconstructive Case** - In the case of a failed IMI port, there are two cases for writing a cache line (for this discussion, we assume that IMI Port D has failed):

- To write Cache Line 0, the NB must read its checkline and cacheline 0 (old value); recalculate checkline, write new value of checkline and cacheline0. The calculation of the checkline is as follows:

$$checkline(new) = checkline(old) \oplus cacheline0(old) \oplus cacheline0(new)$$

- To write Cache Line 2 (assuming that IMI Port D is failed), is to update the  $checkline(2n+2, n+2, 2)$ :

$$checkline(2n+2, n+2, 2) = cacheline(2n+2) \oplus cacheline(n+2) \oplus cacheline(2(new))$$

### Memory RAID Re-silvering Operation

The re-silvering process for Memory RAID requires the NB to read from the other three IMI ports, regenerate the failed IMI Link data and then write the reconstructed data back. To reconstruct the failed IMI (for this example, IMI port D is being re-silvered), use the following equation:

$$IMID = IMIC \oplus IMIB \oplus IMIA$$

**Note:** As in the Memory Mirroring Case, all write operations must also happen to maintain cache coherency of the platform.

When the RAID re-silvering reaches terminal count, the re-silver link is available for normal operation. The size of the re-silvering is determined by the base and size programmed in IMIR3.

### Cache Line Striping

For Memory RAID, the NB will use all four IMI Ports and provide a check cache line for every three cache lines. [Table 6-16](#) describes how the IMI ports stripe the cache line. Also note the “n” in the table is equal to a fourth of all the memory available in the platform. For example, if a platform had 16GB of memory, “n” = 4 GB, 12 GB would be used as system address space and 4 GB is used for “Check lines”.

**Table 6-16. Memory RAID IMI Port Striping**

| IMI RAID Associated Addresses | IMI Port D   | IMI Port C   | IMI Port B   | IMI Port A                                       |
|-------------------------------|--|--|--|--|
| 0                             | Cache Line 2n  | Cache Line n   | Cache Line 0   | Check Line 2n, n, 0<br>(Check Line address - 3n) |
| 1                             | Cache Line n+1   | Cache Line 1   | Check Line 2n+1, n+1, 1<br>(Check Line address - 3n+1) | Cache Line 2n+1                                  |
| 2                             | Cache Line 2   | Check Line 2n+2, n+2, 2<br>(Check Line address - 3n+2) | Cache Line 2n+2  | Cache Line n+2                                   |
| 3                             | Check Line 2n+3, n+3, 3<br>(Check Line address - 3n+3) | Cache Line 2n+3  | Cache Line n+3   | Cache Line 3                                     |

The following pseudo code provides a description of the algorithm to map a front side bus address onto an IMI Port. For readability, the code description ignores the TOLM calculation and the possibility of memory addition in the RAID mode.

*If (in RAID mode) then*

*begin*

*n = 1/4(sum of total available DIMM memory if not in RAID mode)*

*if (n > FSB address >= 0) then use MIR0 Mapping register*

*else if (2n > FSB address >= n) then use MIR1 Mapping register*

*else if (3n > FSB address >= 2n) then use MIR2 Mapping register*

*else NOT a memory address and route to I/O (i.e. FSB address >= 3n)*

*/\*\*\*\*\*\**

*IMI Mapping Calculation*

*\*\*\*\*\*/*

*/\* Determines ROW in Table 9-47 \*/*

*RAID Address Offset = (FSB Address [7:6]);*

*/\* Determine Column and IMI Port in Table 9-47 \*/*

*if (n > FSB address >= 0) then IMI Port # = (1 + RAID Address Offset) && 011b*

*else if (2n > FSB address >= n) then IMI Port # = (2 + RAID Address Offset) && 011b*

*else then IMI Port # = (3 + RAID Address Offset) && 011b*

*end*

*Else (Map System Address per the description in Main Memory Interleaving subsection in the System Address Map chapter).*

The check lines for the platform are at a “3n” base for the system address map. Refer to [Table 6-17](#).

**Table 6-17. Raid Related Address for the Independent Memory Interface Port**

| IMI RAID Associated Address | IMI Port D         | IMI Port C         | IMI Port B         | IMI Port A         |
|-----------------------------|--------------------|--------------------|--------------------|--------------------|
| 0                           | 0,n,2n,3n          | 0,n,2n,3n          | 0,n,2n,3n          | 0,n,2n,3n          |
| 1                           | 1, n+1, 2n+1, 3n+1 | 1, n+1, 2n+1, 3n+1 | 1, n+1, 2n+1, 3n+1 | 1, n+1, 2n+1, 3n+1 |
| 2                           | 2, n+2, 2n+2, 3n+2 | 2, n+2, 2n+2, 3n+2 | 2, n+2, 2n+2, 3n+2 | 2, n+2, 2n+2, 3n+2 |
| 3                           | 3, n+3, 2n+3, 3n+3 | 3, n+3, 2n+3, 3n+3 | 3, n+3, 2n+3, 3n+3 | 3, n+3, 2n+3, 3n+3 |

**Memory Upgrade Support for the Memory RAID**

The NB/XMB provide the ability to allow memory upgrade operations while in the RAID configurations. To allow this possibility the user must program the IMIR registers and have holes in the system address map. An example of this map follows:

```

-----FF_FFFF_FFFFh-----
High MMIO Range
-----4M+LMMIO_SIZE-----
System Parity lines and upgrade of Parity lines.
-----3M+LMMIO_SIZE+N-----
System Memory
-----3M+LMMIO_SIZE-----
Reserved for Memory Upgrade
-----2M+LMMIO_SIZE+N-----
System Memory
-----2M+LMMIO_SIZE-----
Reserved for Memory Upgrade
-----1M+LMMIO_SIZE+N-----
System Memory
-----1M+LMMIO_SIZE-----
Reserved for Memory Upgrade
-----LMMIO_SIZE+N-----
System Memory
-----01_0000_0000-----
Low MMIO HOLE
-----TOLM (01_0000_0000-LMMIO_SIZE)-----
System Memory and Legacy Ranges
-----00_0000_0000-----

```

**Note:** In the example map above, “N” is 1/4 the sum of all the currently installed memory in the platform and “M” represents the maximum amount of memory that is allowed per XMB after an upgrade. “M” is set by BIOS according to system vendor and/or user settings.

Table 6-18 shows the IMIR configuration for this example system map. The user of the platform might prefer not to allow for the possibility of a memory upgrade (this is due to certain OS limitations). The size of the re-silvering is determined by the base and size programmed in IMIR3 LIMIT.

Table 6-18. Raid Memory Upgrade IMIR Possible Settings

| IMIR | LIMIT               | Primary (data) |      |      |      | Secondary (parity) |      |      |      |
|------|---------------------|----------------|------|------|------|--------------------|------|------|------|
|      |                     | Way3           | Way2 | Way1 | Way0 | Way3               | Way2 | Way1 | Way0 |
| 0    | M                   | 0              | 3    | 2    | 1    | 3                  | 2    | 1    | 0    |
| 1    | 2M                  | 1              | 0    | 3    | 2    | 3                  | 2    | 1    | 0    |
| 2    | 3M                  | 2              | 1    | 0    | 3    | 3                  | 2    | 1    | 0    |
| 3    | (3M+N) <sup>a</sup> | 3              | 2    | 1    | 0    | 3                  | 2    | 1    | 0    |

**NOTES:**

a. This is due to accurately calculating the top of parity check blocks.

Figure 6-2 and Figure 6-3 illustrate the pre- and post-upgrade in memory RAID.

Figure 6-2. Pre-Upgrade Memory Map

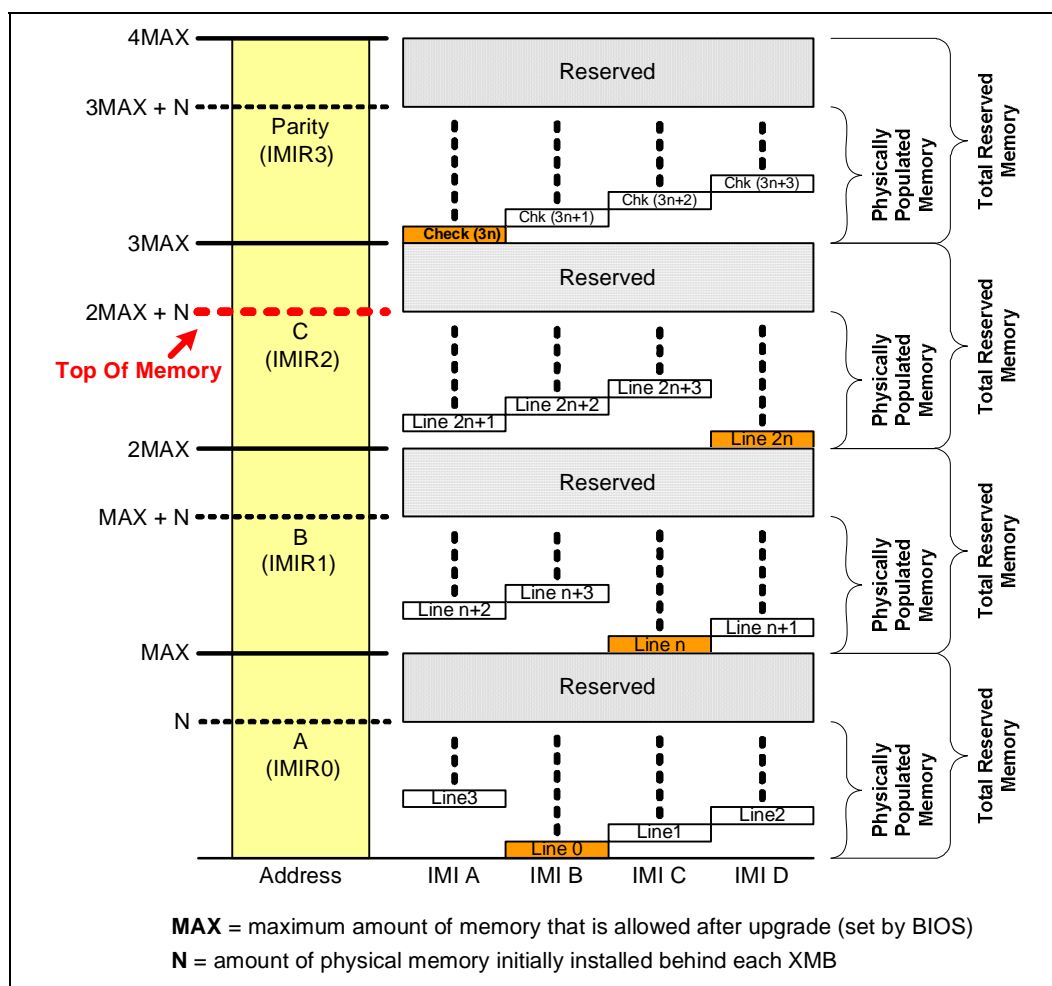
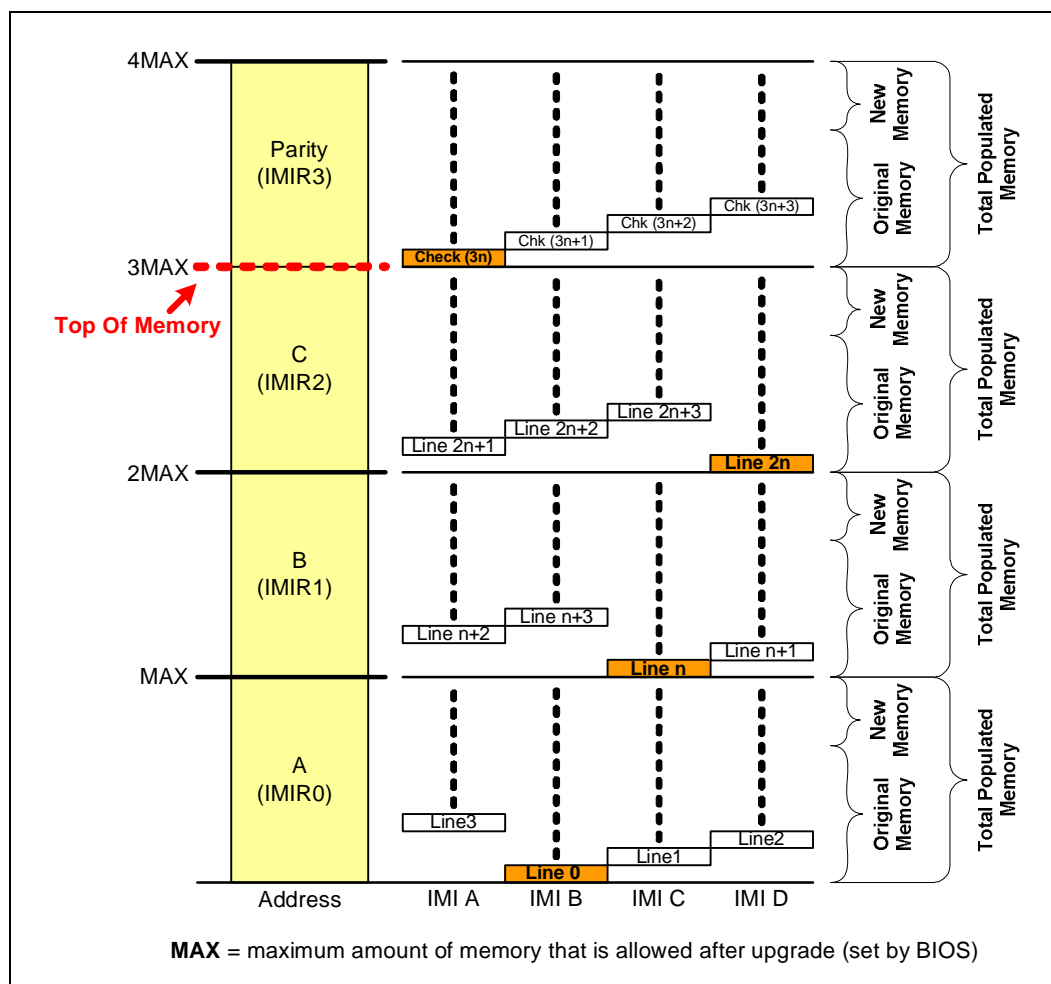


Figure 6-3. Post-Upgrade Memory Map



### 6.3.5.3 Patrol/Demand Scrubbing and DIMM Sparing

These RAS features are located entirely in the XMBs. For a description of these features, refer to *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

### 6.3.6 Initialization

The NB/XMB initialization sequence is mostly linear. The NB does not implement time-outs for each phase, but there is one time-out for the entire sequence. If the initialization protocol fails to advance, a time-out will cause the link to be reset and try again. When the time-out occurs, the NB will set IMIST.State to “disabled”. If the initialization succeeds, IMIST.State will be set to “Ready” (See [Section 4.13.9, “IMIST: IMI Status \(D{8,10,12,14}, F0\)” on page 148](#)). Once software configures the NB and XMB to handle memory transactions it writes IMIHPC.NextState to “Active”. This will be reflected in IMIST.State.

#### 6.3.6.1 Initialization Triggers

All IMI's are initialized whenever the NB is reset. An individual IMI is reset when IMIHPC.State is set to “Reset” or “RecoveryReset” for that IMI. Software will reset the IMI to perform Hot-Plug operations. No error detection by the NB directly causes an IMI to reset (an error may cause the system to be reset, in which case RSTIN# will be asserted).

### 6.3.7 Power Management

Intel® E8501 chipset does not support ACPI power-down of memory. Ports which are not connected to an XMB or connected to a failed XMB can be powered down by setting IMIHPC.STATE to Reset. This will hold the IMI in reset in which state drivers and receivers are not enabled. When in that state, the IMIHCP.PWRCTL can be set, which removes power from the XMB. This is a safe state that allows a memory card to be added without notification.

### 6.3.8 IMI Hot-Plug

The NB supports memory Hot-Plug feature that includes hot removal and hot addition.

These Hot-Plug operations are visible to the OS if the NB is operating in normal mode (non-redundant mode). Any Hot-Plug operation requires support from the OS including allocation and de-allocation of system memory.

If the NB is operating in mirroring or RAID mode in full redundant strength (not in redundancy fail over mode), the Hot-Plug operations are non-visible to the OS. Firmware/BIOS, however, is required to preform the required functionality for seamless addition and removal of XMB memory.

DIMM sparing (regular sparing or zero overhead sparing) on the DDR channels within an XMB is not within the scope of this document. Readers should refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet* for information on this topic.

### 6.3.8.1 Hot-Plug Standard Usage Model

The NB IMI memory Hot-Plug mechanism is designed to allow the system platform to provide the same visual indicators, buttons, and control/status registers as PCI Standard Hot-Plug Controller (SHPC) Specification and PCI Express Hot-Plug standard usage model. The NB IMI memory Hot-Plug mechanism requires support from Intel® E8501 chipset-specific firmware to follow Hot-Plug standard usage model. Intel® E8501 chipset-specific firmware and interrupt service routines together are referred to as software (SW) in this section.

The memory board is a field-replaceable unit or Hot-Pluggable unit. Each memory board implements an attention button, power LED (green), indicator/attention LED (amber), and a Mechanical Retention Latch (MRL) switch to support the standard usage model and to support surprise removal without damage. In this chapter, green LED and power LED are used interchangeably. Indication/attention LED and amber LED are also used interchangeably.

### 6.3.8.2 Hot-Plug Registers

Each IMI has an IMIHPC (Independent Memory Interface Hot-Plug Control) register to control:

1. LED operations
2. Power to the XMB
3. Hot-Plug interrupt enabling mask
4. Next state of the IMI

Each IMI also has a IMIST (Independent Memory Interface Status) register that provides status for:

- Hot-Plug interrupt events
- Current state of the IMI

The NB supports only one IMI Hot-Plug operation at a time. The IMIST register has sufficient information to determine which IMI is being sequenced through the Hot-Plug operation. The IMIHPC register has interrupt enable/disable capability to prevent events from other IMI's from intruding on the current Hot-Plug operation. On completion of any Hot-Plug operation, software must check the status of other IMI's to handle any pending events.



### 6.3.8.3 Interrupt Support for Hot-Plug

#### 6.3.8.3.1 Event Interrupts

The NB has a pin, IMI\_HPINT, dedicated to IMI Hot-Plug interrupts. The 4 IMIST registers have sufficient status information to determine the cause of any IMI\_HPINT interrupt.

Interrupt names and associated events triggering IMI\_HPINT include:

- XMBINT: XMB has sent an “assert IMI\_HPINT” in-band signal on the Independent Memory Interface. Status register in XMB provides the more interrupt information for SW.
- IMIRLINT: MRL sensor change detected whenever the MRL is transition between open and closed positions.
- ATNINT: Attention button pressed is detected for this IMI.
- FAILINT: An IMI has entered the disabled state.
- PRSINT: Present detect changed when PRSNT# changes state.
- PWRINT: Power fault asserted in an IMI.

#### 6.3.8.3.2 Hot-Plug Timer Interrupt

The IMI\_HPTIM register controls a timer dedicated to IMI Hot-Plug software that will interrupt after intervals ranging from 12.5 ms to 12.5 sec. Instead of individual timers for each IMI, there is only 1 IMI\_HPTIM timer for SW use.

### 6.3.9 NB IMI States

NB IMIHPC and IMIST registers define the software-visible states of the NB IMI. Transitions from one state to another may be controlled by software or the NB. Software can observe these states via the IMIST register and force into a state via the IMIHPC register.

Typically, the NB only supports one IMI at a time in the Recovery states. Candidates for recovery wait in the “Disabled” state until they are serviced. Configuration accesses are master aborted when the IMI is not in a fully operational state. Otherwise, an access to a redundant failed port (by error handling, or Hot-Plug/ recovery software) could result in an unpredictable behavior.

### 6.3.10 Hot Swap

The NB Memory Port Hot-Plug capability and RAS operating modes enable a hot swap process which consists of a hot removal and a hot addition of a memory board. Hot swap enables the system to electrically isolate a memory board (with hardware error or by user specification) while the system continues to run (such that the memory board could be replaced without taking the system off-line).

### 6.3.11 NB RAS Operating Modes

Once the RAS operating mode (Normal, Mirroring or RAID) is programmed at boot time, it should not be changed during the Hot-Plug process.

If a system is operating in mirroring mode, either with mirroring pairs {(IMI A, IMI B), (IMI C, IMI D)} or {(IMI A, IMI C), (IMI B, IMI D)}, one XMB/IMI from each mirroring pair (for a total of 2) could be hot removed sequentially. Since all 4 IMI's are participated in providing redundancy, only one XMB/IMI could be hot removed. Once the IMI slot is powered down by the system, it could be replenished by a memory board with adequate capacity/capability by hot addition.

### 6.3.12 Memory Hot Removal

There are two mechanisms to trigger a hot removal sequence:

- Hardware initiated hot removal
- Software/user initiated hot removal

#### 6.3.12.1 Hardware Initiated Hot Removals

In this case, NB detects an interrupt and reports it via IMIST register. The interrupt is due to hardware error or surprise removal of XMB card). These interrupts include:

- XMB interrupt: XMB has sent an “assert IMI\_HPINT” in-band signal on the Independent Memory Interface. An example is XMB leaky bucket threshold overflow event (for normal mode only).
- IMI entering disabled state in mirroring or RAID mode only
- Mechanical Retention Latch (MRL) sensor changed
- Presence detect change
- Power fault detection

#### 6.3.12.2 Software/User Initiated Hot Removals

This mechanism is mainly for preventative maintenance or add-on upgrade purposes. NB could support at least two approaches:

- Pushing the attention button on a XMB card to indicate hot removal intention
- User requests hot removal through system software user interface

The following three subsections discuss hot removal flows for three operating modes:

- 1. Normal (non-redundancy),**
- 2. Mirroring**
- 3. RAID**

Proper interrupt enable bits are assumed to be programmed correctly by software (Intel® E8501 chipset-specific firmware and interrupt handling routines).

### 6.3.12.2.1 Normal Mode (Graceful Degradation)

Figure 6-4 illustrates a hot removal flow in normal mode. The IMI\_x is the IMI to be hot removed where x could be A, B, C or D. IMI\_x is at active state (IMIST[x].state = active) entering the flow. There are five entry points in this flow: 1, 2, 3, 4 and 5. Each represents an independent entry point.

At point 1, the XMB detects a leaky bucket threshold overflow and sends a IMI in-band “assert IMI\_HPINT” signal to the NB. The NB sets IMIST[x].XMBINT that triggers a IMI\_HPINT, software sets the amber attention LED via IMIHPC[x].ATNLED to indicate operational problem and processes this interrupt and exits.

At point 2, the software initiates a graceful degradation to remove IMI\_x and set the indication LED. A technician can initiate the removal process via pushing the attention button at point 5.

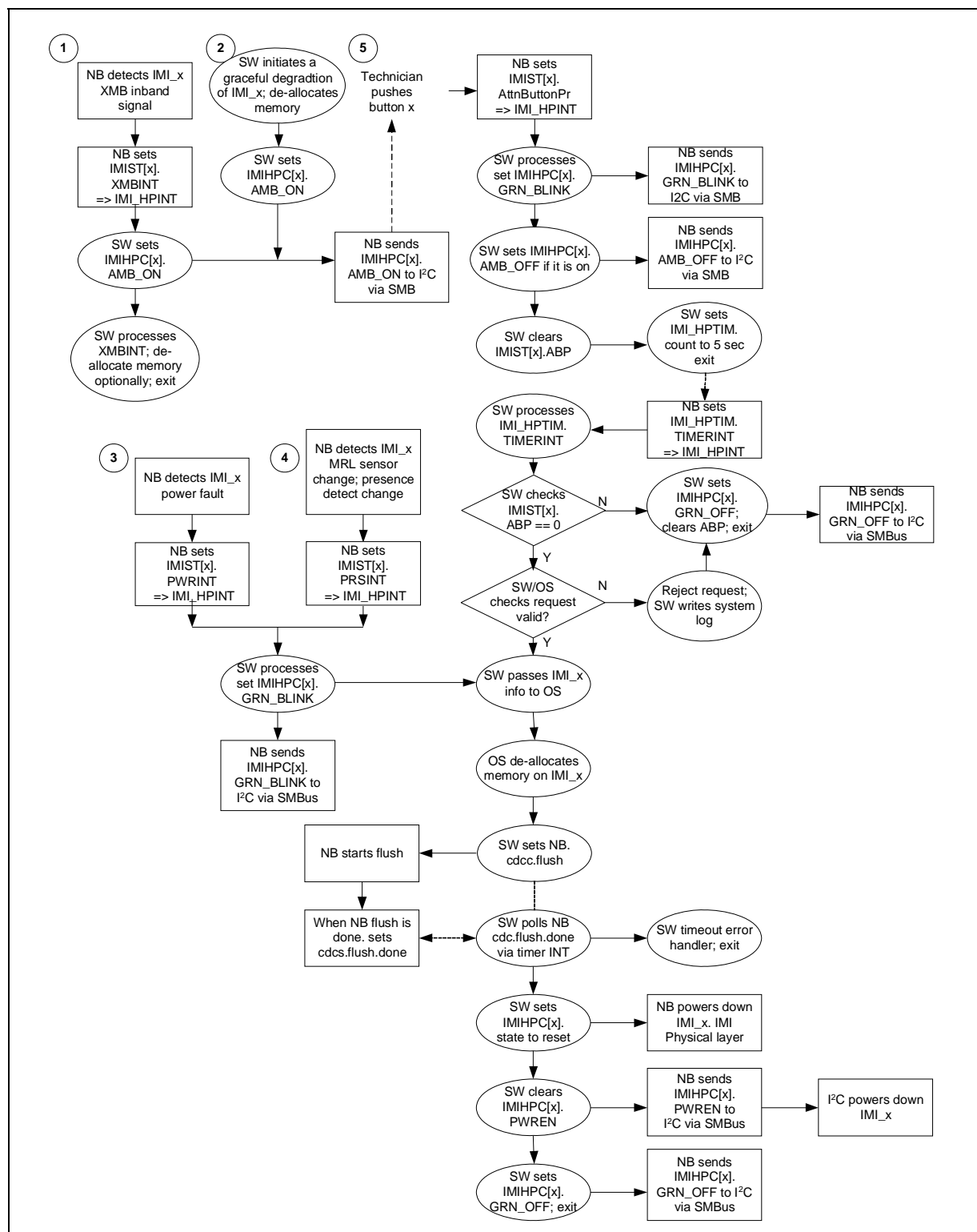
Prompted by the attention LED, the user/technician pushes the attention button following the standard usage model. The attention button pressed event triggers IMI\_HPINT interrupt. The servicing software sets the green power LED to blinking state via IMIHPC[x].PWRLED and turns off attention LED. It also clears the IMIST[x].ATNINT and sets IMI\_HPTIM timer to interrupt after five seconds and then exits. The NB will set IMI\_HPTIM.TIMER after the programmed five second period and triggers a IMI\_HPINT. If the button is pushed again during this five second period, the user indicates intention NOT to remove this IMI per standard Hot-Plug usage model. In that case, software turns off IMIHPC[x].PWRLED, clears the IMIST[x].ATNINT and processes the event and exits.

If the user’s intention is confirmed after the five second period, the software and OS will validate the removal request against system policy (e.g. pinned memory that can not be de-allocated or physical security policy).

Once the request is validated or the NB detects a power fault (entry point C with proper software handling), or the MRL sensor changed (entry point D with proper software handling), OS will de-allocate the system memory in this IMI/XMB. Software will flush NB CDC via setting CDCC.FLUSH bit which starts a NB CDC flushing process. When the NB completes the flushing process, it sets CDCS.FLUSH.DONE bit. Software can use the IMI\_HPTIM to poll this completion bit periodically. Recommended waiting time is 25 ms.

After the CDC flush is completed, software should set IMIHPC[x].state to reset state. The NB will put the IMI into reset state. Software then turns off power to the IMI/XMB via IMIHPC[x].PWRCTL. The Power LED is then turned off via IMIHPC[x].PWRLED by software. At this point, the IMI port is in reset and power to the XMB slot is turned off. Since the power LED is off, the user can remove the XMB per standard usage model.

Figure 6-4. Hot Removal Flow for Capacity Reduction (Graceful Degradation)



### 6.3.12.2.2 Mirroring Mode

Figure 6-5 illustrates a hot removal flow in mirroring mode. IMI\_x is the IMI to be hot removed (where x could be A, B, C or D) while IMI\_y is the mirroring partner of IMI\_x. Both IMI\_x and IMI\_y are at redundant state (IMIST[x].state = redundant and IMIST[y].state = redundant) entering the flow. There are five entry points in this flow: 1, 2, 3, 4 and 5. Each represents an independent entry point.

At point 1, the NB detects a fatal error from IMI\_x (not fatal in mirroring mode) to fail over mode for the mirroring pair (IMI\_x, IMI\_y). The NB sets IMIST[x].FAILINT that triggers a IMI\_HPINT, software sets the amber attention LED via IMIHPC[x].ATNLED (to indicate an operational problem) and processes this interrupt and exits.

At point 2, the software initiates a hot removal by setting IMIHPC[x].state to “Disabled” state (to remove IMI\_x) and sets the indication LED. A technician can initiate the removal process via pushing the attention button at point 5.

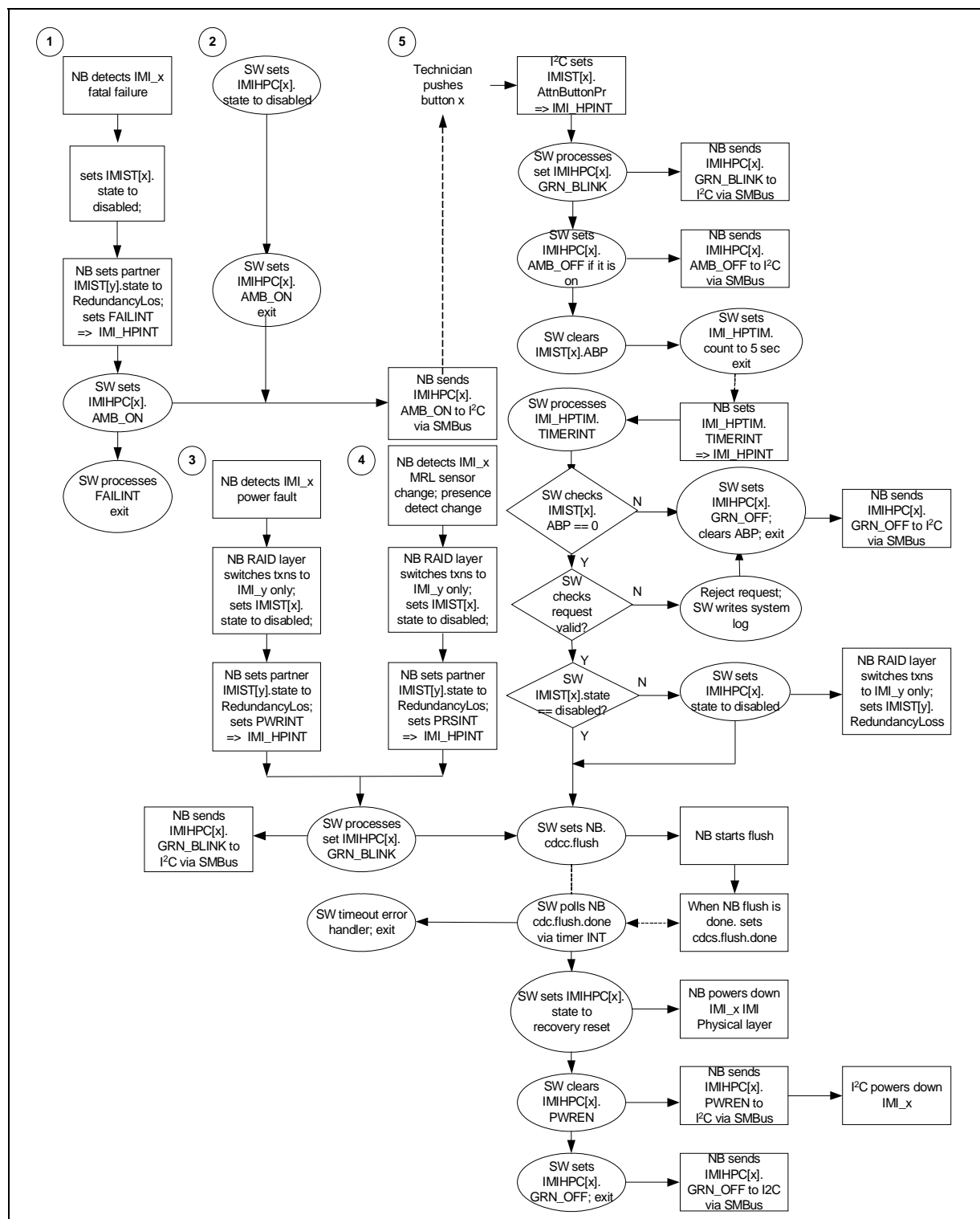
Prompted by the attention LED, the user/technician pushes the attention button following the standard usage model. The “attention button pressed” event triggers an IMI\_HPINT interrupt. The servicing software sets the green power LED to blinking state via IMIHPC[x].PWRLED and turns off the attention LED. It also clears the IMIST[x].ATNINT, and sets the IMI\_HPTIM timer to interrupt after five seconds and then exits. The NB will set IMI\_HPTIM.TIMER after the programmed five seconds period and triggers an IMI\_HPINT. If the button is pushed again during this five second period, the user indicates intention NOT to remove this IMI per standard Hot-Plug usage model. In that case, software turns off IMIHP[x].PWRLED, clears the IMIST[x].ATNINT, processes the event and exits.

If the user’s intention is confirmed after the five second period, the software and OS will validate the removal request against system policy (e.g. physical security policy).

Once the request is validated or NB detects power fault (entry point 3 with proper software handling), or the MRL sensor change (entry point 4 with proper software handling), software will flush the NB CDC via setting CDCC.FLUSH bit which starts a NB CDC flushing process. When the NB completes the flushing process, it sets CDCS.FLUSH.DONE bit. Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting time is 25 ms.

After the CDC flush is completed, software should set MIHPC[x].state to “recovery reset” state. The NB will put the IMI into reset state. Software then turns off power to the IMI/XMB via IMIHPC[x].PWRCTL. The Power LED is then turned off via IMIHPC[x].PWRLED by software. At this point, the IMI port is in reset and power to the XMB slot is turned off. Since the power LED is off, the user can remove the XMB per standard usage model.

### Figure 6-5. Hot Removal for Mirroring Mode



### 6.3.12.2.3 RAID Mode

Figure 6-6 illustrates a hot removal flow in RAID mode. It is similar to the Mirroring mode flow in Figure 6-5 on page 6-294 with the main differences in NB RAID layer processing and software processing of redundant partner IMI's. Shadowed areas in the flowchart indicate the differences.

The IMI\_x is the IMI to be hot removed where x could be A, B, C or D while IMI\_w, IMI\_y, and IMI\_z are the RAID partners of IMI\_x. All IMI's are at redundant state (IMIST[w/x/y/z].state = redundant) entering the flow. There are five entry points in this flow: 1, 2, 3, 4, and 5. Each represents an independent entry point.

At point 1, NB detects a fatal error from IMI\_x (not fatal in RAID mode) and NB RAID layer switches to fail over mode in RAID mode. NB sets IMIST[x].FAILINT, which triggers a IMI\_HPINT, software sets the amber attention LED via IMIHPC[x].ATNLED to indicate an operational problem, processes this interrupt and exits. At point 2, the software initiates a hot removal by setting IMIHPC[x].state to disabled state to remove IMI\_x and set the indication LED. A technician can initiate the removal process by pushing the attention button at point 5.

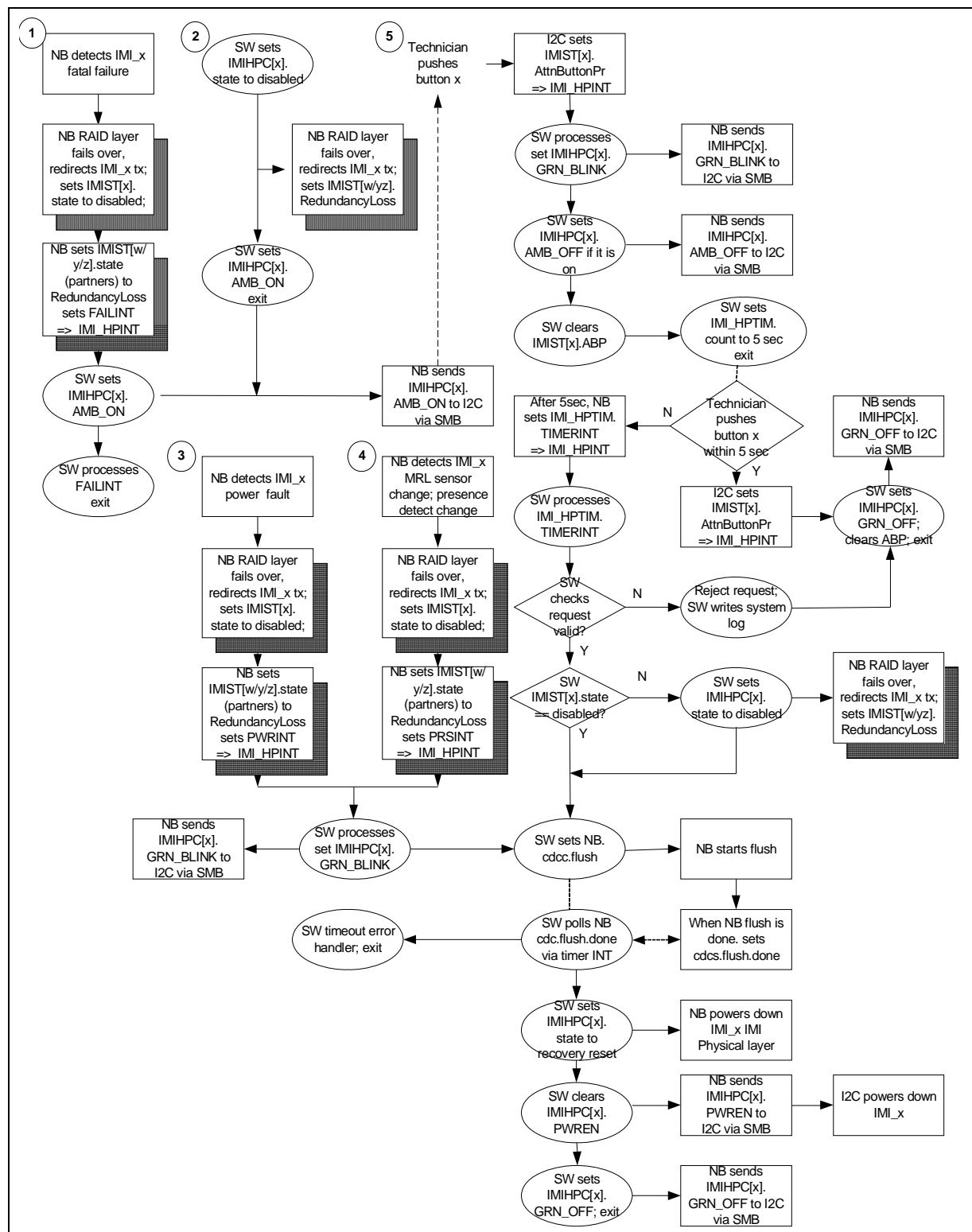
Prompted by the attention LED, the user/technician pushes the attention button, following the standard usage model. The attention button pressed event triggers IMI\_HPINT interrupt. The servicing software sets the green power LED to blinking state via IMIHPC[x].PWRLED and turns off the attention LED. It also clears the IMIST[x].ATNINT and sets IMI\_HPTIM timer to interrupt after five seconds, then exits. NB will set IMI\_HPTIM.TIMER after the programmed five-second period and triggers a IMI\_HPINT. If the button is pushed again during this five-second period, the user indicates his intention NOT to remove this IMI per standard Hot-Plug usage model. In that case, software turns off IMIHP[x].PWRLED, clears the IMIST[x].ATNINT and processes the event and exits.

If the user's intention is confirmed after the five-second period, the software and OS will validate the removal request against system policy (e.g. physical security policy).

Once the request is validated or NB detects power fault (entry point C with NB RAID layer switching and proper software handling) or MRL sensor change (entry point D with NB RAID layer switching and proper software handling), software will flush NB CDC via setting CDCC.FLUSH bit, which starts a NB CDC flushing process. When NB completes the flushing process, it sets CDCS.FLUSH.DONE bit. Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting period is 25 ms; the final value will be tuned with hardware implementation.

After the CDC flush is completed, software should set IMIHPC[x].state to recovery reset state. NB will put the IMI into reset state. Software then turns off power to the IMI/XMB via IMIHPC[x].PWRCTL. Power LED is then turned off via IMIHPC[x].PWRLED by software. At this point, the IMI port is in reset and power to the XMB slot is turned off. Since the power LED is off, the user can remove the XMB per the standard usage model.

Figure 6-6. Hot Remove in RAID Mode





### 6.3.13 Memory Hot Addition

Software/User initiates hot addition for preventative maintenance or add-on upgrade purposes. NB could support at least two approaches:

- The user inserts an XMB card, closes the MRL switch and then pushes the attention button on a XMB card to indicate hot addition intention.
- User requests hot addition through system software user interface.

Hot addition flows in the chapter illustrate the attention button mechanism only.

#### 6.3.13.1 Normal Mode

Figure 6-7 illustrates a hot addition flow in normal mode. The IMI\_x is the IMI to be hot added (where x could be A,B, C or D). IMI\_x is at reset state (IMIST[x].state = reset) entering the flow.

At point A, the user/technician inserts a XMB card into slot x and closes the MRL switch. The NB sets IMIST[x].PRSINT, and triggers an IMI\_HPINT interrupt. Servicing software processes this interrupt and records the possible addition of IMI\_x. The user then pushes the attention button following the standard usage model. The “attention button pressed” event triggers the IMI\_HPINT interrupt. The servicing software sets the green power LED to “blinking state” via IMIHPC[x].PWRLED. It also clears the IMIST[x].ATNINT and sets IMI\_HPTIM timer to interrupt after five seconds and then exits. The NB will set IMI\_HPTIM.TIMER after the programmed five second period and triggers an IMI\_HPINT. If the button is pushed again during this five second period, the user indicates intention NOT to add this IMI per standard Hot-Plug usage model. In that case, software turns off the IMIHP[x].PWRLED, clears the IMIST[x].ATNINT, processes the event and exits.

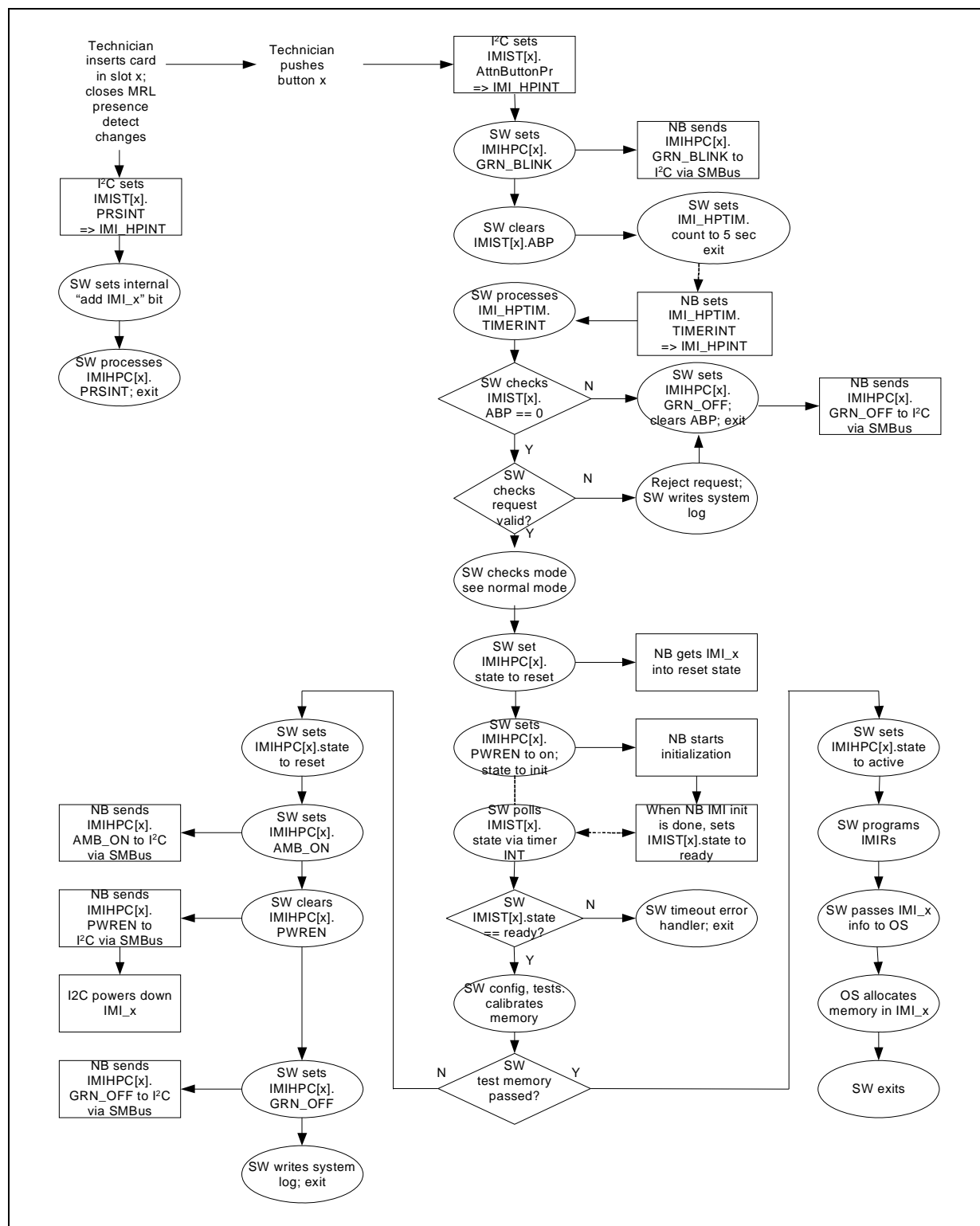
If the user’s intention is confirmed after the five second period, the software and OS will validate the addition request against system policy (e.g. physical security policy).

Once the request is validated, software sets the IMI state to reset for a clean start. Software then advances the IMI state to initialization, and the NB will start the initialization process. When the NB completes the initialization process, it sets the IMIST[x].STATE to “ready” state. Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting time is 25 ms.

Once the IMI is in “ready” state, software performs memory configuration, memory testing and memory calibration. If the XMB memory passes the testing and calibration, then software sets the IMIHPC[x].STATE to active and programs IMIR’s. The OS will allocate the system memory in this IMI/XMB. This hot addition is completed successfully.

If the XMB memory does not pass the testing and calibration, software sets the IMI state back to reset and turns on the amber attention LED to report operational problem. Software then turns off the XMB slot power via IMIHPC[x].PWREN and turns off green power LED. Finally, software writes to the system log and exits.

Figure 6-7. Hot Addition in Normal Mode



### 6.3.13.2 Mirroring Mode

Figure 6-8 illustrates a hot addition flow in mirroring mode. The IMI\_x is the IMI to be hot added (where x could be 0, 1, 2, or 3), while IMI\_y is the mirroring partner of IMI\_x. IMI\_x is at recovery reset state and IMI\_y is at redundancy loss state (IMIST[x].state = recovery reset and IMIST[y].state = redundancy loss) entering the flow.

At point A, the user/technician inserts a XMB card into slot x and closes the MRL switch. The NB sets the IMIST[x].PRSINT and triggers an IMI\_HPINT interrupt. Servicing software processes this interrupt and records the possible addition of the IMI\_x. The user then pushes the attention button following the standard usage model. The “attention button” pressed event triggers IMI\_HPINT interrupt. The servicing software sets the green power LED to “blinking” state via IMIHPC[x].PWRLED, it also clears the IMIST[x].ATNINT, sets IMI\_HPTIM timer to interrupt after five seconds and then exits. The NB will set IMI\_HPTIM.TIMER after the programmed five second period and triggers an IMI\_HPINT. If the button is pushed again during this five second period, the user indicates intention NOT to add this IMI per standard Hot-Plug usage model. In that case, software turns off the IMIHP[x].PWRLED, clears the IMIST[x].ATNINT, processes the event and exits.

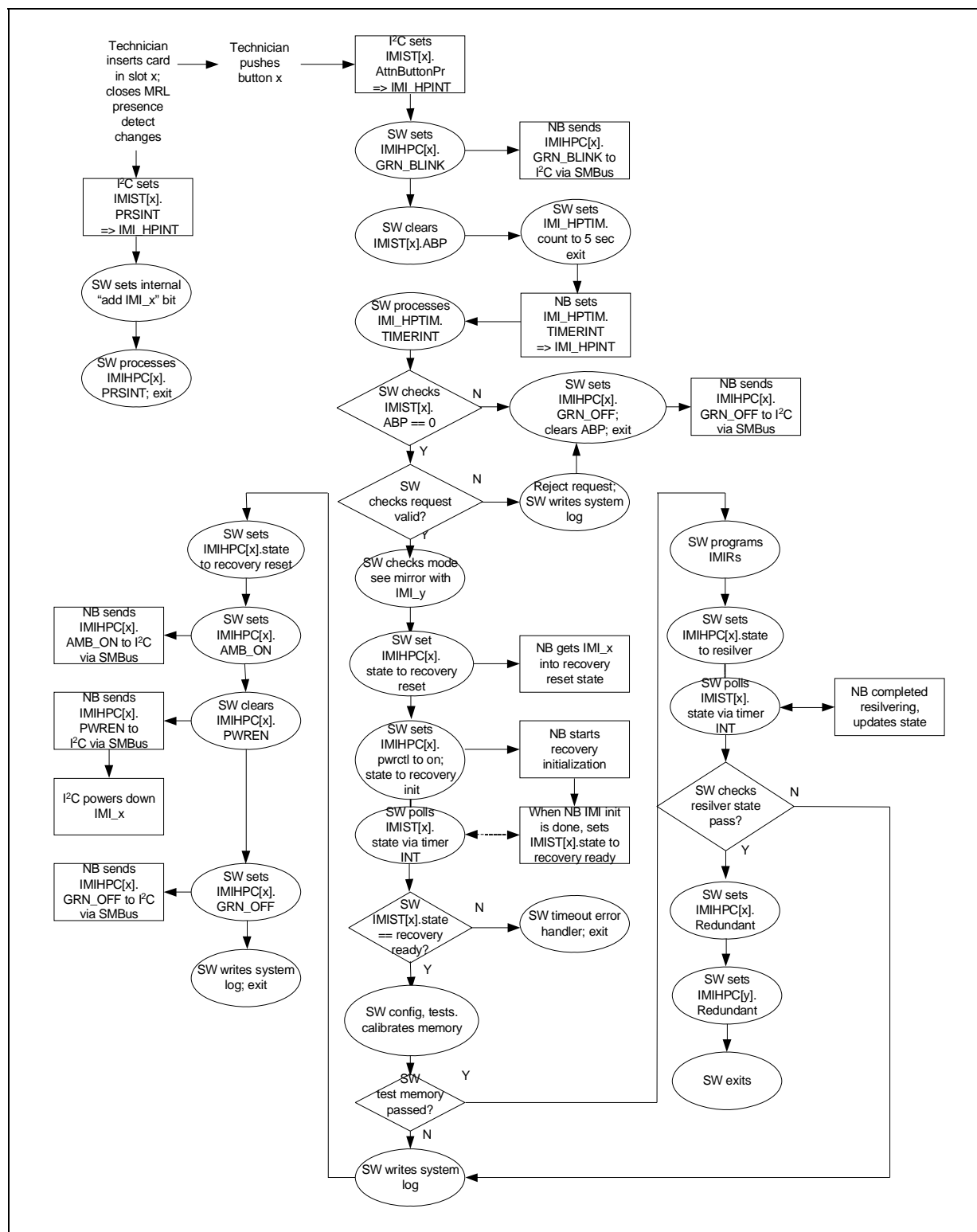
If the user’s intention is confirmed after the five second period, the software and the OS will validate the addition request against system policy (e.g. physical security policy).

Once the request is validated, software sets the IMI state to “recovery” reset for a clean start. Software then advances the IMI state to recovery initialization and the NB will start the recovery initialization process. When the NB completes the recovery initialization process, it sets the IMIST[x].STATE to recovery ready state. Software can use the IMI\_HPTIM to poll this completion bit periodically.

Once the IMI is in the “recovery ready” state, software performs memory configuration, memory testing and memory calibration. If the XMB memory passes the testing and calibration, software then programs the IMIR’s and sets the IMIHPC[x].STATE to “resilver” state. If the re-silvering process is successful, NB will set the IMI state to “recovered” state (IMIST[x].STATE = Recovered). Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting time is 25 ms. Software then sets IMIHPC[x].STATE to “redundant” and IMIHPC[y].STATE to “redundant”. This hot addition is completed successfully.

If the re-silvering fails as indicated by the NB setting IMIST[x].STATE to “recovery failed” or the XMB memory does not pass the testing and calibration, software writes to system log and sets the IMI state back to “recovery reset” and turns on the amber attention LED to report operational problem. Software then turns off the XMB slot power via IMIHPC[x].PWREN and turns off green power LED. Finally, software writes to the system log and exits.

Figure 6-8. Hot Addition in Mirroring Mode



### 6.3.13.3 RAID Mode

Figure 6-9 illustrates a hot addition flow in RAID mode. It is similar to the mirroring mode flow in Figure 6-8 on page 6-300 with main differences in NB RAID layer processing and software processing of redundant IMI partners. Shadowed areas in the flowchart indicate the differences.

The IMI\_x is the IMI to be hot added where x could be A, B, C or D, while IMI\_w, IMI\_y, and IMI\_z are the RAID partners of IMI\_x. IMI\_x is at recovery reset state and IMI\_w, IMI\_y and IMI\_z are at redundancy loss state (IMIST[x].state = recovery reset, IMIST[w].state = IMIST[y].state = IMIST[z].state = redundancy loss) entering the flow.

At point 1, the user/technician inserts a XMB card into slot x and closes the MRL switch. NB sets IMIST[x].PRSINT and it triggers a IMI\_HPINT interrupt. Servicing software processes this interrupt and records the possible addition of IMI\_x. The user then pushes the attention button following the standard usage model. The attention button pressed event triggers IMI\_HPINT interrupt. The servicing software sets the green power LED to blinking state via IMIHPC[x].PWRLD. It also clears the IMIST[x].ATNINT and sets IMI\_HPTIM timer to interrupt after five seconds and then exits. NB will set IMI\_HPTIM.TIMER after the programmed five-second period and triggers a IMI\_HPINT. If the button is pushed again during this five-second period, the user indicates his intention NOT to add this IMI per standard Hot-Plug usage model. In that case, software turns off IMIHPC[x].PWRLD, clears the IMIST[x].ATNINT and processes the event and exits.

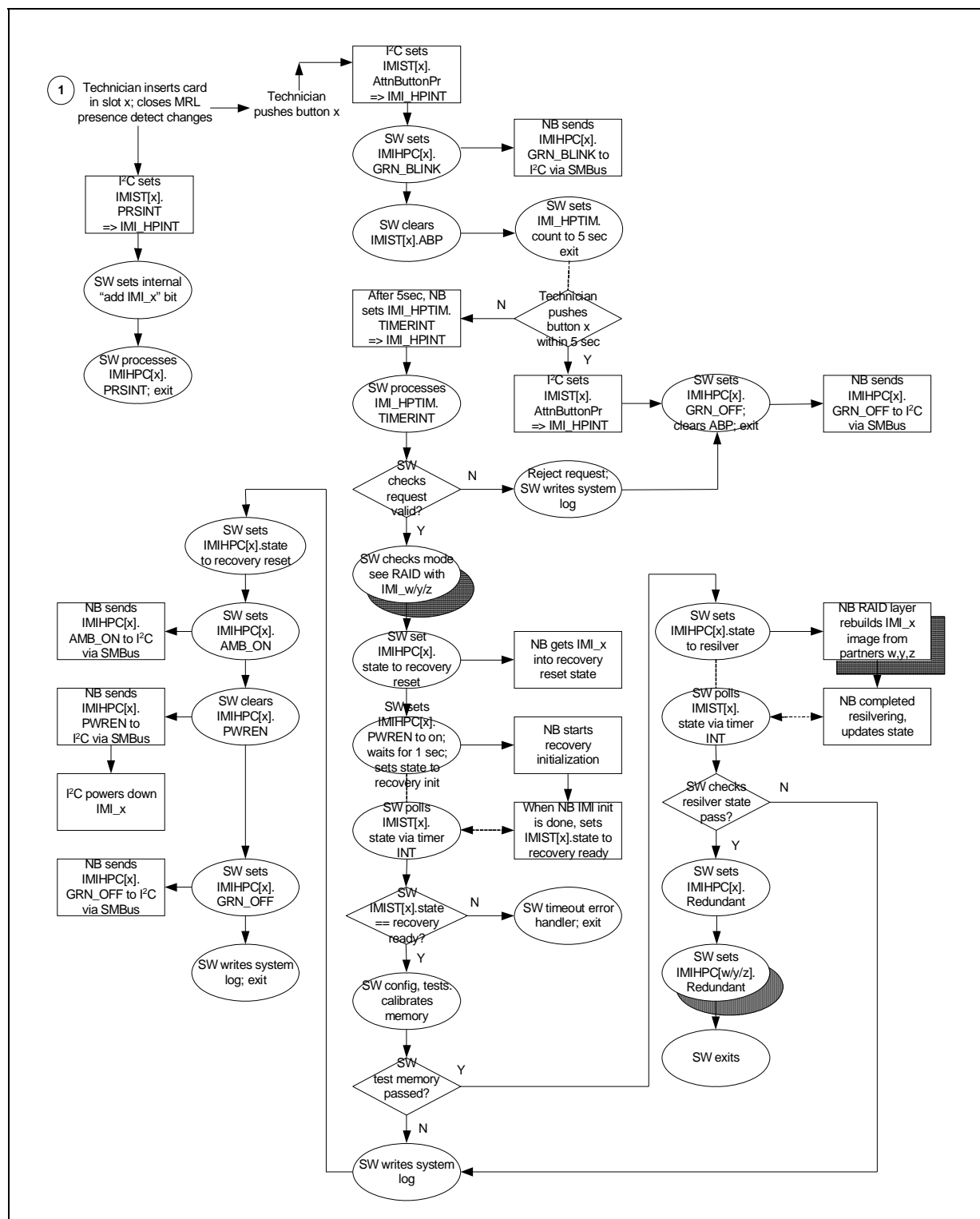
If the user's intention is confirmed after the five-second period, the software and OS will validate the addition request against system policy (e.g. physical security policy).

Once the request is validated, software sets the IMI state to recovery reset for a clean start. Software then advances the IMI state to recovery initialization and NB will start the recovery initialization process. When NB completes the recovery initialization process, it sets the IMIST[x].STATE to recovery ready state. Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting period is 25 ms; the final value will be tuned with hardware implementation.

Once the IMI is in recovery ready state, software performs memory configuration, memory testing and memory calibration. If the XMB memory passes the testing and calibration, software then programs IMIR's and sets the IMIHPC[x].STATE to resilver state. NB RAID layer will re-build the correct image of IMI\_x from its RAID partners: IMI\_w, IMI\_y and IMI\_z. If the re-silvering process is successful, NB will set the IMI state to recovered (IMIST[x].STATE = recovered). Software can use the IMI\_HPTIM to poll this completion bit periodically. The recommended waiting period is 25 ms.; the final value will be tuned with hardware implementation. Software then sets all IMIHPC[x].STATE, IMIHPC[w].STATE, IMIHPC[y].STATE and IMIHPC[z].STATE to redundant. This hot addition is completed successfully.

If the re-silvering failed as indicated by NB setting IMIST[x].STATE to recovery failed, or if XMB memory does not pass the testing and calibration, software writes to the system log, sets the IMI state back to recovery reset and turns on the amber attention LED to report an operational problem. Software then turns off the XMB slot power via IMIHPC[x].PWREN and turns off the green power LED. Finally, software writes to the system log and exits.

Figure 6-9. Hot Addition in RAID Mode



## 6.4 PCI Express Interface

PCI Express is the next generation I/O interface replacing PCI-X. It offers a very high bandwidth to pin interface for general-purpose adapters interfacing a wide variety of I/O devices. The *PCI Express Base Specification*, Revision 1.0 provides the details of the PCI Express protocol.

### 6.4.1 Support

The following table describes the options and limitations supported by the NB-to-PCI Express ports.

**Table 6-19. Options and Limitations**

| Parameter        | Support  |
|------------------|--|
| Max payload      | 256B   |
| Hot-Plug         | Serial port to support pins.   |
| Virtual Channels | NB only supports VC0.  |
| Isochrony        | NB does not support isochrony.   |
| Ordering         | NB only supports strict PCI ordering.  |
| No Snoop         | NB will not snoop processor caches for transactions with the No Snoop attribute.   |
| Power Management | The NB cannot be powered down, but will forward messages, generate PME_Turn_Off and collect PME_TO_ACKs. It will provide a Capabilities structure. |
| Poisoning        | NB will poison data that it cannot correct.  |

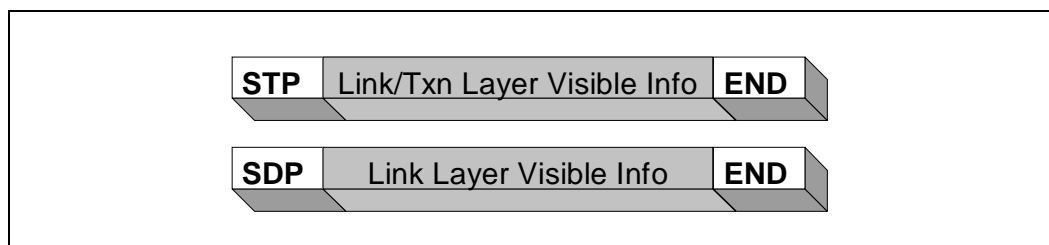
### 6.4.2 Physical Layer

The PCI Express physical layer implements high-speed serial signalling techniques including:

- Differential signalling (1.6 V peak-to-peak)
- 2.5 GHz data rate (up to 2 GB/s/direction peak bandwidth for an x8 link)
- 8b/10b encoding for embedded clocking and packet framing
- Unidirectional data path in each direction supporting full duplex operation
- Random idle packets and spread-spectrum clocking for reduced EMI
- Loop-back mode for testability
- Lane reversal
- Polarity Inversion

Figure 6-10 illustrates the scope of the physical layer on a PCI Express packet. There are two types of packets: Link layer packets and Transaction Layer Packets. The physical layer is responsible for framing these packets with STP/END symbols (Transaction Layer Packets) and SDP/END symbols (Data Link Layer packets). The grayed out segment is not decoded by the Physical layer.

Figure 6-10. PCI Express Packet Visibility by Physical Layer

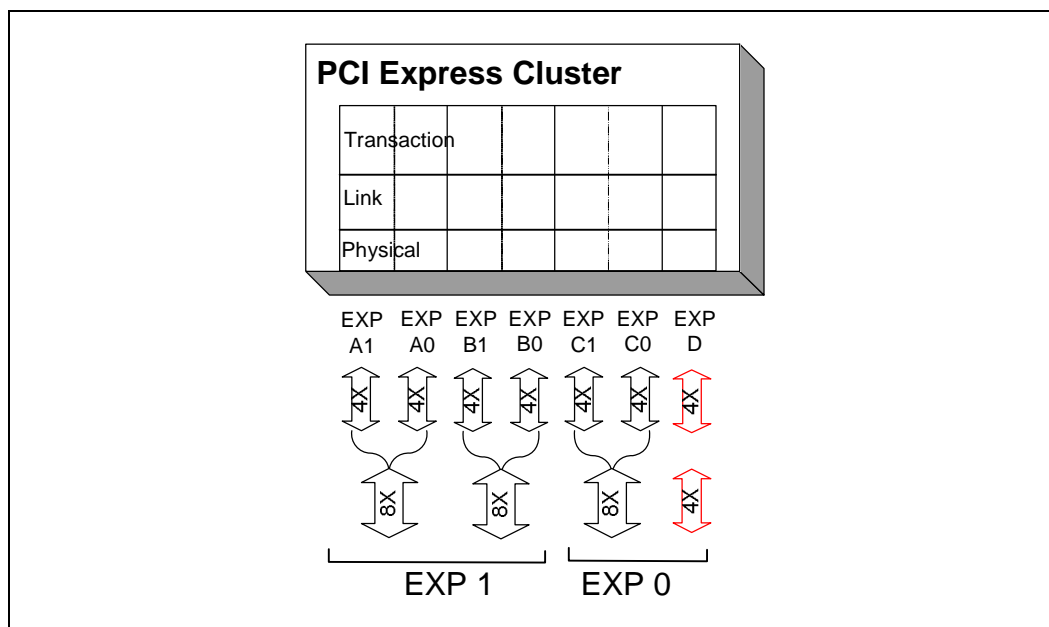


Each lane of a PCI Express port consists of 4 signals: 1 differential pair per direction. (For description of the PCI Express signals refer to [Table 3-5 “Intel® E8501 Chipset North Bridge \(NB\) Signals \(PCI Express\)”](#) on page 3-41).

### 6.4.2.1 Supported Widths and Port Partitioning

Some of the x4 PCI Express ports can be combined to form x8 ports. Ports A0&A1, B0&B1 and C0&C1 can be combined to form x8s. Port D cannot be combined with other ports. Width configuration occurs independently per port through PCI Express training.

Figure 6-11. PCI Express Interface x8 Partitioning



The PCI Express training state machine is capable of automatically determining the port partitioning.



**Table 6-20. Width Strapping Options for Port 1 (EXP\_{ A1/A0/B1/B0})**

| EXP1_WIDTH[2:0] | Port A1   | Port A0 | Port B1 | Port B0 |
|-----------------|---|---------|---------|---------|
| 000             | x4  | x4      | x4      | x4      |
| 001             | x4  | x4      | x8      |         |
| 010             | x8  |         | x4      | x4      |
| 011             | x8  |         | x8      |         |
| 10X             | Reserved  |         |         |         |
| 110             | Reserved  |         |         |         |
| 111             | All port widths determined by link negotiation. |         |         |         |

Table 6-20 illustrates the strapping options for ports C0 and C1.

**Table 6-21. Width Strapping Options for Port 0 (Exp\_{ C1/C0/D})**

| EXP0_WIDTH[1:0] | Port C1   | Port C0 | Port D |
|-----------------|---|---------|--------|
| 00              | x4  | x4      | x4     |
| 01              | Reserved  |         |        |
| 10              | x8  |         |        |
| 11              | All port widths determined by link negotiation. |         |        |

The *PCI Express Base Specification*, Revision 1.0 requires only that a port be capable of negotiating and operating at the native width and x1. However, in order to support a x4 device plugged into a x8 slot, the NB attempts all supported widths narrower than the native width. For example, a port strapped at x8, will first attempt negotiation at x8. If that attempt fails, an attempt is made at x4, then x2 and then x1. When settling on a narrower width and the straps are used to override the auto-negotiation partitioning, the remaining links are unused.

### 6.4.3 Training State Machine

The *PCI Express Base Specification*, Revision 1.0 defines the training state machine required on each port. This state machine is responsible for establishing:

- Negotiated width of the port
- Negotiated frequency of the port
- Presence of a PCI Express component

The *PCI Express Base Specification*, Revision 1.0a defines a training state machine that is incompatible with the state machine defined in specification 1.0. Thus, the NB has strapping pins forcing it to behave with either of the two specifications. The EXP[1:0]\_SEPC10A pins control this behavior.

**Table 6-22. Training State Machine Mode**

| Pin                 | Value | Function  |
|---------------------|-------|---|
| <b>EXP0_SEPC10A</b> | 0     | PCI Express ports D, C0, C1 will use 1.0 specification.       |
|                     | 1     | PCI Express ports D, C0, C1 will use 1.0a specification.      |
| <b>EXP1_SPEC10A</b> | 0     | PCI Express ports B0, B1, A0, A1 will use 1.0 specification.  |
|                     | 1     | PCI Express ports B0, B1, A0, A1 will use 1.0a specification. |

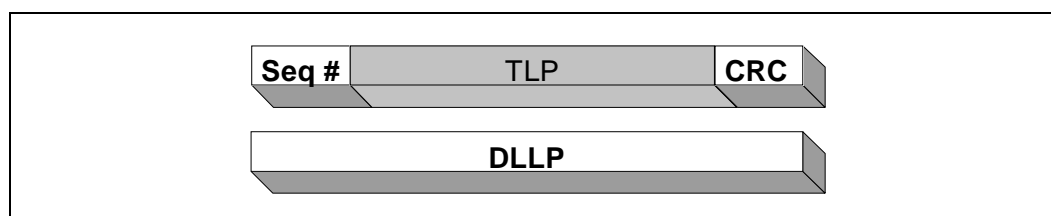
## 6.4.4 Link Layer

The Data Link Layer of the PCI Express protocol is primarily responsible for data integrity. This is accomplished with the following elements:

- Sequence number assignment for each packet
- ACK/NAK protocol to ensure successful transmission of every packet
- CRC protection of packets
- Time-out mechanism to detect “lost” packets
- Credit exchange

Figure 6-12 illustrates the scope of the link layer on a PCI Express packet. There are two types of packets: Data Link Layer Packets (DLLP) and Transaction Layer Packets (TLP). Data Link Layer Packets are sent between the Link Layers of each PCI Express device and do not proceed to the Transaction Layer.

For Transaction Layer Packets (TLP), the Link Layer is responsible for prepending sequence numbers and appending 32-bit CRC. The grayed out segment is not decoded by the Data Link Layer.

**Figure 6-12. PCI Express Packet Visibility by Link Layer**

### 6.4.4.1 Data Link Layer Packets (DLLP)

Refer to *PCI Express Base Specification*, Revision 1.0 for an explicit definition of all the fields in a Data Link Layer packet.

DLLP's are used to ACK or NAK packets as they are sent from the transmitter to the receiver. They are sent by the receivers of the packet to indicate to the transmitter that a packet was successfully received (ACK) or not (NAK). DLLP's are also used to exchange credit information between the transmitter and receiver.

DLLP's are protected with 16b CRC. If the CRC of a DLLP is received indicates an error, the DLLP is dropped. This is safe because the PCI Express protocol supports dropping these packets and the next DLLP allows the transmitter to process successfully.

#### 6.4.4.2 ACK/NAK

The Data Link layer is responsible for ensuring that packets are successfully transmitted between PCI Express agent. PCI Express implements an ACK/NAK protocol to accomplish this. Every packet is decoded by the physical layer (8b/10b) and forwarded to the link layer. The CRC code appended to the packet is then checked. If this comparison fails, the packet is “retried”.

If the comparison is successful, an ACK is issued back to the transmitter and the packet is forwarded for decoding by the receiver's Transaction layer. Typically, as each packet is successfully received by the Data Link layer, the receiver issues an ACK. However, the PCI Express protocol allows that ACK's can be combined.

#### 6.4.4.3 Link Level Retry

The *PCI Express Base Specification*, Revision 1.0 lists all the conditions where a packet gets NAK'ed. One example is on a CRC error. The Link layer in the receiver is responsible for calculating 32b CRC (using the polynomial defined in *PCI Express Base Specification*, Revision 1.0) for incoming packets and comparing the calculated CRC with the received CRC. If they do not match, then the packet is retried by NAK'ing the packet with a NAK DLLP specifying the sequence number of the last good packet. Subsequent packets are dropped until the reattempted packet is observed again.

When the transmitter receives the NAK, it is responsible for retransmitting the packet specified with the Sequence number in the DLLP + 1. Furthermore, any packets sent after the last good packet will also be resent since the receiver has dropped any packets after the corrupt packet.

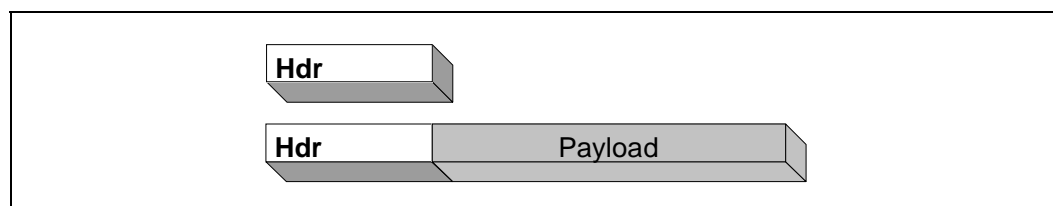
### 6.4.5 Transaction Layer

The PCI Express Transaction Layer is responsible for sending read and write operations between components. This is the PCI Express layer which actually moves software visible data between components. The transaction layer provides the mechanisms for:

- Software configuration of components
- Communication between the FSB and different I/O technologies
- Communication between the memory and different I/O technologies

Figure 6-13 illustrates the scope of the transaction layer on a PCI Express packet. Some transaction layer packets have only a header (e.g. read request). Some transaction layer packets have a header followed by data (e.g. write requests and read completions).

**Figure 6-13. PCI Express Packet Visibility by Transaction Layer**



### 6.4.5.1 Supported Transactions

Table 6-23 lists all the transactions supported by the NB which are expected to be received from the PCI Express interface. Similarly, Table 6-25 lists all the transactions to be expected by an attached PCI Express component. Refer to the *PCI Express Base Specification*, Revision 1.0 for the specific protocol requirements of this interface.

**Table 6-23. Incoming PCI Express Requests**

| PCI Express Transaction | Address Space or Message       | NB Response  |
|-------------------------|--------------------------------|--|
| Inbound Write Requests  | Memory                         | Forward to Main Memory or PCI Express or Hub Interface port depending on address.  |
|                         | I/O                            | Forward to peer PCI Express or Hub Interface port.   |
|                         | Configuration (Type0 or Type1) | Forward to peer PCI Express or Hub Interface port if enabled.  |
| Inbound Read Requests   | Memory                         | Forward to Main Memory, or PCI Express or Hub Interface.   |
|                         | I/O                            | Forward to peer PCI Express or Hub Interface port.   |
|                         | Configuration (Type0 or Type1) | Forward to peer PCI Express or Hub Interface port if enabled.  |
| Inbound Message         | ASSERT_INTA                    | Inband interrupt assertion/de-assertion emulating PCI interrupts.  |
|                         | DEASSERT_INTA                  |  |
|                         | ASSERT_INTB                    | Inband interrupt assertion/de-assertion emulating PCI interrupts.  |
|                         | DEASSERT_INTB                  |  |
|                         | ASSERT_INTC                    | Inband interrupt assertion/de-assertion emulating PCI interrupts.  |
|                         | DEASSERT_INTC                  |  |
|                         | ASSERT_INTD                    | Inband interrupt assertion/de-assertion emulating PCI interrupts.  |
|                         | DEASSERT_INTD                  |  |
|                         | ERR_COR                        | Propagate as an interrupt to system.   |
|                         | ERR_UNC                        | Propagate as an interrupt to system.   |
|                         | ERR_FATAL                      | Propagate as an interrupt to system.   |
|                         | PM_PME                         | Propagate as a general purpose event to the system via the PME_OUT pin.  |
|                         | PM_TO_ACK                      | Set when the NB receives this message from all enabled PCI Express ports.  |
|                         | PM_ENTER_L1 (DLLP)             | Block subsequent TLP issue and wait for all pending TLPs to ACK. Then, send PM_REQUEST_ACK.  |
|                         | ATTENTION_BUTTON_PRESSED       | Terminate the message and set the EXP_SLOTSTS. ATTENTION_BUTTON_PRESSED.<br>If EXPCTRL.ATTENTION_BUTTON_PRESSED Enable and HOT-PLUG INTERRUPT ENABLE bits are set, assert EXP_HPINT.               |
|                         | ASSERT_GPE                     | Assert the EXP_HPINT output signal unless already asserted. This message should be considered a wired-or input with the other EXP_HPINT inputs.<br>NOTE: This is an Intel vendor-specific message. |
|                         | DEASSERT_GPE                   | This message should be considered a wired-or input with the other EXP_HPINT inputs.<br>NOTE: This is an Intel vendor-specific message.   |
|                         | Others                         | Set IO12 error, drop transaction and return credit.  |

**Table 6-24. Incoming PCI Express Completions**

| PCI Express Transaction         | Address Space or Message          | NB Response   |
|---------------------------------|-----------------------------------|---|
| Completions for Outbound Writes | I/O or Configuration <sup>a</sup> | Forward to the FSB, PCI Express or Hub Interface from which the request originated. |
| Completions for Outbound Reads  | Memory, I/O or Configuration      | Forward to the FSB, PCI Express or Hub Interface from which the request originated. |

**NOTES:**

a. Outbound Memory writes are posted and have no completions

**Table 6-25. Outgoing PCI Express Requests**

| PCI Express Transaction | Address Space or Message  | Reason for Issue   |
|-------------------------|---------------------------|--|
| Outbound Write Requests | Memory                    | FSB or peer memory-mapped I/O write targeting PCI Express device.  |
|                         | I/O                       | Processor legacy I/O write targeting PCI Express device.   |
|                         | Configuration             | Processor or peer configuration write targeting PCI Express device.  |
| Outbound Read Requests  | Memory                    | Processor or peer memory-mapped I/O read targeting PCI Express device.   |
|                         | I/O                       | Processor or peer I/O read targeting PCI Express device.   |
|                         | Configuration             | Processor or peer configuration read targeting PCI Express device.   |
| Outbound Messages       | EOI (Intel-specific)      | End-of-interrupt cycle received on FSB, NB broadcasts this message to all active PCI Express ports. Devices supporting edge triggered interrupts will ignore this cycle. |
|                         | Unlock                    | When a locked read or write transaction was previously issued to a PCI bridge, "Unlock" releases the PCI lock.   |
|                         | PM_TURN_OFF               | EXP_GCTRL.PME_TURN_OFF bit was set. This message is broadcast to all enabled PCI Express ports.  |
|                         | PM_REQUEST_ACK (DLLP)     | Received PM_ENTER_L1. This message is continuously issued until link is idle.  |
|                         | Attention_Indicator_On    | EXP_SLOTCTRL."Attention Indicator Control" has been set to On.   |
|                         | Attention_Indicator_Off   | EXP_SLOTCTRL."Attention Indicator Control" has been set to Off.  |
|                         | Attention_Indicator_Blink | EXP_SLOTCTRL."Attention Indicator Control" has been set to Blink.  |
|                         | Power_Indicator_On        | EXP_SLOTCTRL."Power Indicator Control" has been set to On.   |
|                         | Power_Indicator_Off       | EXP_SLOTCTRL."Power Indicator Control" has been set to Off.  |
|                         | Power_Indicator_Blink     | EXP_SLOTCTRL."Power Indicator Control" has been set to Blink.  |
|                         | Set_Slot_Power_Limit      | Whenever the EXP_SLOTCAP register is written, The Slot Power Limit Scale and Slot Power Limit Value are sent in the payload.   |

**Table 6-26. Outgoing PCI Express Completions**

| PCI Express Transaction      | Address Space or Message       | Reason for Issue  |
|------------------------------|--------------------------------|---|
| Completion for Inbound Read  | Memory                         | Response for an inbound read to main memory or a peer I/O device.             |
|                              | I/O                            | Response for an inbound read to a peer I/O device.                            |
|                              | Configuration (Type0 or Type1) | Response for an inbound read to a peer I/O device.                            |
| Completion for Inbound Write | Memory                         | Response for an inbound non-posted write to main memory or a peer I/O device. |
|                              | I/O                            | Response for an inbound non-posted write to a peer I/O device.                |
|                              | Configuration (Type0 or Type1) | Response for an inbound non-posted write to a peer I/O device.                |

### 6.4.6 Interrupt Handling

On PCI Express, interrupts are represented with either MSI or inbound interrupt messages (ASSERT\_INTx/DEASSERT\_INTx).

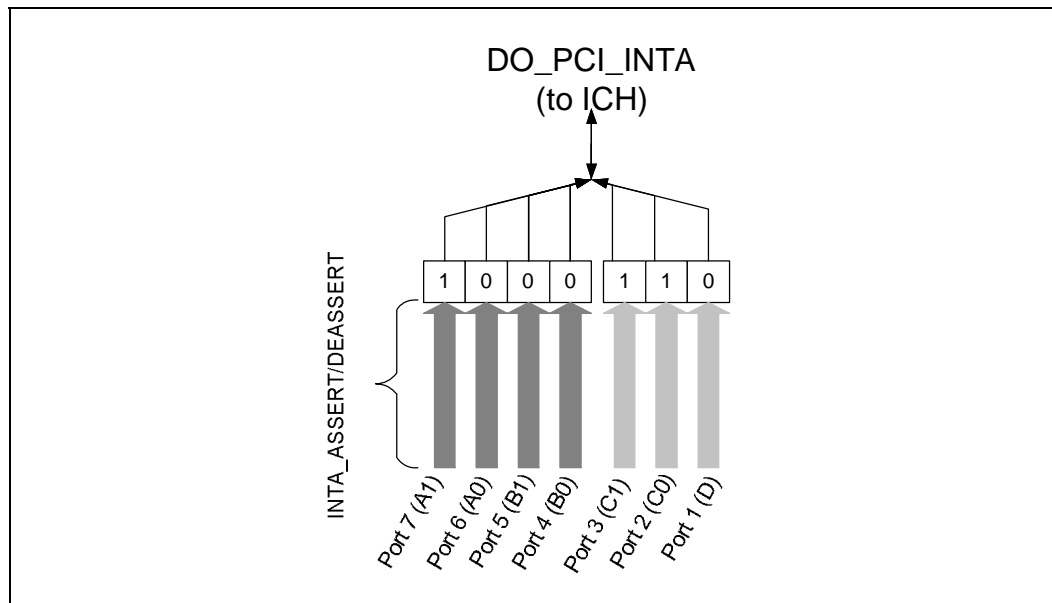
Each PCI Express port of the NB is responsible for tracking assert/deassert messages for each of the four interrupts (INTA, INTB, INTC, INTD) and representing them with four output “virtual wires” to the ICH5’s interrupt controller. These virtual wires are represented with DO\_PCI\_INTA, DO\_PCI\_INTB, DO\_PCI\_INTC, and DO\_PCI\_INTD messages to the ICH5.

Figure 6-14 illustrates how the PCI Express interrupts are routed to the ICH5. The example shown represents Interrupt A and this logic is replicated for the four interrupts. None of the bits depicted are software-visible.

When a PCI Express assert message is received for a specific interrupt, another assert message will not arrive until after a de-assert message has arrived for that interrupt first.

When MSI interrupts are used, the NB treats these writes as any other inbound write. The difference is that MSI writes are detected as a write to addresses in the range FEE0\_0000 - FEDF\_FFFF. If the write falls within this range, the NB issues the write to both FSB’s where it will be claimed by the targeted processor.

Figure 6-14. Legacy Interrupt Routing (INTA Example)



## 6.4.7 Ordering Rules

This section describes the NB ordering rules for transactions progressing through the PCI Express unit.

### 6.4.7.1 Inbound Transaction Ordering Rules

Inbound transactions originate from PCI Express and target main memory. In general, the PCI Express cluster holds inbound transactions in FIFO order. There are exceptions to this order under certain situations. For example, PCI Express requires that read completions are allowed to pass read requests. This forces any read completions to bypass any reads which might be back pressured in the queue. The PCI Express ports have no ordering relationship to each other (aside from the peer-to-peer restrictions below).

Sequential, non-posted requests are not required to be completed in the order they were requested. However, if a non-posted request requires multiple sub-completions (typically due to splitting a memory read into cacheline requests), then those sub-completions must be delivered in order.

Inbound writes cannot be posted beyond the PCI Express domain and outbound writes may only be posted after the write is acknowledged by the destination PCI Express cluster. The posting of writes relies on the fact that the system maintains a certain ordering relationship. Since the NB cannot post inbound writes beyond the PCI Express cluster, the NB must wait for snoop responses before issuing subsequent, order-dependent transactions.

### 6.4.7.2 Inbound Ordering Requirements

In general, there are no ordering requirements between transactions issued on the different PCI Express interfaces. However, the below rules apply to inbound transactions issued on the same interface.

The following rules must be ensured for inbound transactions:

- RULE 1:** Outbound non-posted read and write completions must be allowed to progress past stalled inbound non-posted requests.
- RULE 2:** Inbound posted write requests must be allowed to progress past stalled inbound non-posted requests.
- RULE 3:** Inbound posted write requests, inbound read requests, outbound non-posted read and write completions cannot pass enqueued inbound posted write requests.
- RULE 4:** The Producer - Consumer model, prevents read requests, write requests, and non-posted read or write completions from passing write requests.
- RULE 5:** Outbound non-posted read or write completions must push ahead *all* prior inbound posted write transactions from that PCI Express port.
- RULE 6:** To optimize performance, inbound, coherent, posted writes will issue ownership requests (RFO) without waiting for prior ownership requests to complete.
- RULE 7:** Inbound messages follow the same ordering rules as inbound posted writes.

Inbound messages are listed in [Table 6-23](#). Similarly to inbound posted writes, reads should push these commands ahead.

The above rules apply whether the transaction is coherent or non-coherent. Some regions of memory space are considered non-coherent (e.g. the Don't Snoop attribute is set). The PIQ will order all transactions regardless of its destination.

### 6.4.7.3 Outbound Transaction Ordering Rules

Outbound transactions through the NB are memory, I/O or configuration read/write transactions originating on a processor interface destined for a PCI Express device. Subsequent outbound transactions with different destinations have no ordering requirements between them. Multiple transactions destined for the same PCI Express port are ordered according to the ordering rules specified in *PCI Express Base Specification*, Revision 1.0.



#### 6.4.7.4 Outbound Ordering Requirements

There are no ordering requirements between outbound transactions targeting different PCI Express interfaces. For deadlock avoidance, the following rules must be ensured for outbound transactions within the same PCI Express interface:

- RULE 1:** Inbound non-posted completions must be allowed to progress past stalled outbound non-posted requests.
- RULE 2:** Outbound posted write requests must be allowed to progress past stalled outbound non-posted requests.
- RULE 3:** Outbound non-posted requests, outbound messages, outbound write requests, and inbound completions cannot pass enqueued outbound posted write requests.
- RULE 4:** The Producer - Consumer model prevents read requests, write requests, and read completions from passing write requests.
- RULE 5:** Posted outbound messages must follow the same ordering rules as outbound posted writes.
- RULE 6:** If a non-posted inbound request requires multiple sub-completions, then those sub-completions must be delivered in linearly addressing order.

#### 6.4.7.5 NB Ordering Implementation

The following table summarizes the rules enforced on transactions from a given PCI Express port by the NB.

**Table 6-27. NB Ordering Implementation**

| Transaction         | Will the transaction pass a stalled Posted Request? | Will the transaction pass a stalled Non-Posted Request? | Will the transaction pass a stalled completion? |
|---------------------|---|---|---|
| Posted requests     | never   | always  | always  |
| Non-Posted Requests | never   | sometimes   | always  |
| Completions         | never   | always  | never   |

#### 6.4.7.6 Interrupt Ordering Rules

With MSI, SAPIC and XAPIC, interrupts are simply inbound non-coherent writes to the processor. With legacy interrupts, the interrupts are ASSERT and DEASSERT messages (also following posted write ordering rules). This enforces that the interrupt will not be observed until all prior inbound writes are flushed to their destinations. The NB does not, however, guarantee that the interrupt will be observed by the processor before subsequent writes are visible to a processor.

## 6.4.8 Hot-Plug

Each PCI Express port supports the optional Hot-Plug capability described in *PCI Express Base Specification*, Revision 1.0. The PCI Express Hot-Plug model implies a Hot-Plug controller per port which is identified to software as a capability of the P2P Bridge configuration space.

PCI Express Hot-Plug support requires that the NB supports a set of Hot-Plug messages (listed in [Table 6-23](#) and [Table 6-25](#)) to manage the states between the Hot-Plug controller and the device.

The PCI Express form factor has an impact to the level of support required of the NB. For example, some of the Hot-Plug messages are required only if the LED indicators reside on the actual card and are accessed through the endpoint device (SIOM). The NB supports all of the Hot-Plug messages so that the platform is not constrained to any particular form factor.

### Hot-Plug Controller:

PCI Express Hot-Plug requires that the NB implements a Hot-Plug controller for every Hot-Pluggable interface. The Hot-Plug controller is a capability of the bridge configuration space and the register set is accessible through the standard PCI capability mechanism defined in *PCI Express Base Specification*, Revision 1.0.

### 6.4.8.1 PCI Express Add-in Card Hot-Plug Model

The subsections below describe the signals required for PCI Express Add-in Card Hot-Plug. This model is such that the LEDs and remove button reside on the chassis. The NB provides an SMBus interface to a set of external programmable I/O devices that provide the Hot-Plug pins for any PCI Express ports that support Hot-Plug. This interface is described in [Section 6.6](#).

### 6.4.8.2 Hot-Plug Pins

[Table 6-28](#) describes the Hot-Plug signals used for Hot-Plug. For registers that control or provide the status of these pins please refer to [Section 4.16.8, “GLOBAL\\_FERR: Global First Error Register \(D16, F2\)”](#) on page 196.

**Table 6-28. Hot-Plug Pins**

| Signal Name | Description   |
|-------------|---|
| ATNLED#     | This indicator is connected to the Attention LED on the baseboard.  |
| PWRLED#     | This indicator is connected to the Power LED on the baseboard.  |
| BUTTON#     | Input signal per slot which indicates that the user wishes to hot remove or hot add a PCI Express card.   |
| PRSNT#      | Input signal that indicates if a “Hot-Plugged” PCI Express device is currently plugged into the slot.   |
| PWRFLT#     | Input signal from the power controller to indicate that a power fault has occurred.   |
| PWREN       | Output signal allowing software to enable or disable a PCI Express slot.  |
| EXP_HPINT   | Hot-Plug interrupt output signal. There is only one EXP_HPINT signal for the NB. Both parallel interfaces drive the same output signal.   |
| MRL#        | Manual (mechanical) Retention Latch input indicates that a retention latch is enabled or disabled on the board for this slot. A retention latch is used on the platform to mechanically hold the card in place. |

### 6.4.8.3 SIOM Hot-Plug Model

The SIOM Hot-Plug model is such that the LEDs and remove button reside on the endpoint module. Because of this model, the NB is responsible for issuing in-band messages to the endpoint and the endpoint is responsible for controlling the button, LEDs, etc.

The messages used for the SIOM Hot-Plug model are listed in [Table 6-23](#) and [Table 6-25](#) and describe the behavior of the button and LEDs.

## 6.5 Hub Interface 1.5 - (Compatibility Interface)

The HI1.5 is an 8-bit port responsible for accepting and sending packets between the NB and the ICH5 component.

### 6.5.1 Physical Layer

The compatibility interface supports parallel termination. Parallel termination is required for the routing distances required for Intel® E8501 chipset chip-based platforms. Hub Interface uses a point-to-point bus topology using a combination of common clock framing signals and source-synchronous data transfer. The 8-bit data bus rate is 266 MHz (quad-pumped) using strobe signals. This interface is protected with one parity bit per 32 bits of data.

### 6.5.2 Transaction Layer

[Table 6-29](#) lists all the transactions supported by the NB which are expected to be received from the ICH5. Similarly, [Table 6-31](#) lists all the transactions to be expected by the ICH5. Refer to the *I/O Controller Hub5 (ICH5), I/O Controller Hub5-M Datasheet* for the specific protocol requirements of this interface.

**Table 6-29. Incoming Hub Interface Request Cycles**

| Hub Interface Transaction | Transaction Type              | NB Response  |
|---------------------------|-------------------------------|--|
| Inbound Write Requests    | Memory                        | Forward to Main Memory or PCI Express port depending on address.   |
| Inbound Read Requests     | Memory                        | Forward to Main Memory or PCI Express.   |
| Inbound Special Cycles    | Go C0                         | Ignore. No further action is taken.  |
|                           | Go C3                         | Immediately respond with an "ACK C3" special cycle. No further action is taken.  |
|                           | Go C3A                        | Immediately respond with an "ACK C3A" special cycle. No further action is taken.   |
|                           | APIC Interrupt xmit requested | Since this chipset does not support the serial APIC bus, this special cycle is simply responded to with an "APIC Interrupt xmit granted" special cycle.  |
|                           | SRC                           | Special Reserved Cycle. This command is used for supporting parallel termination. This command is sent when the I/O bridge wants to do an RCOMP calculation. The NB stays off the bus for the duration indicated by the length but otherwise ignores this cycle. |

Table 6-30. Incoming Hub Interface Completions

| Hub Interface Transaction  | Transaction Type | NB Response   |
|----------------------------|------------------|---|
| Outbound Write Completions | I/O              | Forward to the interface that originated the request. |
|                            | Configuration    |   |
| Outbound Read Completions  | Memory           | Forward to the interface that originated the request. |
|                            | I/O              |   |
|                            | Configuration    |   |

Table 6-31. Outgoing Hub Interface Requests Cycles

| Hub Interface Transaction | Transaction Type   | Reason for Issue   |
|---------------------------|--|--|
| Outbound Write Requests   | Memory   | FSB or peer memory-mapped I/O write targeting ICH5.  |
|                           | I/O  | FSB legacy I/O write targeting ICH5.   |
|                           | Configuration  | Configuration write targeting ICH5.  |
| Outbound Read Requests    | Memory   | FSB or PCI Express memory-mapped I/O read targeting ICH5.  |
|                           | I/O  | FSB or PCI Express I/O read targeting ICH5.  |
|                           | Configuration  | Configuration read targeting ICH5.   |
| Outbound Special Cycles   | APIC Interrupt xmit granted                              | The NB will issue this command in response to an "APIC Interrupt xmit requested" command.  |
|                           | Unlock   | When a locked read or write transaction was previously issued to the ICH5, "Unlock" releases the PCI lock.   |
|                           | Shutdown   | Forwarded from the "Shutdown" FSB special cycle. Treated as an outbound write with respect to ordering.  |
|                           | Halt   | Forwarded from the "Halt" FSB special cycle. Treated as an outbound write with respect to ordering.  |
|                           | Stop Grant Ack   | Forwarded from the "StopGrant Ack" FSB special cycle. Treated as an outbound write with respect to ordering.   |
|                           | ACK C3   | The NB will issue this command in response to a "Go C3" command.   |
|                           | ACK C3A  | The NB will issue this command in response to a "Go C3A" command.  |
|                           | NOP  | This command is used on the compatibility port and occurs during the reset sequence. Completion is required.   |
|                           | CPU_RST_DONE   | This command is used on the compatibility port and occurs during the reset sequence. Completion is required. The NB de-asserts CPURST# after the completion is received.       |
|                           | PHLDA On   | The PHOLD protocol has been established and the ISA device can proceed without concern of back-pressure.   |
|                           | Interrupt ACK  | Issued by the NB when the FSB command INTA is received. Returns data from the ICH5 and must maintain same ordering rules as an outbound read.                                  |
|                           | DO_PCI_INTA<br>DO_PCI_INTB<br>DO_PCI_INTC<br>DO_PCI_INTD | Issued by the NB when a PCI Express interface receives a legacy interrupt message. These messages are issued for the assertion and deassertion of the virtual interrupt wires. |

**Table 6-32. Outgoing Hub Interface Completions**

| Hub Interface Transaction | Transaction Type | Reason for Issue  |
|---------------------------|------------------|---|
| Inbound Read Completions  | Memory           | Response for an inbound read to main memory or PCI Express. |

### 6.5.2.1 32/64 Bit Addressing

For inbound and outbound writes and reads, the NB supports 64-bit address format. If an outbound transaction's address is a 32-bit address, the NB will issue the transaction with a 32-bit addressing format on PCI Express. The ICH5 does not support outbound reads or writes with 64-bit addressing and the ICH5 will Master Abort these transactions.

### 6.5.3 Ordering Rules

Ordering for the HI1.5 interface is identical to that for the PCI Express interfaces. For details, refer to [Section 6.4.7, "Ordering Rules" on page 311](#). However, HI1.5 has a stronger requirement for inbound completions of different requests. HI1.5 is strongly ordered for delayed transactions. For example, assume that a series of inbound reads are received by the NB as Rd1, Rd2, Rd3. The NB is required to complete those reads in the same order as was requested (RdCmp1, RdCmp2, RdCmp3).

### 6.5.4 Inbound Transactions

The NB will accept the transactions listed in [Table 6-29](#). This section describes handling that is specific to the NB for transactions that target the NB or main memory.

**Note:** The inbound queue must be deep enough to ensure continuous inbound read requests are not stalled waiting for the first memory read to complete, even under heavily loaded conditions.

#### 6.5.4.1 Read Completion Policy

For inbound read requests, the NB is allowed to split completions into smaller portions if necessary. Typically, this could happen on cacheline boundaries (64B). The maximum size of a read completion is specified by HICTL.MAX\_DATA. If the interface is idle, the NB will return a completion for that read starting at the initial address up to the next cacheline boundary.

If the HI1.5 interface is busy (e.g. another outbound or inbound packet), the NB will opportunistically combine subsequent inbound read completions up to HICTL.MAX\_DATA or until the initial request length is satisfied.

### 6.5.4.2 Inbound Write Transactions

**Note:** This section applies to all write transactions targeting DRAM.

Inbound coherent write transactions actually comprise two operations:

1. Request for ownership
2. Cache line write (mark to Modified state)

The compatibility interface will enqueue each inbound write as a single atomic instruction. As the compatibility interface enqueues the write, it will also bypass all queues by sending a request-for-ownership command (RFO) directly to the FSB's requesting line ownership. The RFO commands are allowed to be issued in any order.

If the NB owns the line after all inbound ordering rules have been met, the write command proceeds and the line is modified. If the line is not owned by the NB after all inbound ordering rules have been met, the write is temporarily stalled until ownership is acquired and requests will continue to fill the inbound queue. When the request for ownership completes, the write command is forwarded where the line is marked in the Modified state.

**Note:** Because of the H1.5 ordering rules, transactions after an inbound write must wait until after the write is globally visible. The inbound queue must be deep enough to ensure that continuous inbound traffic is not stalled waiting for the above write sequence, even under heavily loaded conditions.

### 6.5.4.3 Inbound Write Combining

The NB performs write combining opportunistically in the on-chip CDC. If a write is issued to memory and the NB owns the line, the data buffer will overwrite the buffer with the new data (full or partial data).

### 6.5.4.4 PHOLD Support

The NB supports the PHOLD protocol. This protocol is used for legacy ISA devices which did not allow for the possibility of being both a master and a slave device simultaneously. Example devices that use the PHOLD protocol are legacy floppy drives and parallel port DMA.

## 6.5.5 Outbound Transactions

The NB will generate the outbound transactions listed in [Table 6-31](#). This section describes handling that is specific to the NB for transactions that target the ICH5.

### 6.5.5.1 Outbound Non-posted Transactions

Non-posted transactions that the NB propagates includes Interrupt Acknowledge, memory reads, I/O reads and writes, and configuration reads and writes. When a non-posted transaction is issued from the NB, the ICH5 device will respond with a completion.

The ICH5 supports only one outstanding non-posted transaction comprising transactions issued by the processors or a peer PCI Express device.

### 6.5.5.2 Stalled Non-posted Requests

Non-posted requests are non-blocking transactions. In other words, while a non-posted request is pending, subsequent transactions are required to bypass the transactions which are waiting for a completion.

### 6.5.5.3 Outbound Posted Transactions

Once a posted request (e.g. memory write) is issued from H1.5, the request is considered to be complete and the transaction is removed from the outbound queue. For posted requests, the acknowledge has already been sent to the initiating interface (FSB or alternate PCI Express inbound queue) when the write was enqueued in the outbound PCI Express unit, so proper ordering is guaranteed.

### 6.5.5.4 Outbound Write Combining

The NB does not combine sequential outbound writes. This optimization is left to the processor write combining buffers.

### 6.5.5.5 Lock Support

For legacy PCI functionality, the NB supports bus locks through an explicit sequence of events. The NB can receive a locked transaction sequence (Read-Write or Read-Read-Write-Write) on a FSB directed to the ICH5. The compatibility interface cluster must support the following capabilities:

- Retry all transactions on the Hub Interface
- Generate a locked read request to the Hub Interface target
- Unlock a locked Hub Interface port

## 6.5.6 Peer-to-Peer Support

Peer-to-peer support is defined as transactions which initiate on one I/O interface and target another without going through main memory. This support applies to both PCI Express and HI. The NB supports peer-to-peer transactions for memory and I/O transactions. The compatibility interface can be the destination of a peer-to-peer write or read. The compatibility interface can be the source of a posted peer-to-peer write. Non-posted requests may pre-fetch into MMIO (with potential side effects). Peer-to-peer transactions are not observed on any interface except the target and destination (e.g. no FSB snoops).

Peer-to-peer traffic between the PCI Express ports and the ICH5 must sustain the full write bandwidth. For reads, full bandwidth is required for large request sizes. Inbound coherent transactions and peer-to-peer transactions must maintain ordering rules between each other. Peer-to-peer transactions follow inbound ordering rules until it reaches the head of the inbound queue. Once the transaction reaches the head of the inbound queue, the NB routes the transaction to the next available slot in the outbound queue where PCI ordering is maintained until the end of the transaction. The NB does not support peer-to-peer where the source and destination is the same PCI Express Interface.

## 6.6 RAS

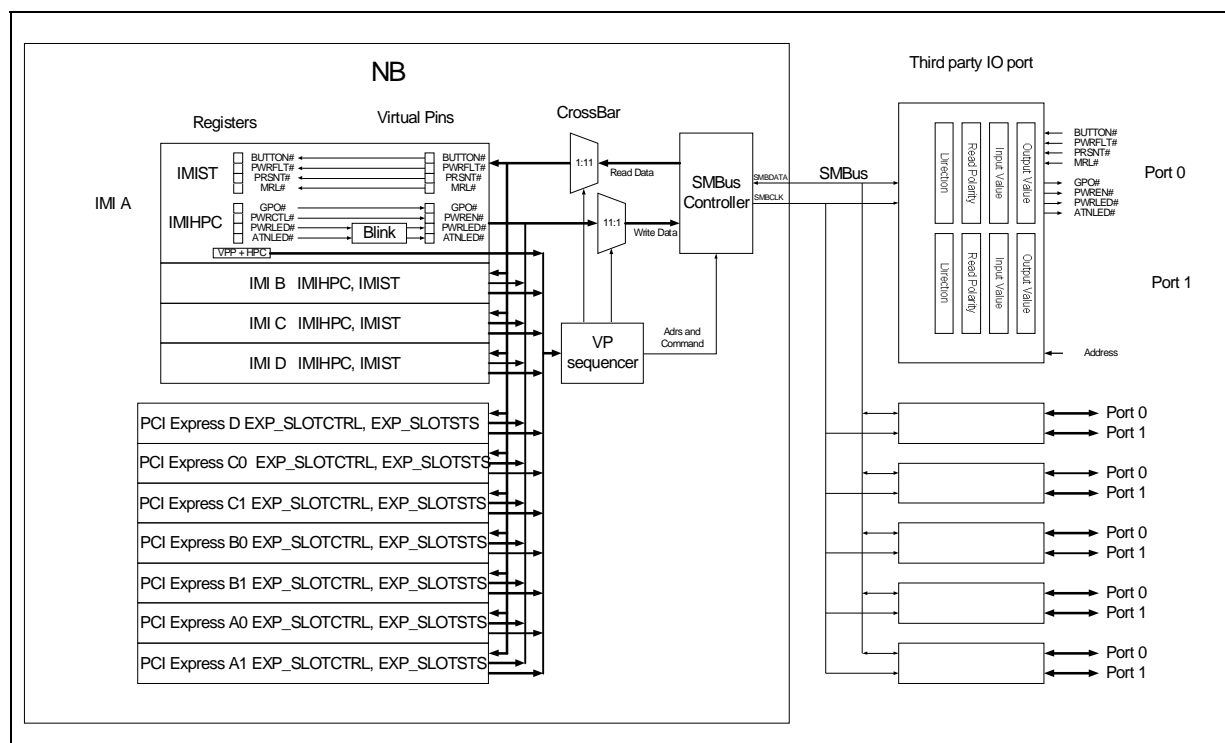
### 6.6.1 Virtual Pins for Hot-Plug

The NB supports 8 Hot-Plug pins on 11 interfaces. To allow platforms to incur cost proportional to the number of interfaces that may be Hot-Plugged, the NB masters a 100 KHz Hot-Plug SMBus interface (pins GP\_SMBCLK, GP\_SMBDATA) that connects to a variable number of serial to parallel I/O ports<sup>1</sup>. Figure 6-15 shows the NB connected to the maximum number of I/O expanders and a conceptual diagram that shows how values in Hot-Plug registers are translated to pins on the I/O expanders.

The NB only supports SMBus devices with registers mapped as per Table 6-33. These components have 16 I/O's, divided into two 8-bit ports that can be configured as inputs or outputs.

The NB has a crossbar which associates each PCI Express and IMI port with one of these 8-bit ports. The mapping is defined by a Virtual Pin Port register field (IMIHPIC.VPP for IMI's and EXP\_CTRL.VPP for PCI Express) for each PCI Express or IMI. The VPP register holds the SMBus address and Port (0 or 1) of the I/O Port associated with the PCI Express or IMI. A[2:0] pins on each I/O Port connected to the NB must be strapped uniquely.

**Figure 6-15. Maximum Configuration for Hot-Plug Pin Expanders**



1. Contact your vendor of choice for the I/O ports.



**Table 6-33. I/O Port Registers Supported by Intel® E8501 Chipset North Bridge (NB)**

| Register | Name                      | Intel® E8501 chipset north bridge (NB) Usage    |
|----------|---------------------------|---|
| 0        | Input Port 0              | Continuously Reads Input Values                 |
| 1        | Input Port 1              |   |
| 2        | Output Port 0             | Continuously Writes Output Values               |
| 3        | Output Port 1             |   |
| 4        | Polarity Inversion Port 0 | Never written by NB                             |
| 5        | Polarity Inversion Port 1 |   |
| 6        | Configuration Port 0      | Direction set as per <a href="#">Table 6-34</a> |
| 7        | Configuration Port 1      |   |

### 6.6.1.1 Operation

When the NB comes out of reset, the I/O ports are inactive. The NB is not aware of how many I/O Ports are connected to it, what their addresses are, nor what PCI Express or IMI ports are Hot-Pluggable. The NB does not master any commands on the SMBus until a Hot-Plug Capable bit is set.

An IMI port is considered Hot-Plug Capable when IMIHPC.HPC bit is set. A PCI Express port is considered Hot-Plug Capable when EXP\_SLOTCAP.HPC bit and EXP\_CTRL.EN\_VPP are set. When a port is considered Hot-Plug Capable, the NB initializes the associated VPP with Direction and Logic Level configuration as shown in [Table 6-34](#). The polarity is left at the default values and never written. When writing to VPP registers outside the NB, addresses are used as described in [Table 6-35](#) for writes to the VPP registers connected to the I<sup>2</sup>C port.

When the NB is not responding to a change in whether a port is Hot-Plug Capable, it performs input register reads and output register writes to all the Hot-Plug Capable VPP's. This sequence repeats indefinitely until there is a change in whether a port is Hot-Plug Capable. To minimize the completion time of this sequence and its complexity, both ports are always read and written. For the maximum number of 6 I/O ports, and assuming no clock stretching, this sequence can take up to 51 ms. If new Hot-Plug capability bits are not being set, this is the maximum timing uncertainty in sampling or driving these signals.

**Table 6-34. Hot-Plug Signals on a Virtual Pin Port (VPP) (Sheet 1 of 2)**

| Bit | Present for |     | Direction | Logic Level | Polarity | Signal  |
|-----|-------------|-----|-----------|-------------|----------|---------|
|     | PCI Express | IMI |           |             |          |         |
| 0   | Yes         | Yes | Output    | 1           | true     | ATNLED# |
| 1   | Yes         | Yes | Output    | 1           | true     | PWRLED# |
| 2   | Yes         | Yes | Input     | 1           | true     | BUTTON# |
| 3   | Yes         | Yes | Input     | 1           | true     | PWRFLT# |
| 4   | Yes         | Yes | Input     | 1           | true     | PRSNT#  |

Table 6-34. Hot-Plug Signals on a Virtual Pin Port (VPP) (Sheet 2 of 2)

| Bit | Present for |     | Direction | Logic Level | Polarity | Signal         |
|-----|-------------|-----|-----------|-------------|----------|----------------|
|     | PCI Express | IMI |           |             |          |                |
| 5   | Yes         | Yes | Output    | 1           | true     | <b>PWREN#</b>  |
| 6   | Yes         | Yes | Input     | 1           | true     | <b>MRL#</b>    |
| 7   | No          | Yes | Input     | 1           | true     | <b>PWRGOOD</b> |

Table 6-35 describes the sequence generated for a write to an I/O port. Both 8-bit ports are always written. If a VPP is valid for the 8-bit port, the Output values are updated as per the IMIHPC or the EXP\_SLOTCTRL registers for the associated IMI or the PCI Express Hot-Plug registers. The Input values affect the IMIST and PCI Express Hot-Plug registers. If no VPP for the 8-bit port is valid, 0s are written.

Table 6-35. VPP Write Command

| Bits | NB Drives       | I/O Port Drives | Comment   |
|------|-----------------|-----------------|---|
| 1    | Start           |                 | SDL (Serial Data Line) falling followed by SCL (Serial Clock Line) falling            |
| 7    | Address[6:0]    |                 | [6:3] = 0100<br>[2:0] = VPP[3:1]  |
| 1    | 0               |                 | indicates write   |
| 1    |                 | ACK             | If NACK is received, NB completes with stop and sets Error T9                         |
| 8    | Register Number |                 | Register Address see Table 6-33<br>[2:1] = 01 for Output, 11 for Direction<br>[0] = 0 |
| 1    |                 | ACK             | If NACK is received, NB completes with stop and sets Error T9                         |
| 8    | Data            |                 | One bit for each bit of port 0 as per Table 6-34                                      |
| 1    |                 | ACK             | If NACK is received, NB completes with stop and sets Error T9                         |
| 8    | Data            |                 | One bit for each bit of port 1 as per Table 6-34                                      |
| 1    |                 | ACK             | If NACK is received, NB completes with stop and sets Error T9                         |
| 1    | Stop            |                 |   |

The NB issues Read Commands to update NB virtual inputs from the I/O Port. The I/O port requires that a command be sent to sample the inputs, then another command is issued to return the data. The NB always reads inputs from both 8-bit ports. If the VPP is valid, the NB updates the associated MIHPS (for IMI) or the EXP\_SLOTSTS (for PCI Express) register according to the values of BUTTON#, PWRFLT#, and PRSNT# read from the value register in the I/O Port. Results from invalid VPP's are discarded. Table 6-36 defines the read command format.

If a VPP register is set to a non-existent address, it will not acknowledge the command and the NB will set the T9 error. The NB will continue to address the existing devices.

**Table 6-36. VPP Read Command**

| Bits | NB Drives           | I/O Port Drives | Comment  |
|------|---------------------|-----------------|--|
| 1    | Start               |                 | SDL falling followed by SCL falling  |
| 7    | Address[6:0]        |                 | [6:3] = 0100<br>[2:0] = VPP[3:1]   |
| 1    | 0                   |                 | Indicates Write  |
| 1    |                     | ACK             | If NACK is received, NB completes with stop and sets Error T9  |
| 8    | RegisterNumber[2:0] |                 | Register Address<br>[2:1] = 00<br>[0] = 0  |
| 1    |                     | ACK             | If NACK is received, NB completes with stop and sets Error T9  |
| 1    | Start               |                 | SDL falling followed by SCL falling  |
| 7    | Address[6:0]        |                 | [6:3] = 0100<br>[2:0] = VPP[3:1]   |
| 1    | 1                   |                 | Indicates Read   |
| 1    |                     | ACK             | If NACK is received, NB completes with stop and sets Error T9  |
| 8    |                     | Data            | One bit for each bit of port 1 as per <a href="#">Table 6-34</a> . The NB always reads from both ports. Results for invalid VPP's are discarded      |
| 1    | ACK                 |                 |  |
| 8    |                     | Data            | One bit for each bit of port 1 as shown in <a href="#">Table 6-34</a> . The NB always reads from both ports. Results for invalid VPP's are discarded |
| 1    | NACK                |                 |  |
| 1    | Stop                |                 |  |

### 6.6.1.2 Limitations

This interface is dedicated to Hot-Plug and does not support aspects of SMBus that are not required for this application.

**Table 6-37. Unsupported Aspects of SMBus**

| Unsupported Aspect                                  | Comment   |
|---|---|
| Command sequences not defined in this specification | Such as Block reads, Process Calls, Host Notification, etc.   |
| Arbitration   | NB is the only master.  |
| PEC   | The targeted I/O Ports do not support it.   |
| Bus Enumeration                                     | BIOS is required to configure VPP's with this information. Variation in the number of devices is not supported for a particular platform. |
| Clock Stretching                                    | NB will drive 100 KHz and I/O Ports can support higher frequencies, so they will never stretch the clock.                                 |
| NACK Retry  | SMBus forbids devices from NACK'ing if they are busy.   |

## 6.7 Error Reporting

The NB recognizes a variety of errors (or exception conditions) and is the collection point for many of these errors. Some errors are internally detected and others are signaled to it from the external interfaces (PCI Express and IMI). All detected errors eventually cause the NB to do one of the following:

- Assert MCERR on both FSB's
- Assert Error pins (ERR[2:0])

The error reporting for the NB is comprised of the status registers (FERR and NERR), the error log registers (recoverable and non-recoverable), and the error pins (ERR[2:0]). The individual errors can be programmed to be masked or to be signaled by ERR[2:0] or by MCERR.

### 6.7.1 Error Types

The errors can be classified into three types: (1) Correctable errors, (2) Uncorrectable Errors, (3) Hardware Fatal errors. The discussion here assumes that for all these error types, hardware provides the capability to detect the error. Errors that cannot be detected by hardware cause silent data corruption, which is an undesirable event.

- **Correctable Errors** are corrected by the hardware and software is completely oblivious to this event. Examples of such errors include single bit ECC errors and successful link level retry. Such events may be logged and reported by the system for a post-mortem by the firmware or system management software.
- **Uncorrectable Errors** are not corrected by the hardware or software. OS or other software layers may be able to recover from such errors, but it may not always be possible. Such errors are typically contained in nature, the system state is intact, and the process and the system is restartable. Errors in this category include multi-bit data error, transaction time out, and so on.
- **Fatal Errors** may compromise system integrity and continued operation may not be possible. Errors in this category include protocol errors.

### 6.7.2 Error Mask and Signaling Mapping Register

Each error is defined to be a recoverable or non-recoverable error. This determines which FERRST, NERRST, and log register get used in reporting the error. In addition, the error also has an Error Mask and Signaling registers. The purpose of the error mask is to mask / allow the observance of the error condition. Each local block has an error mask for the errors detected in that particular block.

Each unmasked error can generally be programmatically routed to the following error signals:

- MCERR
- ERR[2], ERR[1], or ERR[0]
- ICHRST

**Note:** It is up to software to enable only one of the error signaling possibilities (MCERR, ERR[2], ERR[1] & ERR[0], ICHRST signals). Software should not map PCI Express errors to the MCERR signal.

### 6.7.3 Error Status and Log Registers

Error status registers are provided; FERR (first error register), and NERR (Next error register). First fatal and/or first non-fatal errors are flagged in the FERR register; subsequent errors are indicated in the NERR register.

The contents of FERR and NERR are “sticky” across a reset (while PWRGOOD remains asserted). This provides the ability for firmware to perform diagnostics across reboots. Note that only the contents of FERR affects the update of the any error log registers.

The FERR/NERR structure is hierarchical. The Global FERR/NERR registers for the Intel® E8501 chipset are located in the NB the list of FERR/NERR registers are contained in [Table 6-38, “-FERR/NERR and Log Registers”](#).

Once a first error for a type (non-fatal or recoverable) of error has been flagged (and logged), the log registers for that error type remain fixed until either 1) any errors in the local FERR register for which the log is valid are cleared or 2) a power-on reset.

**Table 6-38. -FERR/NERR and Log Registers**

| FERR/NERR Register | Location                        | Log Register                                    |
|--------------------|---------------------------------|---|
| GLOBAL_FERR        | NB                              | N/A   |
| GLOBAL_NERR        |                                 | N/A   |
| IMI_FERR           | NB Independent Memory Interface | NRECIMI<br>RECIMI                               |
| IMI_NERR           |                                 | N/A   |
| FSB{A/B}_FERR      | NB FSB{A/B} Interface Blocks    | NRECFSB{A/B}<br>RECFSB{A/B}                     |
| FSB{A/B}_NERR      |                                 | N/A   |
| INT_FERR           | NB                              | NRECTNB<br>RECTNB<br>RECINT_LOG[4:0]<br>INTLOGC |
| INT_NERR           |                                 | N/A   |
| HIFERR             | NB Hub Interface Block          | NRECHI<br>RECHI                                 |
| HINERR             |                                 | N/A   |
| EXP_FERR           | NB PCI Express Interface Blocks | EXP_DEVSTS                                      |
| EXP_NERR           |                                 | HDRLOG[3:0]<br>EXP_UNITERR                      |

## 6.7.4 Error Signaling

Associated with each pair of FERR/NERR registers are three open drain error pins, one for each error type: fatal, uncorrectable and correctable (ERR#[2:0]). If not masked (EMASK register), these pins will reflect the error status for each type of error in the two error status registers. The NB can signal errors via the following pins:

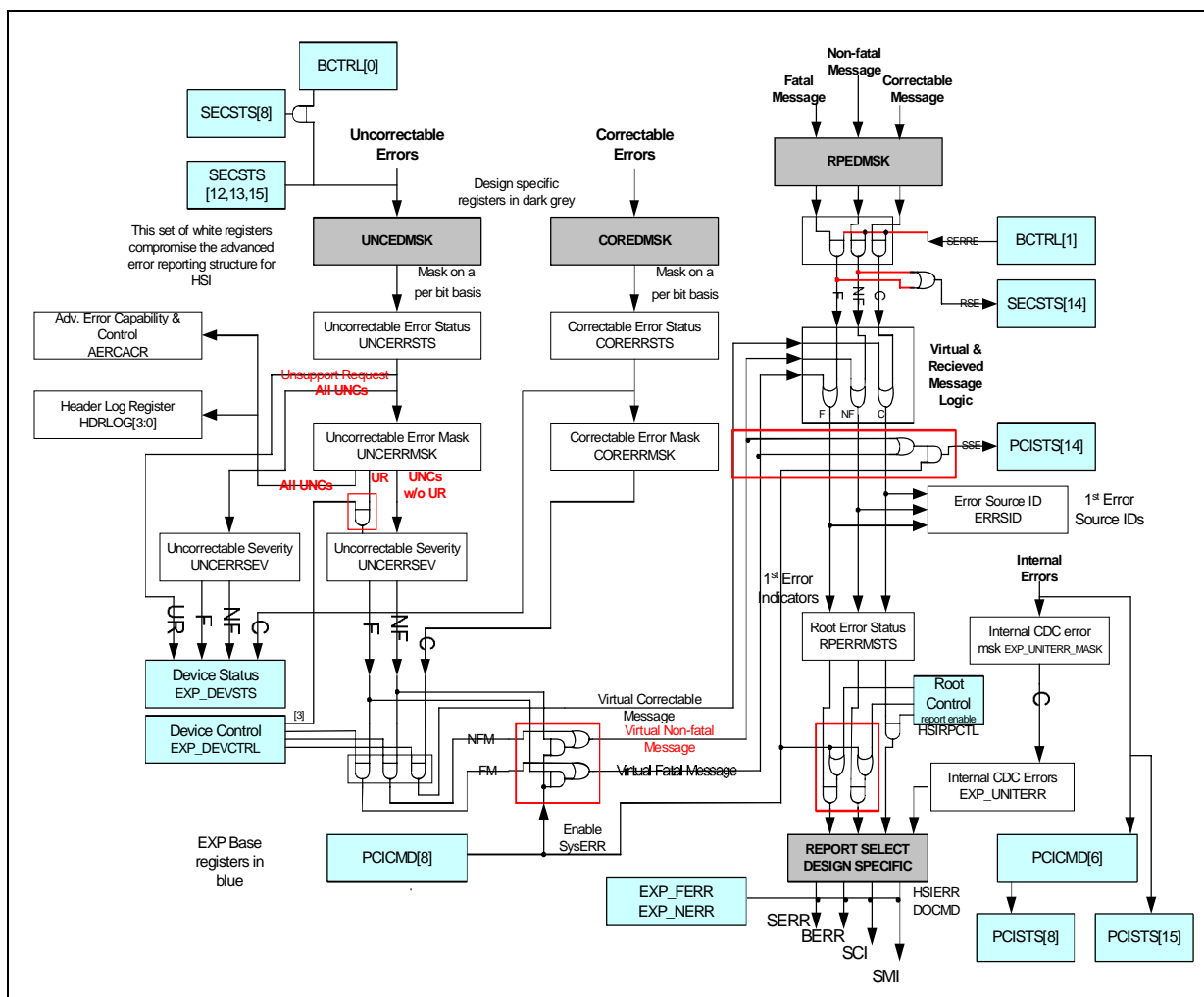
- Err[0] - Correctable Errors (Non-Fatal or Recoverable Error)
- Err[1] - Uncorrectable Errors (Non-Fatal or Recoverable Error)
- Err[2] - Fatal Error
- MCERR- Adhering to the FSB rules for driving MCERR.

The error pins are I/O signals that are synchronous to the 166 MHz bus clock.

## 6.7.5 Error Integration into Intel® E8501 Chipset North Bridge (NB) Error Model

Refer to [Figure 6-5](#) for how the PCI Express errors map into the NB error registers and for how the flow of error detection and logging is handled inside the NB.

Figure 6-16. Error Integration Model



## 6.7.6 Error Detection

In the NB chipset-based system, the task of error detection, isolation and recovery of correctable errors is performed by hardware and is distributed among the NB components. Uncorrectable errors are isolated, logged and reported to system firmware / OS for error handling. All errors, including correctable errors, can be reported to the firmware / OS for logging.

All header and data transmission over the PCI Express interface is protected with a CRC. The CRC code is capable of detecting all single bit and many multi-bit errors, as well as all error patterns with burst length of “n” (where “n” is the CRC size). This covers the error pattern due to a single wire failure on the interface. Independent Memory Interface inbound uses CRC on the link layer and ECC on inbound header and data transfers (and CRC on outbound data). IMI outbound uses CRC on all packets.

Table 6-39 provides the list of errors detected by the Intel® E8501 chipset north bridge (NB). Errors are listed by the unit / interface. Some unit / interface may provide additional error logging registers. The last column of the table, defines which component detects the error and the bit position of the register set. For FSB, IMI and NB the errors have the same bit position in the First Error, Next Error, Emask, and Error Select Registers. The I/O Errors for the Hub Interface also apply to this convention but the PCI Express errors **do not**. The PCI Express errors adhere to the PCI Express definition and location of errors.

Please note that only NB errors are listed here. For the list of XMB errors, readers should refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

**Table 6-39. Errors Detected by the NB (Sheet 1 of 6)**

| Error#            | Error Name   | Error type | Log Register(s)       | Cause / Action  | Definition  | Comp. Reg. Bit Position |
|-------------------|--|------------|-----------------------|---|---|-------------------------|
| <b>FSB Errors</b> |  |            |                       |   |   |                         |
| F0                | Multi-bit ECC Error (Do not Include Poisoned Data) | Non-Fatal  | RECFSB{A/B}           | Received a multi-bit ECC error. Poison Data and forward to the appropriate interface.   | The NB monitors the data/dep signals on the FSB. Set when the NB detects an uncorrectable error during the data transfer in which an F0 error is signalled. | NB-0                    |
| F1                | Correctable ECC Error                              | Non-Fatal  | RECFSB{A/B}           | Correct by Hardware, Cause CMCI.  | The NB monitors the data/dep signals on the FSB. Set when the NB detects an correctable error during the data transfer an F1 error is signalled.            | NB-1                    |
| F2                | Detected BINIT from a processor                    | Non-Fatal  | N/A                   | Do not propagate to other bus, reset arb. unit, and programatically reset platform.   | The NB detected that a processor issued a B-INIT.   | NB-2                    |
| F3                | Detected MCERR from a processor                    | Non-Fatal  | N/A                   | If (receive an MCERR) forward the MCERR to the other bus, adhering to the MCERR protocol.   | The NB detected that a processor issued an MCERR.   | NB-3                    |
| F4                | Request/Address Parity Error                       | Fatal      | NRECFSB{A/B}_LOG[2:0] | Complete transaction on FSB, drop transaction, provide a response. Capture Address/Control information.   | The NB monitors the address and request parity signals on the FSB. A parity discrepancy over these fields during a valid request.                           | NB-4                    |
| F5                | Address Strobe Glitch                              | Fatal      | NRECFSB{A/B}_LOG[2:0] | Take the received address and attempt to complete the transaction, this may cause the NB to Malfuction. Log which FSB the error occurred on. Let request continue with what it decodes to, correct operation is not guaranteed. | The NB detects that an address strobe toggled when ADS# wasn't valid.   | NB-5                    |



**Table 6-39. Errors Detected by the NB (Sheet 2 of 6)**

| Error#                           | Error Name   | Error type | Log Register(s)        | Cause / Action   | Definition   | Comp. Reg. Bit Position |
|----------------------------------|--|------------|------------------------|--|--|-------------------------|
| F6                               | Data Strobe Glitch   | Fatal      | NRECFSB{A/B} _LOG[2:0] | Take the received data and attempt to complete the transaction, this may cause the NB to Malfuction.                     | The NB detects that one (or more) of the complimentary FSB data strobe pairs did not toggle in an alternating fashion. | NB-6                    |
| F7                               | FSB Protocol Error   | Fatal      | NRECFSB{A/B} _LOG[2:0] | Alias to a known response.   | The NB detected an unsupported FSB response encoding.  | NB-7                    |
| F8                               | Unsupported FSB Transaction  | Fatal      | NRECFSB{A/B} _LOG0     | Unsupported transaction or unsupported data sizes. Transactions alias to a similar transaction to complete.              | The NB detected an FSB Unsupported transaction or unsupported data sizes.  | NB-8                    |
| F9                               | Data Parity Error (for 64-bit Intel® Xeon® processor MP with 1MB L2 cache & Dual-Core Intel® Xeon® processor 7000 sequence ) | Fatal      | NRECFSB                | Parity Error was detected on the Data, DINV, DSTB when there was no correctable ECC Error.                               | The NB detected a Parity Error on the Data, DINV, DSTB when there was no correctable ECC Error.                        | N/A                     |
| F10                              | FSB Hang   | Fatal      | NRECFSB{A/B} _LOG0     | An access issued on the FSB has timed out.   | The NB detected that a timely FSB transaction completion did not occur.  | NB -10                  |
| <b>IMI.NB Errors<sup>a</sup></b> |  |            |                        |  |  |                         |
| IMI0                             | Uncorrectable Error in read return packet before retry limit exceeded  | Non-Fatal  | RECIMI, REDPIMIH       | Capture the Syndrome, Locator, and Address, If possible, scrub location using redundant resources. Re-Issue IMI Request. | The NB detected an uncorrectable error on an IMI transaction before the retry limit was exceeded.                      | NB-0                    |
| IMI1                             | Inbound Correctable ECC Error  | Non-Fatal  | RECIMI, REDPIMIH       | Capture the Syndrome, Locator, and Address, Correct.   | The NB detected an Correctable Error on the 1st request for a IMI transaction.   | NB-1                    |
| IMI2                             | Command Time-Out   | Non-Fatal  | RECIMI                 | Re-issue Request Over M Link, log CDC and IMI Transaction IDs.   | The NB failed to receive a timely response to a request.   | NB-2                    |
| IMI3                             | Inbound CRC Error  | Non-Fatal  | N/A                    | NB will drop response, and rely on retry to correct.   | The NB received a link CRC error.  | NB-3                    |
| IMI4                             | Memory Write Data Poisoned.  | Non-Fatal  | N/A                    | The NB has poisoned the flit that contains the error and written the data to memory. (See XMI10)                         | The NB has poisoned the flit that contains the error and written the data to memory. (See IMI.XMB10)                   | NB-4                    |
| IMI5                             | Inbound Link Layer Control Error   | Non-Fatal  | N/A                    | N/A  | The NB detected a link layer control error on the Inbound link.  | NB-5                    |
| IMI6                             | Abort  | Non-Fatal  | RECIMI                 | N/A  | The NB detected a protocol abort from the XMB.   | NB-6                    |
| IMI7                             | SMBus Hot-Plug Error   | Non-Fatal  | N/A                    | N/A  | The NB detected an error on the Hot-Plug SMBus port.   | NB-7                    |

Table 6-39. Errors Detected by the NB (Sheet 3 of 6)

| Error#              | Error Name  | Error type | Log Register(s) | Cause / Action  | Definition  | Comp. Reg. Bit Position |
|---------------------|---|------------|-----------------|---|---|-------------------------|
| IMI8                | Outstanding request to Failed IMI                       | Non-Fatal  | RECIMI          | In RAID/Mirroring config, if requests are pending when IMI enters failed state. Attempt to complete requests using redundant resources. | The NB in RAID/Mirroring config, if requests are pending when IMI enters failed state.  | NB-8                    |
| IMI9                | Failed on last retry. Co-exist with IMI13               | Non-Fatal  | RECIMI          | In RAID/Mirroring config, attempt to complete request using redundant resources.  | The NB in RAID/Mirroring config and not in Redundancy lost state and not in Resilver state received an uncorrectable data error on the IMI retry request. | NB-9                    |
| IMI10               | Config write data poisoned.                             | Non-Fatal  | N/A             | The NB has poisoned the flit that contains the error and written the config to the XMB. (See XMI18).                                    | The NB sent a Config memory write with poisoned data. (See XMI18)   | NB-10                   |
| IMI11               | NB received a correctable error message from the XMB    | Non-Fatal  | N/A             | NB will signal that XMB recorded an error.  | The NB received a IMI virtual wire that the XMB has detected a "correctable" error event.   | NB-11                   |
| IMI12               | NB received an uncorrectable error message from the XMB | Non-Fatal  | N/A             | NB will signal that XMB recorded an error.  | The NB received a IMI virtual wire that the XMB has detected an "uncorrectable" error event.  | NB-12                   |
| IMI13               | Failed on last retry. Co-exist with IMI9                | Non-Fatal  | RECIMI          | If (RAID or Mirror) Capture failed IMI Request.   | The NB in RAID/Mirroring config, receives a timeout on the retry of transaction.  | NB-13                   |
| IMI14               | NB received a fatal error message from the XMB          | Fatal      | N/A             | NB will signal that XMB recorded an error.  | The NB received an IMI virtual wire "signal" that the XMB has detected a "fatal" error event.   | NB-14                   |
| IMI15               | <b>Reserved</b>   | N/A        | N/A             | N/A   | N/A   | N/A                     |
| <b>HI1.5 Errors</b> |   |            |                 |   |   |                         |
| IO0                 | HI - Target Abort                                       | Non-Fatal  | RECHI           | Received from the ICH5.   | The NB receives a Target-Abort for any cycle for which it was the master from the ICH5.   | NB-0                    |
| IO1                 | HI - Cmd Parity Error                                   | Non-Fatal  | RECHI           | Received from the ICH5.   | The NB detected a parity error in the command portion of the packet received from the ICH5.   | NB-1                    |
| IO2                 | HI - Data Phase Parity Error                            | Non-Fatal  | RECHI           | Received from the ICH5.   | The NB detected a parity error in the data portion of the packet received from the ICH5.  | NB-2                    |
| IO3                 | HI - Parity Error on Outbound Data                      | Non-Fatal  | RECHI           | N/A   | The NB detected an internal parity error on outbound data.  | NB-3                    |
| IO4                 | HI - Outbound poison                                    | Non-Fatal  | N/A             | N/A   | The NB detected a parity error in the address/header from the ICH5.   | NB-4                    |

**Table 6-39. Errors Detected by the NB (Sheet 4 of 6)**

| Error#                    | Error Name                                 | Error type | Log Register(s) | Cause / Action                 | Definition   | Comp. Reg. Bit Position |
|---------------------------|--|------------|-----------------|--------------------------------|--|-------------------------|
| IO5                       | HI - Port has made an illegal access       | Fatal      | RECHI           | Received from the ICH5         | The NB detected unsupported request from the ICH5.   | N/A                     |
| IO6                       | HI - Parity Error on Header / Address      | Fatal      | RECHI           | Received from the ICH5         | The NB detected a parity error in the address portion of the packet received from the ICH5.                  | N/A                     |
| IO6b                      | HI - Received STOP during SRC              | Fatal      | N/A             | Received from the ICH5         | ICH5 illegally drove STOP.   | N/A                     |
| <b>PCI Express Errors</b> |  |            |                 |                                |  |                         |
| IO7                       | PCI Express - Receiver Error               | Corr       | N/A             | N/A                            | Received bad 8b/10b encoding error.  | NB - I/O Unit           |
| IO8                       | PCI Express - Bad TLP Error                | Corr       | N/A             | N/A                            | Received bad CRC or a bad sequence number in a transport layer packet.                                       | NB - I/O Unit           |
| IO9                       | PCI Express - BAD DLLP                     | Corr       | N/A             | N/A                            | Log Header of Error'ed Packet.   | NB - I/O Unit           |
| IO10                      | PCI Express - Replay_Num Rollover          | Corr       | N/A             | N/A                            | Replay maximum count for the Retry Buffer has been exceeded.   | NB - I/O Unit           |
| IO11                      | PCI Express - Replay Timer Timeout         | Corr       | N/A             | N/A                            | Replay timer timed out waiting for an ACK or NAK DLLP.   | NB - I/O Unit           |
| IO12                      | PCI Express - Received Unsupported Request | UnCorr     | HDRLOG[3:0]     | Log Header of Packet.          | Received an unsupported request, similar to master abort.  | NB - I/O Unit           |
| IO13                      | PCI Express - Training Error               | N/A        | N/A             | N/A                            | The NB never reports this error.   | NB - I/O Unit           |
| IO14                      | PCI Express - Poisoned TLP                 | UnCorr     | HDRLOG[3:0]     | Log Header of Error'ed Packet. | Received a poisoned transaction layer packet from the southbridge.   | NB - I/O Unit           |
| IO15                      | PCI Express - Flow Control Protocol Error  | Fatal      | N/A             | N/A                            | NB has detected a PCI-Express Flow Control Protocol Error.   | NB - I/O Unit           |
| IO16                      | PCI-Express - Completion Timeout           | UnCorr     | N/A             | N/A                            | Pending transaction was ACKed in the data link layer but not within the time limit.                          | NB - I/O Unit           |
| IO17                      | PCI Express - Completer Abort              | UnCorr     | HDRLOG[3:0]     | Log Header of Error'ed Packet. | Received return CA status for horrible error on the component. This is equivalent to a target abort on PCI.  | NB - I/O Unit           |
| IO18                      | PCI Express - Unexpected Completion Error  | UnCorr     | HDRLOG[3:0]     | Log Header of Error'ed Packet. | Received a Completion RequestorID that matches the requestor but the Tag does not match any pending entries. | NB - I/O Unit           |
| IO19                      | PCI Express - Malformed TLP                | Fatal      | HDRLOG[3:0]     | Do not update content          | Received a transaction layer packet that does not follow the TLP formation rules.                            | NB - I/O Unit           |

Table 6-39. Errors Detected by the NB (Sheet 5 of 6)

| Error#           | Error Name   | Error type | Log Register(s) | Cause / Action  | Definition   | Comp. Reg. Bit Position |
|------------------|--|------------|-----------------|---|--|-------------------------|
| IO20             | PCI Express - Receive Buffer Overflow Error                          | Fatal      | N/A             | Correct by Hardware   | Receiver gets more data or transactions than credits allow.  | NB - I/O Unit           |
| IO21             | PCI Express - Data Link Layer Protocol Error                         | Fatal      | N/A             | N/A   | The NB detected a DLLP error.  | NB - I/O Unit           |
| IO22             | N/A  | N/A        | N/A             | N/A   | N/A  | N/A                     |
| IO23             | N/A  | N/A        | N/A             | N/A   | N/A  | N/A                     |
| IO24             | PCI Express - Received Correctable Error Message                     | Corr       | N/A             | N/A   | NB received a correctable error message from the south bridge.   | N/A                     |
| IO25             | PCI Express - Received NonFatal Error Message                        | Non-Fatal  | N/A             | N/A   | NB received a non-fatal error message from the south bridge.   | N/A                     |
| IO26             | PCI Express - Received Fatal Error Message                           | Fatal      | N/A             | N/A   | NB received a fatal error message from the south bridge.   | NB - I/O Unit           |
| <b>NB Errors</b> |  |            |                 |   |  |                         |
| T1               | Single-bit Data ECC Error from CDC                                   | Non-Fatal  | REDTNB          | Corrected by Hardware, log CDC entry.   | The NB detected in an internal block a correctable ECC error (This error was not generated by receiving bad data from an external interface).    | NB-0                    |
| T2               | Uncorrectable Data ECC Error from CDC (Do not Include Poisoned Data) | Non-Fatal  | NREDTNB         | Detected by Hardware, log CDC entry.  | The NB detected in an internal block an uncorrectable ECC error. (This error was not generated by receiving bad data from an external interface) | NB-7                    |
| T3               | Multi-Tag Hit from CDC   | Fatal      |                 |   | The NB does not detect this error.   | NB-5                    |
| T4               | Coherency Violation Error  | Fatal      | NRECTNB         | Log CDC entry   | The NB detected a cache coherency protocol error.  | NB-6                    |
| T5               | Address Map Error  | Non-Fatal  | REDTNB          |   | The NB received a request for an address that does not exist in the system.  | NB-1                    |
| T6               | Poison passed to another poison capable domain.                      | Non-Fatal  | REDTNB          |   | The NB created or detected poisoned data and gave that data to another poison capable domain inside NB.  | NB-2                    |
| T7               | Uncorrectable Data Error during a Re-silvering Process               | Non-Fatal  | RECINT_LOG[4:0] | Logged by RAID/mirror logic in response to PM19. Capture failed request. Poison data in memory. | The NB detected an uncorrectable error on the primary image and secondary method to recover the data is not available.                           | NB-3                    |
| T8               | Poison leaving a poison capable domain                               | Fatal      | NRECTNB         |   | The NB has non-poison capable domains and poison capable domains. When poison leaves a poison capable domain, this error is detected.            | NB-4                    |

**Table 6-39. Errors Detected by the NB (Sheet 6 of 6)**

| Error# | Error Name   | Error type | Log Register(s) | Cause / Action | Definition  | Comp. Reg. Bit Position |
|--------|--|------------|-----------------|----------------|---|-------------------------|
| T9     | SMBus Virtual Pin Interface Error                      | Fatal      | N/A             |                | The NB detected an error on the SMBus virtual pin interface.  | NB - I/O Unit           |
| T10    | I/O Unit Detected Failure                              | Fatal      | N/A             |                | The NB I/O Unit detected an internal failure.<br>Uncorrectable Data Error Detected<br>Address/Control Parity Error. | NB - I/O Unit           |
| T11    | I/O Unit Detected a correctable ECC error from CDC.    | Non-Fatal  | N/A             |                |   | NB - I/O Unit           |
| T12    | I/O Unit Detected an uncorrectable ECC error from CDC. | Fatal      | N/A             |                |   | NB - I/O Unit           |

**NOTES:**

- a. For IMI errors seen from the XMB side, readers should refer to chapter 6 of *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*

## 6.8 Interrupts

The NB chipset supports both the xAPIC and traditional 8259 methods of interrupt delivery. I/O interrupts, and inter-processor interrupts (IPIs) appear as write or interrupt transactions in the system and are delivered to the target processor via the FSB. This chipset does not support the three-wire sideband bus (the APIC bus) that is used by Pentium® and Pentium® Pro processors.

xAPIC interrupts that are generated from I/O will need to go through an I/O(x)APIC device unless they support Message Signalled Interrupts (MSI). In this document, I/O(x)APIC is an interrupt controller. This functionality will be embedded into the Intel 6700PXH 64-bit PCI Hub and ICH5 components of the chipset.

The legacy 8259 functionality is embedded in the ICH5 component. The NB chipset will support inband 8259 interrupt messages from PCI Express devices for boot. The chipset also supports the processor generated “interrupt acknowledge” (for legacy 8259 interrupts), and “end-of-interrupt” transactions (xAPIC).

Routing and delivery of interrupt messages and special transactions are described in this chapter.

### 6.8.1 xAPIC Interrupt Message Delivery

For Message Delivery and Format, refer to the [Section 2.5, “Interrupt Delivery”](#) on page 31 of this document.

## 6.8.2 xAPIC Destination Modes

The destination mode refers to how the processor interprets the destination field of the interrupt message. There are two types of destination modes:

1. **Physical Destination Mode**
2. **Logical Destination Mode**

The destination mode is selected by A[2] in PCI Express and Ab[5] on the FSB.

### 6.8.2.1 Physical Destination Mode (xAPIC)

In physical mode, the APIC ID is 8 bits, supporting up to 255 agents. Each processor has a Local APIC ID Register where the lower 5 bits are initialized by hardware (Cluster ID=ID[4:3], Bus Agent ID=ID[2:1], thread ID=ID[0]). The upper 3 bits default to 0s at system reset. These values can be modified by software. The Cluster ID is set by address bits A[12:11] during reset. By default, the NB will drive A[12:11] to '00' for Front Side Bus A, and '01' for Front Side Bus B. The value driven on bit A[12] during reset can be modified through the POC register on the NB.

The NB will not rely on the cluster ID or any other fields in the APIC ID to route interrupts. The NB will ensure the interrupt is seen on both busses and the processor with the matching APIC ID will claim the interrupt.

Physical destination mode interrupts can be directed, broadcast, or redirected. An xAPIC message with a destination field of all 1s denotes a broadcast to all.

In a directed physical mode message the agent claims the interrupt if the upper 8 bits of the destination field (DID field) matches the Local APIC ID of the processor or the interrupt is a broadcast interrupt.

### 6.8.2.2 Logical Destination Mode (xAPIC)

In logical destination mode, destinations are specified using an 8-bit logical ID field. Each processor contains a register called the Logical Destination Register (LDR) that holds this 8-bit logical ID. Interpretation of the LDR is determined by the contents of the processor's Destination Format Register (DFR). The DFR establishes if the processor is in flat or cluster mode. Logical destination mode interrupts can be directed (fixed delivery), redirectable (lowest priority delivery), or broadcast. The LDR is initialized to flat mode (0) at reset and is programmed by firmware (and can be changed by system software). The NB also has an equivalent bit in the XTPR0 register to indicate flat or cluster mode.

Interpretation of the destination field of the xAPIC message and the logical ID of the processor is different whether the processor is in flat or cluster mode. The 2 models are flat and cluster:

**Flat Model** - The 8-bit logical ID is compared to the 8-bit destination field of the incoming interrupt message. If there is a bit-wise match, then the local xAPIC is selected as a destination of the interrupt. Each bit position in the destination field corresponds to an individual Local xAPIC Unit. The flat model supports up to 4 agents in the system. An xAPIC message where the DID (destination field) is all 1's is a broadcast interrupt.

**Cluster Model** - The 8-bit logical ID is divided into two fields, where the upper four bits contain a cluster ID, and the lower 4-bits identifies the agent within the cluster using the same encoding scheme as the flat model. Up to 8 logical clusters (2 agents each) can be supported. An xAPIC message where the lower 4-bits of the DID is all 1's is a broadcast interrupt within a cluster. Interrupt redirection can only be applied to processors *within* the cluster.

Interrupt messages that originate from I/O(x)APIC devices or from processing nodes must be routed and delivered to the target agents in the system. In general xAPIC messages are delivered to both FSB's because there is no reliable way to determine the destination node of the message for the destination field. Interrupts originating from I/O can be generated from a PCI agent using MSI interrupts, or by an interrupt controller on a bridge chip such as the Intel 6700PXH 64-bit PCI Hub or ICH5. [Table 6-40](#) shows the routing rules used for routing xAPIC messages in a NB platform. This table is valid for both broadcast and non-broadcast interrupts.

**Table 6-40. NB xAPIC Interrupt Message Routing and Delivery**

| Source     | Type  | Routing   |
|------------|---|---|
| I/O        | physical or logical directed                    | Deliver to both FSB's as an interrupt transaction.                            |
| Processor  | physical or logical directed                    | Deliver to other FSB as an interrupt transaction.                             |
| Any Source | logical, redirectable<br>physical, redirectable | Redirection is performed by the NB and is delivered to both front side buses. |

### 6.8.3 EOI

For Intel® Xeon® Processor Family (XPF) platforms using xAPIC, the EOI is a specially encoded FSB transaction with the interrupt vector attached. Since the EOI is not directed, the NB will broadcast the EOI transaction to all I/O(x)APICs.

**Note:** Since the ICH5 does not support the EOI special cycle, the Intel® E8501 chipset will translate the EOI into a directed write to the EOI register in the ICH5.

### 6.8.4 I/O Interrupts

For I/O interrupts from the Intel 6700PXH 64-bit PCI Hub and ICH5 components receive interrupts with either dedicated interrupt pins or with writes to the integrated redirection table. The I/OxAPIC controller integrated within these components turns these interrupts into writes destined for the FSB with a specific address.

Interrupts triggered from an I/O device can be triggered with either a dedicated interrupt pin or through an inbound write message from the PCI bus (MSI). Note that if the interrupt is triggered by a dedicated pin, the I/OxAPIC controller in the I/O bridge (Intel 6700PXH 64-bit PCI Hub or ICH5) turns this into an inbound write. On the FSB, the interrupt is converted to an interrupt request. Other than a special interrupt encoding, the FSB interrupt follows the same format as discussed in [Section 2.5, “Interrupt Delivery” on page 31](#). Therefore, to all components other than the Intel 6700PXH 64-bit PCI Hub, ICH5, and the processors, an interrupt is an inbound write following the format mentioned in [Section 2.5](#), the NB will not write combine or cache the APIC address space.

I/O(x)APICs can be configured through two mechanisms. The traditional mechanism is the hard coded FEC0\_0000h to FECF\_FFFFh range is used to communicate with the IOAPIC controllers in the Intel 6700PXH 64-bit PCI Hub or ICH5.

The second method is to use the standard MMIO range to communicate to the Intel 6700PXH 64-bit PCI Hub. To accomplish this, the PXH.MBAR must be programmed within the PCI Express device MMIO region.

## 6.8.5 Ordering

Handling interrupts as inbound writes has inherent advantages. First, there is no need for the additional APIC bus resulting in extra pins and board routing concerns. Second, with an out-of-band APIC bus, there are ordering concerns. Any interrupt needs to be ordered correctly and all prior inbound writes must get flushed ahead of the interrupt. The *PCI Local Bus Specification*, Revision 2.2 attempts to address this by requiring all interrupt routines to first read the PCI interrupt register. Since PCI read completions are required to push all writes ahead of it, then all writes prior to the interrupt are guaranteed to be flushed. This, However assumes that all drivers perform this read.

## 6.8.6 Hardware IRQ IOxAPIC Interrupts

Dedicated pin interrupts may be edge or level-triggered. They are routed to IRQ pins on IOxAPIC device such as the Intel 6700PXH 64-bit PCI Hub and ICH5. The IOxAPIC device will convert the interrupt into either an xAPIC or 8259 interrupt.

For level-triggered interrupts, the I/OxAPIC will generate an interrupt message when any of the interrupt lines coming into it become asserted. The processor will handle the interrupt and eventually write to the initiating device that the interrupt is complete. The device will de-assert the interrupt line to the I/OxAPIC. After the interrupt has been serviced, the processor sends an EOI command to inform the I/OxAPIC that the interrupt has been serviced. Since the EOI is not directed, the NB will broadcast the EOI transaction to all I/O(x)APIC's. If the original I/O(x)APIC sees the interrupt is still asserted, it knows there's another interrupt (shared interrupts) and will send another interrupt message.

For edge-triggered interrupts, the flow is the same except that there is no EOI message indicating that the interrupt is complete. Since the interrupt is issued whenever an edge is detected, EOIs are not necessary.

While not recommended, agents can share interrupts to better utilize each interrupt (implying level-triggered interrupts). Due to ordering constraints, agents can not use an interrupt controller that resides on a different PCI bus. Therefore only agents on the same PCI bus can share interrupts (or the driver MUST follow the PCI requirement that interrupt routines must first read the PCI interrupt register).

The NB supports the INTA (interrupt acknowledge) special bus cycle for legacy 8259 support. These are routed to the compatibility ICH5 in the system. The INTA will return data that provides the interrupt vector.

## 6.8.7 Message Signalled Interrupts (MSI)

A second mechanism for devices to send interrupts is to issue the Message Signalled Interrupt (MSI) introduced in the *PCI Local Bus Specification*, Revision 2.2 . This appears as a 1 DWORD write on the PCI/PCI-X/PCI Express bus.

With PCI devices, there are 2 types of MSIs. One type is where a PCI device issues the inbound write to the interrupt range. The other type of MSI is where a PCI device issues an inbound write to the upstream APIC controller (for example, in the Intel 6700PXH 64-bit PCI Hub) where the APIC controller converts it into an inbound write to the interrupt range. The second type of MSI can be used in the event the OS doesn't support MSIs, but the BIOS does. For either way, the interrupt will appear as an inbound write to the NB over the PCI Express ports.



MSI is expected to be supported by the operating systems about the same time frame as Intel® E8501 chipset availability. A NB chipset-based platform will also feature a backup interrupt mechanism in the event that there is a short period of time when MSI is not available. This is described in the next section.

### 6.8.8 Non-MSI Interrupts - “Fake MSI”

For interrupts coming through the Intel 6700PXH 64-bit PCI Hub or ICH5 components, their APIC controller will convert interrupts into inbound writes, so inbound interrupts will appear in the same format as an MSI.

For interrupts that are not coming through an APIC controller (for example Dual Northway, a dual port 1 GbE) it is still required that the interrupt appear as an MSI-like interrupt. If the OS does not yet support MSI, the PCI Express device can be programmed by the BIOS to issue inbound MSI interrupts to an IOxAPIC in the system. The safest IOxAPIC to choose would be the ICH5 since it is always present in a system. The NB does not support the PCI Express “Assert\_Int” and “Deassert\_Int” packets for xAPIC interrupts.

In this method, PCI Express devices are programmed to enable MSI functionality, and given a write path directly to the pin assertion register in a selected IOxAPIC already present in the platform. The IOxAPIC will generate an interrupt message in response, thus providing equivalent functionality to a virtual (edge-triggered) wire between the PCI Express endpoint and the IOxAPIC.

All PCI Express devices are strictly required to support MSI. When MSI is enabled, PCI Express devices generate a memory transaction with an address equal to the IOxAPIC\_MEM\_BAR + 20 and a 32-bit data equal to the interrupt vector number corresponding to the device. This information is stored in the device's MSI address and data registers, and would be initialized by the system firmware (BIOS) prior to booting a non-MSI aware operating system (With the theory that an MSI aware O/S would then over-write the registers to provide interrupt message delivery directly from the endpoint to the CPU complex).

The PCI Express memory write transaction propagates to the NB and is redirected down the appropriate PCI Express port following the NB IOAPIC address mapping definition. The IOAPIC memory space ranges are fixed and cannot be relocated by the OS. The assert message is indistinguishable from a memory write transaction, and is forwarded to the destination IOxAPIC (which will then create an upstream APIC interrupt message in the form of an inbound memory write). The write nature of the message “pushes” all applicable pre-interrupt traffic through to the NB core, and the NB core architecture guarantees that the subsequent APIC message cannot pass any posted data already within the NB.

### 6.8.9 Inter Processor Interrupts (IPIs)

The IPIs will be covered in the future revision of this document.

## 6.8.10 Chipset Generated Interrupts

The Intel® E8501 chipset can trigger interrupts for chipset errors and for PCI Express and IMI Port Hot-Plug. For these events, the chipset can be programmed to assert pins that the system can route to an APIC controller. The following is a preliminary list of interrupts that can be generated:

1. Chipset Error: Chipset asserts appropriate ERR pin, depending on severity. This can be routed by the system to generate an interrupt at an interrupt controller. (NB pins ERR[2:0], MCERR, ICH Reset). For details on Chipset error types and reporting, please see [Section 6.7.1](#).
2. IMI Hot-Plug: Chipset asserts **IMI\_HPINT** on behalf of an IMI Hot-Plug event. This can be routed by the system to generate an interrupt. This document assumes that **IMI\_HPINT** will be connected either to a system interrupt, SMI interrupt, or SCI (ACPI) general purpose event.
3. PCI Express Error: Chipset asserts appropriate ERR pin, depending on severity. This can be routed by the system to generate an interrupt.
  - The NB can receive error indications from the PCI Express ports. These are in the form of inbound ERR\_COR/UNC/FATAL messages. The NB will assert the appropriate ERR signal just like any internal NB error.
4. PCI Express Hot-Plug: The NB asserts EXP\_HPINT on behalf of a PCI Express Hot-Plug event.
  - NB generated Hot-Plug event such as PresDet change, Attn button, MRL sensor changed, power fault, etc. Each of these events has a corresponding bit in the PCI Express Hot-Plug registers (Attention Button, Power Indicator, Power Controller, Presence Detect, MRL Sensor, Port Capabilities/Slot registers). This will generate an interrupt via the EXP\_HPINT pin, or it will generate an MSI.
    - **EXP\_HPINT**: When software has completed servicing the Hot-Plug event, it will clear the appropriate bit in the PCI Express Hot-Plug register(s), at which point, the NB can deassert EXP\_HPINT.
    - **MSI**: If the MSICTRL.MSIEN bit (MSI enabled) is set, the NB will generate an MSI in response to a PCI Express Hot-Plug event. More details will be added in the subsequent revision of this document.

- PCI Express Hot-Plug event from downstream. This could be either an MSI or a GPE message.
    - **MSI:** Handled like a normal MSI interrupt.
    - **GPE Message:** Upon receipt of a Assert\_GPE message from PCI Express, NB will assert the EXP\_HPINT signal to generate this interrupt. To generate an SCI (ACPI), this signal will be routed to the ICH5 appropriate GPIO pin to match the GPE0\_EN register settings. When the Hot-Plug event has been serviced, the NB will receive a Deassert\_GPE message. At this point the NB can deassert EXP\_HPINT. There needs to be a tracking bit per PCI Express port to keep track of Assert/Deassert\_GPE pairs. These tracking bits should be ORed together to determine whether to drive the EXP\_HPINT pin. If one or more of the tracking bits are set (meaning we have received one or more Assert\_GPE messages), EXP\_HPINT must be set until all the matching Deassert\_GPE messages are received.
    - **Sideband Signals:** Some systems may choose to connect the interrupt via sideband signals directly to the ICH5. No action is required from the NB.
5. PCI Express PM: The NB asserts PME\_OUT pin when a power management event is detected. PCI Express sends a PME message.
- Upon receipt of the PME message, the NB will assert the PME\_OUT signal to generate this interrupt if enabled through bit 3 in ‘EXP\_RTCTRL[7:1]: PCI Express Root Control Register (D1-7, F0)’. To generate an SCI (ACPI), this signal will be routed to the ICH5 appropriate GPIO pin to match the GPE0\_EN settings. When software has completed servicing the power management event, it will clear the PCI Express RTSTS.PMESTS bit (by writing 1), at which point the NB can deassert PME\_OUT.
6. PCI Hot-Plug: The NB will receive an Assert/Deassert GPE message from the PCI Express port when a PCI Hot-Plug event is happening. Assert/Deassert GPE messages should be treated the same as Assert/Deassert GPE messages for PCI Express Hot-Plug. (Keep track of Assert/Deassert GPE messages from each port and assert EXP\_HPINT appropriately).

Table 6-41 summarizes the different types of chipset generated interrupts that were discussed. Although the interrupt and SW mechanism is flexible and can be changed depending on how the system is hooked up, for reference this table also describes what SW mechanism is expected to be used.

**Table 6-41. Chipset Generated Interrupts**

| Source   | Signalling Mechanism                  | NB Signal Method                 | Expected SW Mechanism             |
|--|---------------------------------------|----------------------------------|-----------------------------------|
| Chipset Error  | NB Chipset registers                  | ERR[2:0], MCERR, ICHReset        | Any                               |
| IMI HP   | NB Chipset registers                  | IMI_INT                          | Any (SCI, SMI, system (MSI/APIC)) |
| PCI Express Error  | PCI Express ERR_COR/UNC/FATAL message | ERR[2:0], MCERR, ICHReset        | Any                               |
| PCI Express HP (PresDet chg, attn button, etc.)                | NB Chipset registers                  | EXP_HPINT or MSI                 | SCI->ACPI or MSI                  |
| PCI Express HP form downstream device (Native)                 | MSI                                   | MSI interrupt <sup>a</sup> (FSB) | MSI                               |
| PCI Express HP form downstream device (Intel Part, Non-Native) | PCI Express Assert/Deassert GPE       | EXP_HPINT                        | SCI->ACPI                         |
| PCI Express HP form downstream device (Intel Part, Non-Native) | Sideband signals directly to ICH5     | N/A                              | SCI->ACPI                         |
| Downstream PCI HP  | PCI Express Assert/Deassert GPE       | EXP_HPINT                        | SCI->ACPI                         |
| Power Management Event (PME)                                   | PCI Express PM_PME message            | PME_OUT                          | SCI->ACPI                         |

**NOTES:**

a. Technically, this is not chipset generated, but is included for completeness.

## 6.8.11 Legacy/8259 Interrupts

The 8259 interrupt controller is supported in NB platforms. 8259 interrupt request is delivered using the interrupt group sideband signals LINT[1:0] (a.k.a. NMI/INTR) or through an I/O xAPIC using the message based interrupt delivery mechanism with the delivery mode set to ExtINT (b111). There can be only one active 8259 controller in the system.

The mechanism in which a PCI Express device requests an 8259 interrupt is a PCI Express inband message. (ASSERT\_INTA/B/C/D, DEASSERT\_INTA/B/C/D).

The target processor for the interrupt uses the interrupt acknowledge transaction to obtain the interrupt vector from the 8259 controller. The NB forwards the interrupt acknowledge to the ICH5 where the active 8259 controller resides.

The NB will support PCI Express devices that generate 8259 interrupts (for example, during boot). 8259 interrupts from PCI Express devices will be sent in-band to the NB which will forward these interrupts to the ICH5.

The NB will have a mechanism to track inband 8259 interrupts from each PCI Express and assert virtual interrupt signals to the 8259 through the inband DO\_PCI\_INT HL special cycle. This is done by a tracking bit per interrupt (A, B, C, D) in each PCI Express which are combined (ORed) into virtual signals that are sent to the ICH5. Each interrupt signal (A, B, C, D) from each PCI Express is ORed together to form virtual INT A, B, C, and D signals to the ICH5

(DO\_PCI\_INTA/B/C/D (assertion encoding)). When all the tracking bits for a given interrupt (A, B, C, or D) are cleared from all PCI Express ports, the virtual signal A, B, C, or D is deasserted via the inband DO\_PCI\_INT (deassertion encoding).

For PCI Express hierarchies, interrupts will be consolidated at each level. For example, a PCI Express switch connected to a NB PCI Express port will only send a maximum of 4 interrupts at a time, regardless of how many interrupts are issued downstream.

SMI (System Management Interrupt) interrupts are initiated by the SMI# signal in the platform. On accepting a System Management Interrupt, the processor saves the current state and enters SMM.

## 6.9 Reset

### 6.9.1 Introduction

This section describes NB-specific aspects of hardware reset. Subsequent I/O initialization procedures requiring configuration register dialogue are not covered in this section.

NB expects to receive RSTIN# from the ICH5 chip. NB uses this signal to reset the internal state of NB, and additionally, forwards this reset to the processor(s) in the system via the H\_A\_RST# and H\_B\_RST# signals. NB controls the reset of the XMB chips connected to NB via software using the IMI\_{A/B/C/D}\_RST# signals which are expected to be connected from NB to XMB.

A system is expected to connect the ICHRST# pin of NB to the PLD controlling the system reset logic that generates the PCIRST# signal into the ICH5 chip.

NB will keep H\_{A/B}\_RST# asserted on an FSB which indicates no end agent is present via the H\_{A/B}\_PRSENT# pin; the system should keep the core and cache VR disabled in this case to avoid any CPU thermal issues.

### 6.9.2 Types of Reset

- Power-up
- Power Good
- PWROK  
The PWROK reset spawns a hard reset.
- Hard  
The hard reset spawns IMI, PCI Express, and Processor resets.
- IMI
- Warm
- PCI Express
- JTAG
- SMBus

### 6.9.3 Triggers of Reset

- Energize power supplies
- PWRGOOD de-assertion
- RESTIN# assertion
- NB.SYRE.SYSRST (refer to [Section 4.14.8](#))
- IMI.ICHRST\_inband\_signal
- NB.SYRE.ROR (refer to [Section 4.14.8](#))
- NB.IMIHPC.NEXTSTATE change (Refer to [Section 4.13.10](#))  
IMI initialization time-out is covered by STATE change.
- NB.BCTRL.SRESET (Refer to [Section 4.11.27](#))
- SMBus protocol

### 6.9.4 Trigger to Type Association

This section describes which triggers initiate which types:

- Energize power supplies: Power-up
- PWRGOOD de-assertion: Power good
- RESTIN# assertion: Hard
- NB.SYRE.ROR: Warm
- NB.IMIHPC.NEXTSTATE set to “Reset” or “RecoveryReset”: IMI
- NB.BCTRL.SRESET: PCI Express
- TRST# assertion or TCK/TMS protocol: JTAG
- SMBus protocol: SMBus

### 6.9.5 Logic Domain Behavior

During reset, each of the logic domains is treated as follows:

- Unaffected by reset:
  - PLL's
- Indirectly affected by reset:
  - Arrays  
Initialized by BIST engines
  - Analog I/O compensation  
Only triggered by power-up
- {Boundary scan chains, JTAG protocol engine}:
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, asynchronous TRST# assertion, ITP\_TRST# asserted, or synchronous TCK/TMS protocol navigation to reset state: Reset

- SMBus protocol engine:
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, or synchronous SMBus reset protocol: Reset
- Sticky configuration bits:
 

Configuration bits with the “ST” attribute are sticky

  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted: Defaults
  - (Synchronized RESTIN# assertion or synchronized RESTIN# asserted) while PWRGOOD asserted: No-Change

Sticky configuration bits must be protected from spurious activity at RESTIN# transitions and while RESTIN# is asserted during hard reset.
- IMI (NB):
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, one cycle after synchronized RESTIN# assertion, IMISC.STATE set to “Reset” or “RecoveryReset” set: reset and tri-state outputs.
  - Synchronized RESTIN# de-assertion, IMISC.STATE set to “Reset” or “RecoveryReset” cleared and synchronized RESTIN# de-asserted: Initialize then begin normal operation.
- RESTIN# pad:
  - Synchronized through two HCLKIN-ed stages

This is the synchronized RESTIN#.
- ICHRST# pad:
  - asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted: de-asserted
  - ICHRST# cycle counter not extinguished: Asserted
- PCI Express:
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted: Tri-state and Reset
  - PWRGOOD asserted, one cycle after synchronized RESTIN# assertion, BCTRL.SRESET set: link down
  - RESTIN# de-assertion, BCTRL.SRESET cleared: initialize, train, link up
- IMI\_{A/B/C/D}\_RST# pad:
  - Controlled by BIOS
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, one cycle after synchronized RESTIN# assertion, IMISC.STATE set to “Reset” or “RecoveryReset” set: Asserted
  - Synchronized RESTIN# de-assertion, IMISC.STATE set to “Reset” or “RecoveryReset” cleared and synchronized RESTIN# de-asserted: De-asserted.
- H\_{A/B}\_RST# pad:
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, one cycle after synchronized RESTIN# assertion, SYRE.ROR asserted and bus locks cleared and IOQ’s flushed and data buffers flushed and IMI.REFRESH detected: assert
- SYRE.ROR configuration bit
  - asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, one cycle after synchronized RESTIN# assertion, 1 HCLKIN after processor RESET# pad asserted: clear

- Power-On Configuration:
  - Minimum of 1 HCLKIN after processor RESET# pad asserted: Assert
  - 2-19 HCLKIN after processor RESET# pad de-asserted: De-assert
- Hub Interface:
  - Asynchronous PWRGOOD de-assertion, PWRGOOD de-asserted, one cycle after synchronized RESTIN# assertion: Reset and Tri-stated
  - Synchronized RESTIN# de-asserted: Send NOP -> wait for NOP\_ACK -> send CPU\_RESET\_DONE

## 6.9.6 PWRGOOD De-asserted

Trigger = PWRGOOD de-assertion: Asynchronous

Power and master clocks remain stable.

- De-assert ICHRST# asynchronously.
- Assert H\_{A/B}\_RST# and IMI\_{A/B/C/D}\_RST# asynchronously.
- De-assert other front side bus I/O asynchronously.
- Tri-state other I/O.
- Toggle PLL outputs.
- Reset I/O Ports.
- Resolve multiple drivers to a non-destructive state.

## 6.9.7 PWRGOOD Assertion

Trigger = PWRGOOD assertion: Synchronized

Voltages are within specifications. Master clocks are stable. The TCK signal may be in any state.

- Sample straps.
- Enable Power-On-Configuration (POC) to the front side bus.
- Un-tri-state I/O.
- Hold PCI Express link down.

## 6.9.8 NB ICHRST# Sequence

Triggers = {H\_{A/B}\_RST#, ICHRST#, IMI\_{A/B/C/D}\_RST# Reset Signal and NB.SYRE.SYSRST Set}: Synchronous

- Assert ICHRST# for approximately 100  $\mu$ s asynchronously to CLK66
- De-assert ICHRST# asynchronously to CLK66.  
This de-assertion must wait until 100  $\mu$ s elapses, even though RESTIN# will be asserted before 100  $\mu$ s elapses.
- Clear SYRE.SYSRST when ICHRST# is asserted.



## 6.9.9 Hard Reset Asserted

Trigger = RESTIN# assertion: Synchronized

PWRGOOD is asserted.

- Protect sticky configuration bits.  
Sticky configuration bits must not log spurious errors resulting from the reset process. These processes include de-activated buses, initialization sequences, and spurious inputs on internal interfaces.
- Synchronously assert internal asynchronous flip-flop initialization inputs.  
Private JTAG chains may be reset.  
Exceptions: synchronous test-mode flip-flops, sticky configuration bits, JTAG controller and boundary-scan logic, and analog I/O compensation.
- Assert H\_{A/B}\_RST#.
- Do not assert IMI\_{A/B/C/D}\_RST# - software causes this to assert.
- Initialize non-PCI Express I/O port operation.
- Tri-state IMI I/O after 16 HCLKIN.
- Reset PCI Express protocol.
- Take PCI Express link down.
- Drive processor Power-On-Configuration (POC).  
POC is driven from the SYRE.CPUBIST, POC, and POC\_AUX{A/B} configuration registers. The default values of these configuration registers do not require any processor request signals to be asserted when PWRGOOD is first asserted.
- De-assert non-POC front side bus signals.

## 6.9.10 Hard Reset De-assertion

Trigger = RESTIN# de-assertion: synchronized

PWRGOOD is asserted.

- Allow normal operation of sticky configuration bits.
- Initiate physical IMI initialization.
- Initiate each remaining IMI initialization sequence: handshake, link-width negotiation, and deskew-and-frame.
- Send NOP message to Hub Interface. Wait for NOP\_ACK reply from Hub Interface. Send CPU\_RESET\_DONE message to Hub Interface.
- Initialize PCI Express link.
- Engage PCI Express link training.
- Bring PCI Express link up.
- After approximately 1 ms, de-assert processor RESET#.
- After processor RESET# de-assertion + 2 HCLKIN, disable POC.

### 6.9.11 PCI Express Reset Asserted

Trigger = BCTRL.SRESET set: Synchronous

- Initialize PCI Express protocol.
- Take PCI Express link down.

### 6.9.12 NB PCI Express Reset De-asserted

Trigger = BCTRL.SRESET cleared: synchronous

- Initialize PCI Express link.
- Engage PCI Express link training.
- Bring PCI Express link up.

### 6.9.13 NB IMI Reset Assertion

Trigger = IMIHPC.NEXTSTATE set to “Reset” or “RecoveryReset”: synchronous

- Assert IMI\_{A/B/C/D}\_RST#.
- Tri-state IMI I/O (not including IMI\_{A/B/C/D}\_RST#).

### 6.9.14 NB IMI Reset De-assertion

Trigger = IMIHPC.NEXTSTATE set to “Init” or “RecoveryInit”: Synchronous

- De-assert XMB IMI\_RST#.
- IMI initiates physical initialization.
- After completion of IMI physical initialization, each IMI initiates each remaining initialization sequence: handshake, link-width negotiation, and deskew-and-frame.

### 6.9.15 Warm Reset Sequence

Trigger = SYRE.ROR set or SYRE.CPURST set: Synchronous

- If SYRE.ROR is set, wait for an inband IMI.REFRESH signal from IMI designated by SYRE.REFPMI.
- Assert H\_{A/B}\_RST#.

#### 6.9.15.1 Processor Reset Sequence

This is the entry point for a processor reset spawned by a “hard” reset. This is also a continuation of the warm reset sequence.

Trigger = Processor RESET# assertion: Synchronous

- After processor RESET# assertion + minimum of 1 HLCKIN, enable POC.  
POC is driven from the SYRE.CPUBIST, POC, and POC\_AUX[1:0] configuration registers.

- Logically mask front side bus inputs.
- Clear SYRE.ROR and SYRE.CPURST.
- After minimum of 1 ms, de-assert processor RESET#.
- After observing de-assertion of processor RESET#, resume front side bus protocol.
- After processor RESET# de-assertion + minimum of 2 HCLKIN, disable POC.

### 6.9.16 JTAG Reset Assertion

Triggers = {TRST# assertion: asynchronous; TMS asserted for 5 TCK rising edges: Synchronous}

- Initialize JTAG finite-state-machine.
- Initialize boundary-scan chain.

### 6.9.17 JTAG Reset De-assertion

Trigger = ITP\_TRST# de-assertion: Asynchronous

- Release JTAG port and to operate normally.
- Release boundary-scan chain to operate normally.

### 6.9.18 SMBus Reset Sequence

Trigger = SMBus protocol: Synchronous

- Reset SMBus interface

## 6.10 System Management

The NB chipset supports three methods of providing system management to the platform:

- **Processor Access** - All registers of the NB Chipset are available via a FSB access.
- **SMBus Access** - Via an SMBus access to the NB, a register access can be generated to the NB, any XMB, PCI Express device or ICH5. In addition, an SMBus access can go directly to the XMB. It should be noted that unlike processor accesses, the SMBus interface does have some restrictions, namely:
  - SMBus cannot generate a Memory access at the NB or XMB
- **JTAG Access** - The same limitation and restrictions that apply to the SMBus interface also apply to the JTAG interface of the NB components.

The NB chipset provides a fully functional SMBus (or JTAG) target interface, which gives direct access to all internal chipset configuration registers. SMBus/JTAG access provides for a highly flexible platform management architecture when used in conjunction with a baseboard management controller (BMC) with an integrated network interface controller (NIC) function.

## 6.10.1 SMBus Access

System Management software in a NB platform can initiate system management access to the configuration registers. This can be done through SMBus accesses.

The mechanism for the Server Management (SM) software to access configuration registers is a slave port that is close to SMBus Specification, Revision 2.0, but not fully compliant. Some Intel® E8501 chipset components contain this slave port and allow accesses to their configuration registers. The product specific details are compatible with the Intel 6700PXH 64-bit PCI Hub SMBus configuration access mechanism. The NB/XMB do not require the Intel 6700PXH 64-bit PCI Hub memory read/write because all registers (including the Intel 6700PXH 64-bit PCI Hub registers) can be accessed through the configuration mechanism.

SMBus operations are made up of two major steps:

- Writing information to registers within each component
- Reading configuration registers from each component.

The following sections describe the protocol for an SMBus master to access a NB component's internal configuration registers. For the bus protocol, timings, and waveforms, refer to the SMBus Specification, Revision 2.0.

Each component in the NB platform must have a unique address. NB component addresses are defined in [Table 6-42](#).

**Table 6-42. SMBus Addresses for the Intel® E8501 Chipset Platform**

| Intel® E8501 Chipset Component         | SMBus Address (bits [7:1]) |
|--|----------------------------|
| Intel® E8501 Chipset North Bridge (NB) | 0001100                    |
| eXternal Memory Bridge D (XMB D)       | 0001011                    |
| eXternal Memory Bridge C (XMB C)       | 0001010                    |
| eXternal Memory Bridge B (XMB B)       | 0001001                    |
| eXternal Memory Bridge A (XMB A)       | 0001000                    |
| Devices south of the NB                | 0000000 - 0000111          |

**NOTES:**

1. Bit 0 is not applicable to the address, since it is a R/W bit.
2. The NB does not implement the SMBALERT# pin. The fact that NB uses 0001100 means no slave-only device that requires use of the SMBALERT# signal and the subsequent access to the 0001100 address can be used in the system.

### 6.10.1.1 Supported SMBus Commands

NB components SMBus Rev. 2.0 slave ports support the following six SMBus commands:

- Block Write
- Word Write
- Byte Write
- Block Read
- Word Read
- Byte Read

Sequencing these commands will initiate internal accesses to the component's configuration registers.

Each configuration read or write first consists of an SMBus write sequence which initializes the Bus Number, Device Number, etc. The term sequence is used, since these variables may be written with a single block write or multiple word or byte writes. Once these parameters are initialized, the SMBus master can initiate a read sequence (which perform a configuration read) or a write sequence (which performs a configuration write).

Each SMBus transaction has an 8-bit command driven by the master. The format for this command is illustrated in [Table 6-43](#) below.

**Table 6-43. SMBus Command Encoding**

| 7     | 6   | 5    | 4      | 3:2  | 1:0   |
|-------|-----|------|--------|--|---|
| Begin | End | Rsvd | PEC_en | Internal Command:<br>00 - Read DWord<br>01 - Write Byte<br>10 - Write Word<br>11 - Write DWord | SMBus Command:<br>00 - Byte<br>01 - Word<br>10 - Block<br>11 - Rsvd |

The *Begin* bit indicates the first transaction of a read or write sequence.

The *End* bit indicates the last transaction of a read or write sequence.

The *PEC\_en* bit enables the 8-bit PEC generation and checking logic.

The *Internal Command* field specifies the internal command to be issued by the SMBus slave logic. Note that the Internal Command must remain consistent (i.e. not change) during a sequence that accesses a configuration register. Operation cannot be guaranteed if it is not consistent when the command setup sequence is done.

The *SMBus Command* field specifies the SMBus command to be issued on the bus. This field is used as an indication of the length of transfer so the slave knows when to expect the PEC packet (if enabled).

Reserved bits should be written to zero to preserve future compatibility.

### 6.10.1.2 Configuration Register Read Protocol

Configuration reads are accomplished through an SMBus write(s) and later followed by an SMBus read. The write sequence is used to initialize the Bus Number, Device, Function, and Register Number for the configuration access. The writing of this information can be accomplished through any combination of the supported SMBus write commands (Block, Word or Byte). The *Internal Command* field for each write should specify Read DWord.

After all the information is set up, the last write (*End* bit is set) initiates an internal configuration read. If the data is not available before the slave interface acknowledges this last write command (ACK), the slave will “clock stretch” until the data returns to the SMBus interface unit. If an error occurs during the internal access, the last write command will receive a NACK. A status field indicates abnormal termination and contains status information such as target abort, master abort, and time-outs. The status field encoding is defined in [Table 6-44](#).

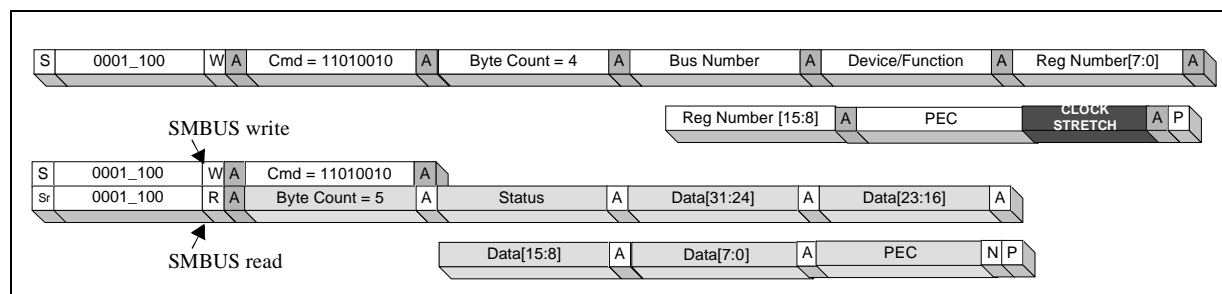
**Table 6-44. Status Field Encoding for SMBus Reads (Sheet 1 of 2)**

| Bit | Description           |
|-----|-----------------------|
| 7:6 | Reserved              |
| 5   | Internal Master Abort |

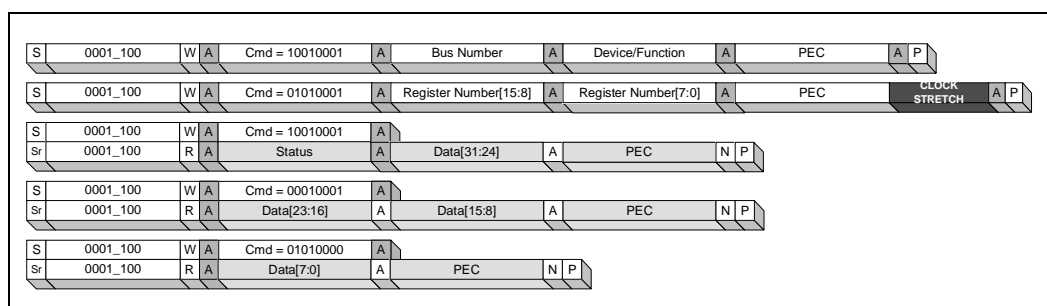
**Table 6-44. Status Field Encoding for SMBus Reads (Sheet 2 of 2)**

| Bit | Description           |
|-----|-----------------------|
| 4   | Internal Target Abort |
| 3:1 | Reserved              |
| 0   | Successful            |

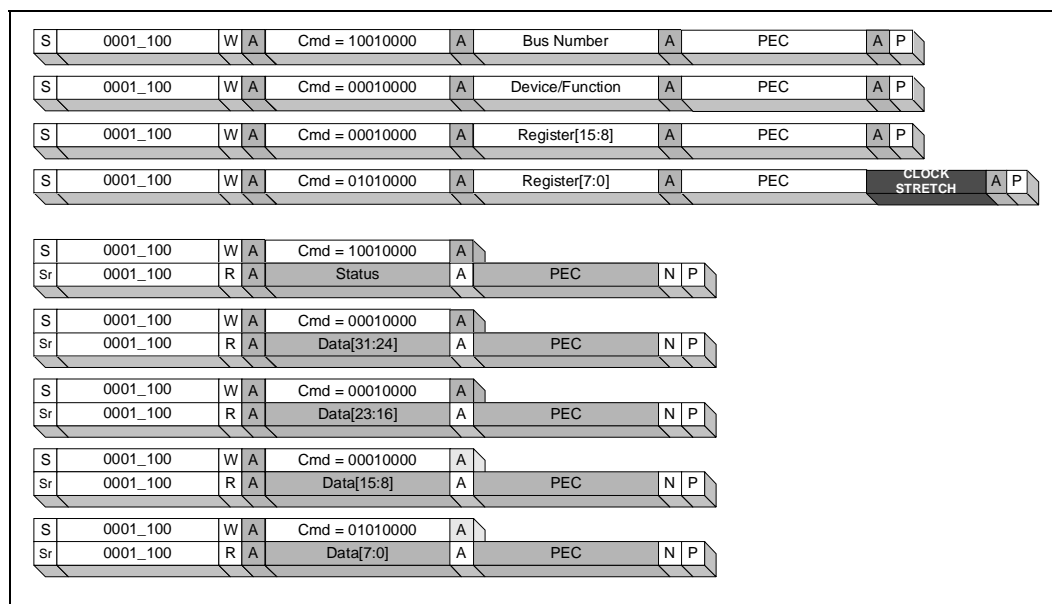
Examples of configuration reads are illustrated below. All of these examples use the NB address and have PEC (Packet Error Code) enabled. Refer to [Table 6-42, “SMBus Addresses for the Intel® E8501 Chipset Platform”](#) for other Intel® E8501 chipset component addresses. If the master does not support PEC, then bit 4 of the command would be cleared and there would not be a PEC phase. For the definition of the diagram conventions below, refer to the *SMBus Specification*, Revision 2.0. For SMBus read transactions, the last byte of data (or the PEC byte if enabled) is NACK'ed by the master to indicate the end of the transaction. For diagram compactness, “Register Number[]” is also sometimes referred to as “Reg Number” or “Reg Num”.

**Figure 6-17. SMBus Configuration Read (Block Write / Block Read, PEC Enabled)**

This is an example using word reads. The final data is a byte read.

**Figure 6-18. SMBus Configuration Read (Word Writes / Word Reads, PEC Enabled)**

The following example uses byte reads.

**Figure 6-19. SMBus Configuration Read (Write Bytes / Read Bytes, PEC Enabled)**


### 6.10.1.3 Configuration Register Write Protocol

Configuration writes are accomplished through a series of SMBus writes. As with configuration reads, a write sequence is first used to initialize the Bus Number, Device, Function, and Register Number for the configuration access. The writing of this information can be accomplished through any combination of the supported SMBus write commands (Block, Word or Byte).

**Note:** On SMBus, there is no concept of byte enables. Therefore, the Register Number written to the slave is assumed to be aligned to the length of the Internal Command. In other words, for a Write Byte internal command, the Register Number specifies the byte address. For a Write DWord internal command, the two least-significant bits of the Register Number are ignored. This is different from PCI, where the byte enables are used to indicate the byte of interest.

After all the information is set up, the SMBus master initiates one or more writes, which sets up the data to be written. The final write (*End* bit is set) initiates an internal configuration write. The slave interface could potentially clock stretch the last data write until the write completes without error. If an error occurred, the SMBus interface NACK's the last write operation just before the stop bit.

Examples of configuration writes are illustrated below. All of these examples use the NB address. Refer to [Table 6-42, "SMBus Addresses for the Intel® E8501 Chipset Platform"](#) for other Intel® E8501 chipset addresses. For the definition of the diagram conventions below, refer to the *SMBus Specification*, Revision 2.0.

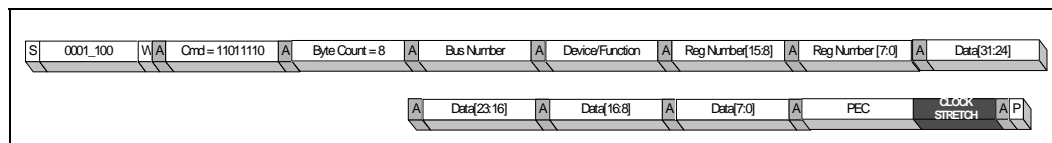
**Figure 6-20. SMBus Configuration Write (Block Write, PEC Enabled)**


Figure 6-21. SMBus Configuration Write (Word Writes, PEC Enabled)

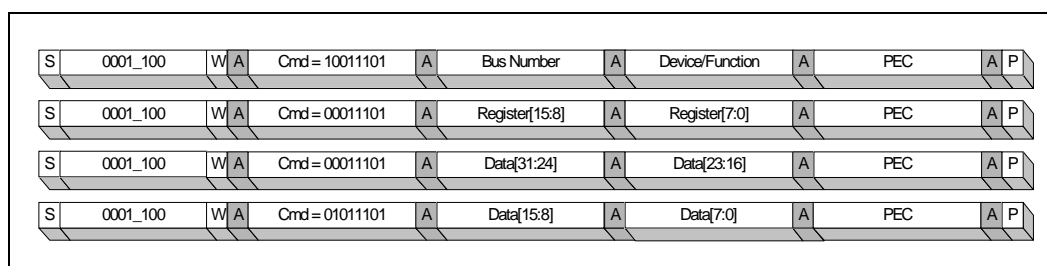
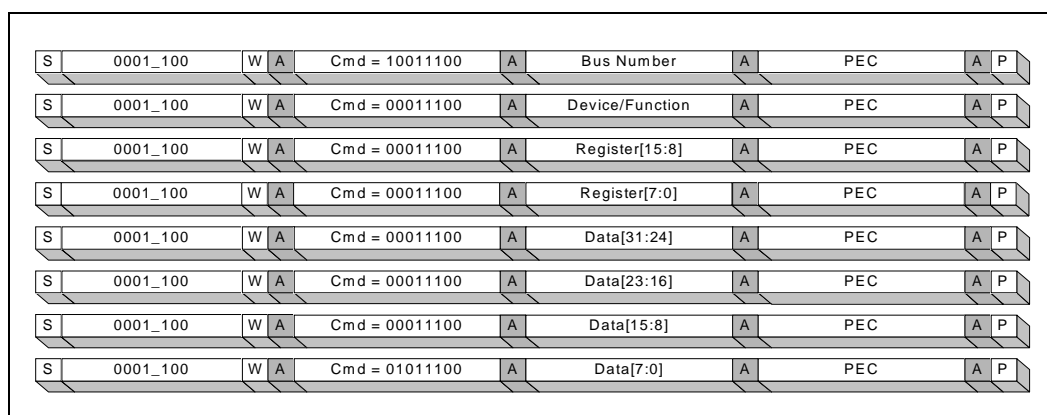


Figure 6-22. SMBus Configuration Write (Write Bytes, PEC Enabled)



#### 6.10.1.4 SMBus Error Handling

The SMBus slave interface handles two types of errors: Internal and PEC. For example, internal errors can occur when the NB issues a configuration read on the PCI Express port Scalability Port and that read terminates in error. These errors manifest as a Not-Acknowledge (NACK) for the read command (*End* bit is set). If an internal error occurs during a configuration write, the final write command receives a NACK just before the stop bit. If the master receives a NACK, the entire configuration transaction should be reattempted.

If the master supports packet error checking (PEC) and the PEC\_en bit in the command is set, then the PEC byte is checked in the slave interface. If the check indicates a failure, then the slave will NACK the PEC packet.

#### 6.10.1.5 SMBus Interface Reset

The slave interface state machine can be reset by the master in two ways:

- The master holds SCL low for 25ms cumulative. “Cumulative” in this case means that all the “low time” for SCL is counted between the Start and Stop bit. If this totals 25 ms before reaching the Stop bit, the interface is reset.
- The master holds SCL continuously high for 50 ms.

**Note:** Since the configuration registers are affected by the reset pin, SMBus masters will not be able to access the internal registers while the system is reset.



## 6.10.2 JTAG Access

NB chipset provides a JTAG configuration access mechanism that allows a user to access any register in the system. Table 6-45 defines the mapping of registers to JTAG bit positions.

**Table 6-45. JTAG Configuration Register Access**

| Bit   | Description  |
|-------|--|
| 71:40 | <b>Data</b>  |
| 39:32 | <b>Register Address[7:0]</b>   |
| 31:29 | <b>Function[2:0]</b>   |
| 28:24 | <b>Device ID[4:0]</b>  |
| 23:16 | <b>Bus number[7:0]</b>   |
| 15:12 | <b>Extended Register Address[11:8]</b>   |
| 11:8  | <b>Reserved</b>  |
| 7:4   | Status   |
| 3:0   | <b>Command:</b><br>0xxx = NOP used in polling the chain to determine if the unit is busy.<br>1001 = write byte<br>1010 = write word<br>1011 = write dword<br>1100 = read dword |

### 6.10.2.1 JTAG Accesses to Registers on Other Components

The Intel® E8501 chipset north bridge (NB) provides functionality that allows accessing registers in the system through the NB JTAG port. The NB will translate these accesses into configuration accesses to the other components. For XMB, ICH5, and PCI Express components, the accesses will be the same as processor initiated register accesses.

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## 7 *Ballout/Pinout and Package Information*

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This chapter specifies the ballout/pinout and mechanical specifications for the Intel® E8501 chipset north bridge (NB), and provides references to documents that contain similar information for the remaining core components of the Intel® E8501 chipset, specifically:

**XMB** Intel® E8501 Chipset eXternal Memory Bridge (XMB)

**ICH5** Intel® 82801EB I/O Controller Hub 5 (ICH5)

This information is intended to help with component placement and board routing.

### 7.1 *Intel® E8501 Chipset North Bridge (NB) Ballout/Pinout*

The NB ballout includes the front-side bus (FSB) interfaces, the Independent Memory Interfaces (IMI), the PCI Express interfaces, the Hub 1.5 interface, and the various power, ground, and reference pins.

For detailed information about the XMB ballout and pin list, refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

For detailed information about the ICH5 ballout and pin list, refer to the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 (ICH5R) Datasheet*. The ICH5 Datasheet is available at: <http://developer.intel.com/design/chipsets/datashts>.

Figure 7-1. NB Ballout (Top View)

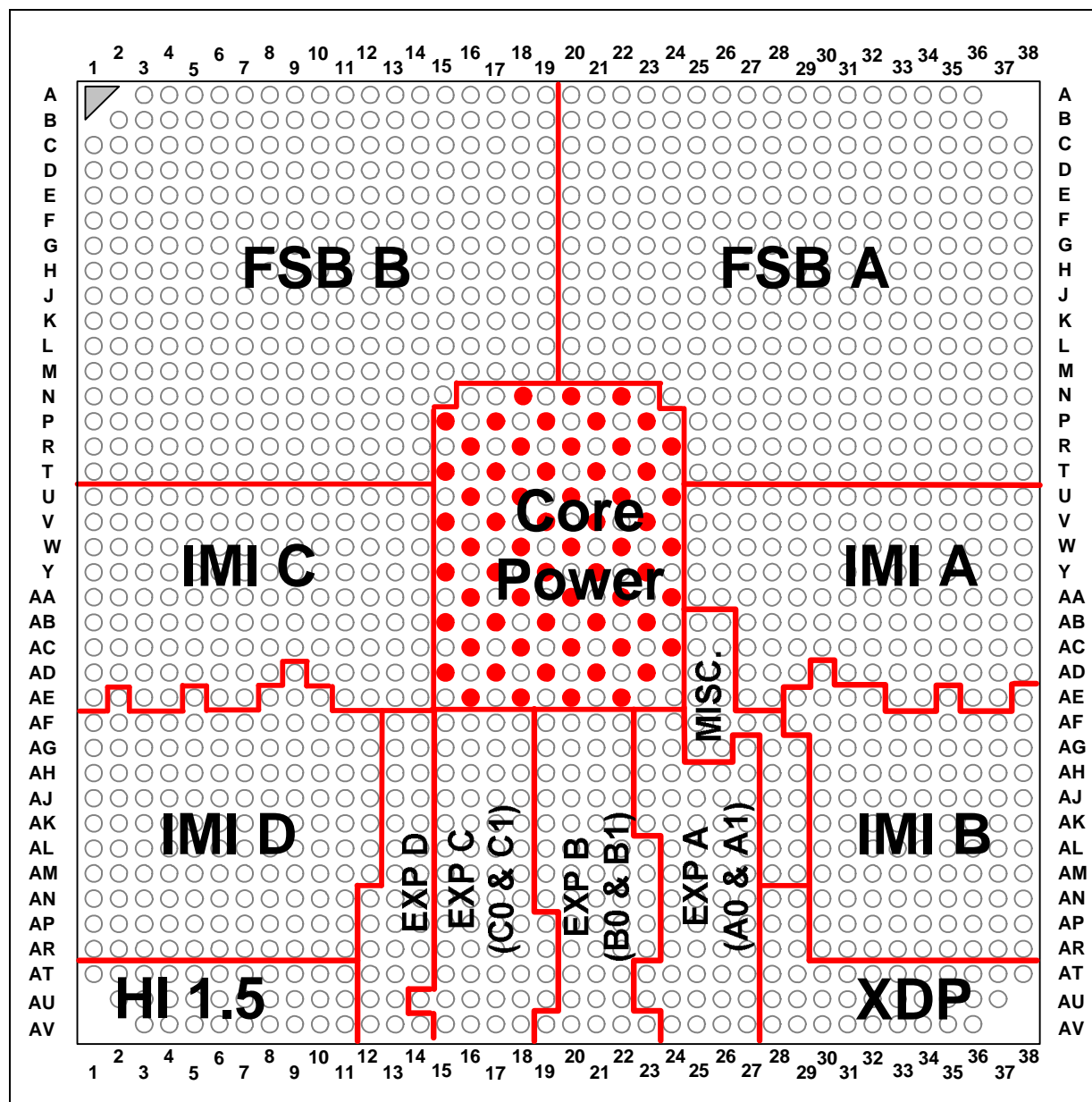


Figure 7-2. NB Ballout with Signal Names (Top View - Left Region)

|    | 1            | 2            | 3          | 4            | 5            | 6           | 7            | 8            | 9            | 10                  | 11                    | 12           | 13          |    |
|----|--------------|--------------|------------|--------------|--------------|-------------|--------------|--------------|--------------|---------------------|-----------------------|--------------|-------------|----|
| A  |              |              | VSS        | VSS          | H B D44#     | H B D43#    | VSS          | H B D35#     | H B D39#     | VSS                 | H B D32#              | H B D15#     | VSS         | A  |
| B  |              | VSS          | H B D62#   | H B DEP4#    | H B D47#     | VSS         | H B DBI2#    | H B D38#     | VTT          | H B D37#            | H B D34#              | VSS          | H B DSTBP0# | B  |
| C  | VSS          | H B D56#     | H B DBI3#  | H B DEP5#    | VSS          | H B D42#    | H B D40#     | VSS          | H B DSTBP2#  | H B DSTBN2#         | VSS                   | H B D14#     | H B D10#    | C  |
| D  | H B D59#     | H B D57#     | H B D61#   | VSS          | H B D46#     | H B D45#    | VTT          | H B D41#     | H B D33#     | VSS                 | H B D36#              | H B D12#     | VTT         | D  |
| E  | H B D63#     | H B D58#     | VSS        | H B D55#     | H B D53#     | VSS         | H B D52#     | H B D50#     | VSS          | H B DSTBP1#         | H B DSTBN1#           | VSS          | H B D25#    | E  |
| F  | H B DEP6#    | VSS          | H B D60#   | H B D54#     | VTT          | H B D51#    | H B D48#     | VSS          | H B DEP3#    | H B D31#            | VTT                   | H B D30#     | H B D28#    | F  |
| G  | VSS          | H B ID7#     | H B DEP7#  | VSS          | H B DSTBP3#  | H B DSTBN3# | VSS          | H B D49#     | Reserved     | VSS                 | H B DEP2#             | H B D24#     | VSS         | G  |
| H  | H B ID4#     | H B ID5#     | VTT        | H B A37#     | H B VREF0    | VSS         | H B VREF1    | Reserved     | VTT          | Reserved            | Reserved              | VSS          | H B ID6#    | H  |
| J  | H B ID1#     | VSS          | H B ID0#   | H B REQ4#    | VSS          | H B A3#     | H B REQ1#    | VSS          | H B A18#     | H B A19#            | VSS                   | H B IDS#     | H B OOD#    | J  |
| K  | VTT          | H B BPR1#    | H B ID2#   | VSS          | H B REQ2#    | H B REQ3#   | VTT          | H B A24#     | H B ADSTB1#  | VSS                 | H B A39#              | Reserved     | VTT         | K  |
| L  | H B HIT#     | H B DEFER#   | VSS        | H B A7#      | H B A4#      | VSS         | H B REQ0#    | H B A28#     | VSS          | H B A25#            | H B A17#              | VSS          | H B HITM#   | L  |
| M  | H B RS1#     | VSS          | H B RS2#   | H B A6#      | VTT          | H B A5#     | H B A8#      | VSS          | H B A29#     | H B A23#            | VTT                   | H B BINIT#   | H B AP0#    | M  |
| N  | VSS          | H B BNR#     | H B RS0#   | VSS          | H B A9#      | H B ADSTB0# | VSS          | H B A21#     | H B A30#     | VSS                 | H B A22#              | H B AP1#     | VSS         | N  |
| P  | H B TRDY#    | H B BREQ0#   | VTT        | H B A36#     | H B A11#     | VSS         | H B A15#     | H B A34#     | VTT          | H B A20#            | H B A26#              | VSS          | H B MCERR#  | P  |
| R  | H B ADS#     | VSS          | H B DRDY#  | H B A16#     | VSS          | H B A12#    | H B A13#     | VSS          | H B A27#     | H B A35#            | VSS                   | H B RSP#     | Reserved    | R  |
| T  | VTT          | H B LOCK#    | H B DBSY#  | VSS          | H B A10#     | H B A14#    | VTT          | H B A33#     | H B A31#     | VSS                 | H B A32#              | H B A38#     | VTT         | T  |
| U  | IMI_C_RXN0   | IMI_C_ICOMP1 | VSS        | IMI_C_RXN1   | IMI_C_ICOMP0 | VSS         | IMI_C_RXN8   | Reserved     | VSS          | IMI_C_RXN9          | IMI_C_FRA ME          | VSS          | IMI_C_VCCBG | U  |
| V  | IMI_C_RXP0   | VSS          | IMI_C_TXN0 | IMI_C_RXP1   | P1V5         | IMI_C_TXN1  | IMI_C_RXP8   | VSS          | IMI_C_TXN8   | IMI_C_RXP9          | P1V5                  | IMI_C_TXN9   | IMI_C_VSSBG | V  |
| W  | VSS          | IMI_C_RXN2   | IMI_C_TXP0 | VSS          | IMI_C_RXN3   | IMI_C_TXP1  | VSS          | IMI_C_RXN10  | IMI_C_TXP8   | VSS                 | IMI_C_TXN11           | IMI_C_TXP9   | VSS         | W  |
| Y  | IMI_C_TXN2   | IMI_C_RXP2   | P1V5       | IMI_C_TXN3   | IMI_C_RXP3   | VSS         | IMI_C_RXN12  | IMI_C_RXP10  | P1V5         | IMI_C_RXN13         | IMI_C_RXP11           | VSS          | Reserved    | Y  |
| AA | IMI_C_TXP2   | VSS          | IMI_C_RXN4 | IMI_C_TXP3   | VSS          | IMI_C_RXN5  | IMI_C_RXP12  | VSS          | IMI_C_RXN14  | IMI_C_RXP13         | VSS                   | IMI_C_RXN15  | Reserved    | AA |
| AB | P1V5         | IMI_C_TXN4   | IMI_C_RXP4 | VSS          | IMI_C_TXN5   | IMI_C_RXP5  | P1V5         | IMI_C_RXN16  | IMI_C_RXP14  | VSS                 | IMI_C_RXN17           | IMI_C_RXP15  | P1V5        | AB |
| AC | IMI_C_RXN6   | IMI_C_TXP4   | VSS        | IMI_C_RXN7   | IMI_C_TXP5   | VSS         | IMI_C_LINKN0 | IMI_C_RXP16  | VSS          | IMI_C_LINKN1        | IMI_C_RXP17           | VSS          | IMI_D_VCCBG | AC |
| AD | IMI_C_RXP6   | VSS          | IMI_C_TXN6 | IMI_C_RXP7   | P1V5         | IMI_C_TXN7  | IMI_C_LINKP0 | VSS          | IMI_D_RXN10  | IMI_C_LINKP1        | P1V5                  | IMI_C_LINKN2 | IMI_D_VSSBG | AD |
| AE | VSS          | IMI_D_RXN0   | IMI_C_TXP6 | VSS          | IMI_D_RXN1   | IMI_C_TXP7  | VSS          | IMI_D_RXN11  | IMI_D_RXP10  | VSS                 | IMI_C_RST#            | IMI_C_LINKP2 | VSS         | AE |
| AF | IMI_D_TXN0   | IMI_D_RXP0   | P1V5       | IMI_D_TXN1   | IMI_D_RXP1   | VSS         | IMI_D_RXN12  | IMI_D_RXP11  | P1V5         | ICHRST#             | IMI_D_FRA ME          | VSS          | Reserved    | AF |
| AG | IMI_D_TXP0   | VSS          | IMI_D_RXN2 | IMI_D_TXP1   | VSS          | IMI_D_RXN3  | IMI_D_RXP12  | VSS          | IMI_D_RXN13  | PME_OUT/EXP1_WIDTH2 | VSS                   | Reserved     | Reserved    | AG |
| AH | P1V5         | IMI_D_TXN2   | IMI_D_RXP2 | VSS          | IMI_D_TXN3   | IMI_D_RXP3  | P1V5         | IMI_D_RXN14  | IMI_D_RXP13  | VSS                 | EXP_HPINT/EXP1_WIDTH1 | IMI_HPINT    | P1V5        | AH |
| AJ | IMI_D_RXN4   | IMI_D_TXP2   | VSS        | IMI_D_RXN5   | IMI_D_TXP3   | VSS         | IMI_D_RXN15  | IMI_D_RXP14  | VSS          | V3REF1              | Reserved              | VSS          | EXP_D_RXP0  | AJ |
| AK | IMI_D_RXP4   | VSS          | IMI_D_TXN4 | IMI_D_RXP5   | P1V5         | IMI_D_TXN5  | IMI_D_RXP15  | VSS          | IMI_D_RXN16  | Reserved            | P1V5                  | EXP1_SPEC10A | EXP_D_RXN0  | AK |
| AL | VSS          | IMI_D_RXN6   | IMI_D_TXP4 | VSS          | IMI_D_RXN7   | IMI_D_TXP5  | VSS          | IMI_D_RXN17  | IMI_D_RXP16  | VSS                 | Reserved              | Reserved     | VSS         | AL |
| AM | IMI_D_TXN6   | IMI_D_RXP6   | P1V5       | IMI_D_TXN7   | IMI_D_RXP7   | VSS         | IMI_D_LINKN0 | IMI_D_RXP17  | P1V5         | Reserved            | Reserved              | VSS          | EXP_D_RXP1  | AM |
| AN | IMI_D_TXP6   | VSS          | IMI_D_RXN8 | IMI_D_TXP7   | VSS          | IMI_D_RXN9  | IMI_D_LINKP0 | VSS          | IMI_D_LINKN1 | Reserved            | VSS                   | EXP_D_TXP2   | EXP_D_RXN1  | AN |
| AP | P1V5         | IMI_D_TXN8   | IMI_D_RXP8 | VSS          | IMI_D_TXN9   | IMI_D_RXP9  | P1V5         | IMI_D_LINKN2 | IMI_D_LINKP1 | VSS                 | Reserved              | EXP_D_TXN2   | P1V5        | AP |
| AR | IMI_D_ICOMP1 | IMI_D_TXP8   | VSS        | IMI_D_ICOMP0 | IMI_D_TXP9   | VSS         | IMI_D_RST#   | IMI_D_LINKP2 | VSS          | Reserved            | Reserved              | VSS          | Reserved    | AR |
| AT | VSS          | HI11         | HI0        | HI3          | P1V5         | HI10        | HI5          | VSS          | HIRCOMP      | Reserved            | P1V5                  | EXP_D_TXP3   | EXP_D_TXN3  | AT |
| AU |              | VSS          | HI1        | HI2          | HI8          | HI9         | VSS          | HI7          | HIVSWING     | VSS                 | Reserved              | Reserved     | VSS         | AU |
| AV |              |              | VSS        | HI_STBS      | HI_STBF      | VSS         | HI4          | HI6          | P1V5         | HIVREF              | Reserved              | VSS          | EXP_D_RXP3  | AV |
|    | 1            | 2            | 3          | 4            | 5            | 6           | 7            | 8            | 9            | 10                  | 11                    | 12           | 13          |    |

Figure 7-3. NB Ballout with Signal Names (Top View - Center Region)

|    | 14              | 15              | 16              | 17              | 18              | 19              | 20              | 21              | 22              | 23              | 24               | 25              |    |
|----|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|-----------------|----|
| A  | H B D11#        | H B D9#         | VSS             | H B D8#         | H B D4#         | VSS             | H A D46#        | H A D45#        | VSS             | H A D41#        | H A D39#         | VSS             | A  |
| B  | H B_DSTBN<br>0# | VTT             | H B D6#         | H B D0#         | VSS             | H B DEP1#       | H A DEP4#       | VTT             | H A D43#        | H A DBI2#       | VSS              | H A D37#        | B  |
| C  | VSS             | H B D5#         | H B D3#         | VSS             | H B D1#         | H B DEP0#       | VSS             | H A D44#        | H A D42#        | VSS             | H A_DSTBP<br>2#  | H A_DSTBN<br>2# | C  |
| D  | H B D13#        | H B D2#         | VSS             | H B D7#         | H B DBI0#       | VTT             | H A DEP5#       | H A D47#        | VSS             | H A D40#        | H A D38#         | VTT             | D  |
| E  | H B D26#        | VSS             | H B D22#        | H B D21#        | VSS             | H B D17#        | H A DEP7#       | VSS             | H A D59#        | H A D57#        | VSS              | H A D62#        | E  |
| F  | VSS             | H B D27#        | H B D23#        | VTT             | H B D18#        | H B D16#        | VSS             | H A D60#        | H A D58#        | VTT             | H A D61#         | H A D54#        | F  |
| G  | H B D29#        | H B DBI1#       | VSS             | H B D20#        | H B D19#        | VSS             | H A DEP6#       | H A D63#        | VSS             | H A D56#        | H A DBI3#        | VSS             | G  |
| H  | H B DP1#        | VTT             | H B DP0#        | H B VREF2       | VSS             | Reserved        | Reserved        | VTT             | H A VREF1       | H A DP0#        | VSS              | H A DP1#        | H  |
| J  | VSS             | H B DP2#        | H B DP3#        | VSS             | TESTLO4         | P1V5            | VSS             | HCLKINN         | HCLKINP         | VSS             | H A DP2#         | H A BPM5#       | J  |
| K  | EXP1_WIDT<br>H0 | H B ID3#        | VSS             | H VSSA          | H VCCA          | VTT             | VSSA            | VCCA            | VSS             | H A DP3#        | H A BPM4#        | VTT             | K  |
| L  | H B_BREQ1<br>#  | VSS             | H_SLWCRE<br>S   | H CRES          | VSS             | Reserved        | TESTLO3         | VSS             | TESTH1          | TESTLO2         | VSS              | H A AP1#        | L  |
| M  | VSS             | H B_BPM4#       | H_ODTCRE<br>S   | VTT             | TESTLO1         | Reserved        | VSS             | H_A_PRSNT<br>#  | H_B_PRSNT<br>#  | VTT             | TESTLO5          | H A_BREQ1<br>#  | M  |
| N  | H B_RST#        | H B_BPM5#       | VSS             | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | H A_OOD#         | VSS             | N  |
| P  | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | P1V5            | P  |
| R  | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5             | VSS             | R  |
| T  | IMI_C_CLKP      | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | P1V5            | T  |
| U  | IMI_C_CLKN      | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5             | IMI_A_CLKP      | U  |
| V  | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | IMI_A_VCCA      | V  |
| W  | IMI_C_VSSA      | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5             | IMI_A_VSSA      | W  |
| Y  | IMI_C_VCCA      | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | IMI_A_VSSB<br>G | Y  |
| AA | IMI_D_CLKP      | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5             | IMI_A_VCCB<br>G | AA |
| AB | IMI_D_CLKN      | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | IMI_B_VCCA      | AB |
| AC | IMI_D_VSSA      | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5             | IMI_B_VSSA      | AC |
| AD | IMI_D_VCCA      | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS              | IMI_B_CLKN      | AD |
| AE | Reserved        | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | P1V5            | VSS             | EXP0_WIDT<br>H0  | IMI_B_CLKP      | AE |
| AF | Reserved        | Reserved        | CLK66           | HI_VCCA         | HI_VSSA         | EXP_VSSBG       | EXP_CLKP        | EXP_CLKN        | EXP_VCCA        | IMI_B_VSSB<br>G | IMI_B_VCCB<br>BG | SMBCLK          | AF |
| AG | VSS             | EXP_C0_TX<br>P0 | Reserved        | VSS             | EXP_C1_RX<br>N3 | EXP_VCCB<br>G   | VSS             | EXP_B1_RX<br>N3 | EXP_VSSA        | VSS             | EXP_A0_TX<br>P0  | GP_SMBDA<br>TA  | AG |
| AH | EXP_D_TXP<br>0  | EXP_C0_TX<br>N0 | VSS             | EXP_C0_RX<br>P0 | EXP_C1_RX<br>P3 | P1V5            | EXP_B0_TX<br>P0 | EXP_B1_RX<br>P3 | VSS             | EXP_A0_RX<br>P0 | EXP_A0_TX<br>N0  | P1V5            | AH |
| AJ | EXP_D_TXN<br>0  | VSS             | EXP_C0_TX<br>P1 | EXP_C0_RX<br>N0 | VSS             | EXP_B0_RX<br>P0 | EXP_B0_TX<br>N0 | VSS             | EXP_B1_TX<br>N3 | EXP_A0_RX<br>N0 | VSS              | EXP_A0_TX<br>P1 | AJ |
| AK | VSS             | EXP_C0_RX<br>P1 | EXP_C0_TX<br>N1 | P1V5            | EXP_C1_TX<br>N3 | EXP_B0_RX<br>N0 | VSS             | EXP_B0_TX<br>P1 | EXP_B1_TX<br>P3 | P1V5            | EXP_A0_RX<br>P1  | EXP_A0_TX<br>N1 | AK |
| AL | EXP_D_TXP<br>1  | EXP_C0_RX<br>N1 | VSS             | EXP_C1_RX<br>N2 | EXP_C1_TX<br>P3 | VSS             | EXP_B0_RX<br>P1 | EXP_B0_TX<br>N1 | VSS             | EXP_B1_RX<br>N2 | EXP_A0_RX<br>N1  | VSS             | AL |
| AM | EXP_D_TXN<br>1  | P1V5            | EXP_C0_TX<br>P2 | EXP_C1_RX<br>P2 | VSS             | EXP_B0_TX<br>P2 | EXP_B0_RX<br>N1 | P1V5            | EXP_B1_TX<br>N2 | EXP_B1_RX<br>P2 | VSS              | EXP_A0_TX<br>P2 | AM |
| AN | VSS             | EXP_C0_RX<br>P2 | EXP_C0_TX<br>N2 | VSS             | EXP_C1_TX<br>N2 | EXP_B0_TX<br>N2 | VSS             | EXP_B1_RX<br>N1 | EXP_B1_TX<br>P2 | VSS             | EXP_A0_RX<br>P2  | EXP_A0_TX<br>N2 | AN |
| AP | EXP_D_RXP<br>2  | EXP_C0_RX<br>N2 | VSS             | EXP_C1_TX<br>N1 | EXP_C1_TX<br>P2 | P1V5            | EXP_B0_RX<br>P2 | EXP_B1_RX<br>P1 | VSS             | EXP_B1_TX<br>N1 | EXP_A0_RX<br>N2  | P1V5            | AP |
| AR | EXP_D_RXN<br>2  | VSS             | EXP_ICOMP<br>I  | EXP_C1_TX<br>P1 | VSS             | EXP_C1_RX<br>N1 | EXP_B0_RX<br>N2 | VSS             | EXP_RCOMP<br>P  | EXP_B1_TX<br>P1 | VSS              | ITP_TRST#       | AR |
| AT | VSS             | EXP_C0_RX<br>P3 | EXP_C0_RX<br>N3 | P1V5            | Reserved        | EXP_C1_RX<br>P1 | VSS             | EXP_B1_TX<br>P0 | EXP_B1_TX<br>N0 | P1V5            | EXP_A0_RX<br>P3  | EXP_A0_TX<br>N3 | AT |
| AU | EXP_C0_TX<br>P3 | EXP_C0_TX<br>N3 | VSS             | EXP_C1_RX<br>P0 | EXP_C1_RX<br>N0 | VSS             | EXP_B0_RX<br>P3 | EXP_B0_RX<br>N3 | VSS             | EXP_A0_TX<br>P3 | EXP_A0_TX<br>N3  | VSS             | AU |
| AV | EXP_D_RXN<br>3  | P1V5            | EXP_C1_TX<br>P0 | EXP_C1_TX<br>N0 | VSS             | EXP_B0_TX<br>P3 | EXP_B0_TX<br>N3 | P1V5            | EXP_B1_RX<br>P0 | EXP_B1_RX<br>N0 | VSS              | EXP_A1_TX<br>P0 | AV |
|    | 14              | 15              | 16              | 17              | 18              | 19              | 20              | 21              | 22              | 23              | 24               | 25              |    |

Figure 7-4. NB Ballout with Signal Names (Top View - Right Region)

|    | 26           | 27            | 28            | 29           | 30            | 31            | 32            | 33          | 34            | 35            | 36         | 37            | 38            |    |
|----|--------------|---------------|---------------|--------------|---------------|---------------|---------------|-------------|---------------|---------------|------------|---------------|---------------|----|
| A  | H A D32#     | H A D15#      | VSS           | H A D11#     | H A D10#      | VSS           | H A D6#       | H A D0#     | VSS           | H A DEP1#     | VSS        |               |               | A  |
| B  | H A D33#     | VTT           | H A DSTBP0#   | H A DSTBN0#  | VSS           | H A D5#       | H A D3#       | VTT         | H A D1#       | H A DEP0#     | H A D26#   | VSS           |               | B  |
| C  | VSS          | H A D36#      | H A D12#      | VSS          | H A D13#      | H A D2#       | VSS           | H A D7#     | H A DBI0#     | VSS           | H A DBI1#  | H A D23#      | VSS           | C  |
| D  | H A D35#     | H A D34#      | VSS           | H A D14#     | H A D9#       | VTT           | H A D8#       | H A D4#     | VSS           | Reserved      | H A D27#   | H A D22#      | H A D21#      | D  |
| E  | H A D55#     | VSS           | H A D51#      | H A D52#     | VSS           | H A DEP3#     | H A D31#      | VSS         | H A D28#      | H A D25#      | VSS        | H A D20#      | H A D19#      | E  |
| F  | VSS          | H A DSTBP3#   | H A DSTBN3#   | VTT          | H A D50#      | H A DEP2#     | VSS           | H A D24#    | H A D30#      | VTT           | H A D18#   | H A D16#      | VSS           | F  |
| G  | H A D53#     | H A D48#      | VSS           | H A D49#     | Reserved      | VSS           | H A DSTBP1#   | H A DSTBN1# | VSS           | H A D29#      | H A D17#   | VSS           | H A LOCK#     | G  |
| H  | Reserved     | VTT           | Reserved      | Reserved     | VSS           | H A VREF2     | Reserved      | VTT         | H A VREF0     | H A A14#      | VSS        | H A DRDY#     | H A DBSY#     | H  |
| J  | VSS          | H A RSP#      | H A A38#      | VSS          | H A A31#      | H A A33#      | VSS           | H A A10#    | H A A13#      | VSS           | H A TRDY#  | H A ADS#      | VSS           | J  |
| K  | H A MCERR#   | H A RST#      | VSS           | H A A35#     | H A A27#      | VTT           | H A A12#      | H A A15#    | VSS           | H A A16#      | H A BREQ0# | VTT           | H A BNR#      | K  |
| L  | H A AP0#     | VSS           | H A A32#      | H A A26#     | VSS           | H A A34#      | H A ADSTB0#   | VSS         | H A A11#      | H A A36#      | VSS        | H A RS2#      | H A RS0#      | L  |
| M  | VSS          | H A BINIT#    | H A A20#      | VTT          | H A A21#      | H A A30#      | VSS           | H A A8#     | H A A9#       | VTT           | H A HIT#   | H A RS1#      | VSS           | M  |
| N  | H A HITM#    | H A ID3#      | VSS           | H A A22#     | H A A29#      | VSS           | H A REQ0#     | H A A5#     | VSS           | H A A6#       | H A DEFER# | VSS           | H A BPR#      | N  |
| P  | Reserved     | VTT           | H A A25#      | H A A23#     | VSS           | H A A28#      | H A REQ3#     | VTT         | H A A4#       | H A A7#       | VSS        | H A ID0#      | H A ID2#      | P  |
| R  | VSS          | H A IDS#      | H A A17#      | VSS          | H A ADSTB1#   | H A A24#      | VSS           | H A REQ1#   | H A REQ2#     | VSS           | H A ID4#   | H A ID1#      | VSS           | R  |
| T  | H A ID6#     | H A A39#      | VSS           | H A A19#     | H A A18#      | VTT           | H A A37#      | H A A3#     | VSS           | H A REQ4#     | H A ID5#   | VTT           | H A ID7#      | T  |
| U  | IMI A CLK#   | VSS           | IMI A LINK P2 | Reserved     | VSS           | IMI A LINK P1 | IMI A RST#    | VSS         | IMI A TXP7    | IMI A ICOM PI | VSS        | IMI A TXP6    | IMI A ICOM PO | U  |
| V  | VSS          | IMI A LINK P0 | IMI A LINK N2 | P1V5         | IMI A RXP1 7  | IMI A LINK N1 | VSS           | IMI A RXP7  | IMI A TXN7    | P1V5          | IMI A RXP6 | IMI A TXN6    | VSS           | V  |
| W  | Reserved     | IMI A LINK N0 | VSS           | IMI A RXP1 6 | IMI A RXN1 7  | VSS           | IMI A RXP1 5  | IMI A RXN7  | VSS           | IMI A TXP5    | IMI A RXN6 | VSS           | IMI A TXP4    | W  |
| Y  | Reserved     | P1V5          | IMI A RXP1 4  | IMI A RXN1 6 | VSS           | IMI A RXP1 3  | IMI A RXN1 5  | P1V5        | IMI A RXP5    | IMI A TXN5    | VSS        | IMI A RXP4    | IMI A TXN4    | Y  |
| AA | VSS          | IMI A RXP1 2  | IMI A RXN1 4  | VSS          | IMI A RXP1 1  | IMI A RXN1 3  | VSS           | IMI A TXP3  | IMI A RXN5    | VSS           | IMI A TXP2 | IMI A RXN4    | VSS           | AA |
| AB | Reserved     | IMI A RXN1 2  | VSS           | IMI A RXP1 0 | IMI A RXN1 1  | P1V5          | IMI A TXP8    | IMI A TXN3  | VSS           | IMI A RXP3    | IMI A TXN2 | P1V5          | IMI A RXP2    | AB |
| AC | Reserved     | VSS           | IMI A TXP9    | IMI A RXN1 0 | VSS           | IMI A RXP8    | IMI A TXN8    | VSS         | IMI A TXP1    | IMI A RXN3    | VSS        | IMI A TXP0    | IMI A RXN2    | AC |
| AD | VSS          | IMI A RXP9    | IMI A TXN9    | P1V5         | IMI B LINK P2 | IMI A RXN8    | VSS           | IMI A RXP1  | IMI A TXN1    | P1V5          | IMI A RXP0 | IMI A TXN0    | VSS           | AD |
| AE | GP_SMBCLK    | IMI A RXN9    | VSS           | IMI B RST#   | IMI B LINK N2 | VSS           | IMI B LINK P1 | IMI A RXN1  | VSS           | IMI B TXP9    | IMI A RXN0 | VSS           | IMI B TXP8    | AE |
| AF | V3REF0       | ITP_TCK       | ITP_TDI       | IMI B_FRA ME | VSS           | IMI B_LINK P0 | IMI B_LINK N1 | P1V5        | IMI B_RXP9    | IMI B_TXN9    | VSS        | IMI B_RXP8    | IMI B_TXN8    | AF |
| AG | VSS          | EXP_A1_RX N3  | PWRGOOD       | VSS          | IMI B_RXP1 7  | IMI B_LINK N0 | VSS           | IMI B_TXP7  | IMI B_RXN9    | VSS           | IMI B_TXP6 | IMI B_RXN8    | VSS           | AG |
| AH | EXP_A1_TX N3 | EXP_A1_RX P3  | ITP_TMS       | RSTIN#       | IMI B_RXN1 7  | P1V5          | IMI B_RXP1 6  | IMI B_TXN7  | VSS           | IMI B_RXP7    | IMI B_TXN6 | P1V5          | IMI B_RXP6    | AH |
| AJ | EXP_A1_TX P3 | VSS           | Reserved      | Reserved     | VSS           | IMI B_RXP1 5  | IMI B_RXN1 6  | VSS         | IMI B_TXP5    | IMI B_RXN7    | VSS        | IMI B_TXP4    | IMI B_RXN6    | AJ |
| AK | VSS          | EXP_A1_RX N2  | ERR0#         | P1V5         | IMI B_RXP1 4  | IMI B_RXN1 5  | VSS           | IMI B_RXP5  | IMI B_TXN5    | P1V5          | IMI B_RXP4 | IMI B_TXN4    | VSS           | AK |
| AL | EXP_A1_TX N2 | EXP_A1_RX P2  | VSS           | ERR1#        | IMI B_RXN1 4  | VSS           | IMI B_RXP1 3  | IMI B_RXN5  | VSS           | IMI B_TXP3    | IMI B_RXN4 | VSS           | IMI B_TXP2    | AL |
| AM | EXP_A1_TX P2 | P1V5          | EXP0_SPEC 10A | ERR2#        | VSS           | IMI B_RXP1 2  | IMI B_RXN1 3  | P1V5        | IMI B_RXP3    | IMI B_TXN3    | VSS        | IMI B_RXP2    | IMI B_TXN2    | AM |
| AN | VSS          | EXP_A1_RX N1  | EXP_ODTC RES  | VSS          | IMI B_RXP1 1  | IMI B_RXN1 2  | VSS           | IMI B_TXP1  | IMI B_RXN3    | VSS           | IMI B_TXP0 | IMI B_RXN2    | VSS           | AN |
| AP | EXP_A1_TX N1 | EXP_A1_RX P1  | VSS           | EXP_SLWC RES | IMI B_RXN1 1  | P1V5          | IMI B_RXP1 0  | IMI B_TXN1  | VSS           | IMI B_RXP1    | IMI B_TXN0 | P1V5          | IMI B_RXP0    | AP |
| AR | EXP_A1_TX P1 | VSS           | SMBDATA       | EXP_CRES     | VSS           | IMI B_FRA ME  | IMI B_RXN1 0  | VSS         | IMI B_ICOM PI | IMI B_RXN1    | VSS        | IMI B_ICOM PO | IMI B_RXN0    | AR |
| AT | VSS          | EXP0_WIDTH1   | EXP_D15#      | P1V5         | EXP_D13#      | EXP_D12#      | VSS           | EXP_D10#    | EXP_D9#       | VSS           | EXP_DSTBP  | EXP_DSTBN     | VSS           | AT |
| AU | EXP_A1_RX P0 | EXP_A1_RX N0  | ITP_TDO       | EXP_D14#     | EXP_D5#       | P1V5          | EXP_D11#      | EXP_D2#     | P1V5          | EXP_D8#       | EXP_RDY#   | VSS           |               | AU |
| AV | EXP_A1_TX N0 | P1V5          | EXP_D7#       | EXP_D6#      | VSS           | EXP_D4#       | EXP_D3#       | VSS         | EXP_D1#       | EXP_D0#       | VSS        |               |               | AV |
|    | 26           | 27            | 28            | 29           | 30            | 31            | 32            | 33          | 34            | 35            | 36         | 37            | 38            |    |

Table 7-1. NB Pin List (by Ball Number) (Sheet 1 of 13)

| Ball No. | Signal    | Ball No. | Signal      | Ball No. | Signal      |
|----------|-----------|----------|-------------|----------|-------------|
| A3       | VSS       | B6       | VSS         | C7       | H_B_D40#    |
| A4       | VSS       | B7       | H_B_DBI2#   | C8       | VSS         |
| A5       | H_B_D44#  | B8       | H_B_D38#    | C9       | H_B_DSTBP2# |
| A6       | H_B_D43#  | B9       | VTT         | C10      | H_B_DSTBN2# |
| A7       | VSS       | B10      | H_B_D37#    | C11      | VSS         |
| A8       | H_B_D35#  | B11      | H_B_D34#    | C12      | H_B_D14#    |
| A9       | H_B_D39#  | B12      | VSS         | C13      | H_B_D10#    |
| A10      | VSS       | B13      | H_B_DSTBP0# | C14      | VSS         |
| A11      | H_B_D32#  | B14      | H_B_DSTBN0# | C15      | H_B_D5#     |
| A12      | H_B_D15#  | B15      | VTT         | C16      | H_B_D3#     |
| A13      | VSS       | B16      | H_B_D6#     | C17      | VSS         |
| A14      | H_B_D11#  | B17      | H_B_D0#     | C18      | H_B_D1#     |
| A15      | H_B_D9#   | B18      | VSS         | C19      | H_B_DEP0#   |
| A16      | VSS       | B19      | H_B_DEP1#   | C20      | VSS         |
| A17      | H_B_D8#   | B20      | H_A_DEP4#   | C21      | H_A_D44#    |
| A18      | H_B_D4#   | B21      | VTT         | C22      | H_A_D42#    |
| A19      | VSS       | B22      | H_A_D43#    | C23      | VSS         |
| A20      | H_A_D46#  | B23      | H_A_DBI2#   | C24      | H_A_DSTBP2# |
| A21      | H_A_D45#  | B24      | VSS         | C25      | H_A_DSTBN2# |
| A22      | VSS       | B25      | H_A_D37#    | C26      | VSS         |
| A23      | H_A_D41#  | B26      | H_A_D33#    | C27      | H_A_D36#    |
| A24      | H_A_D39#  | B27      | VTT         | C28      | H_A_D12#    |
| A25      | VSS       | B28      | H_A_DSTBP0# | C29      | VSS         |
| A26      | H_A_D32#  | B29      | H_A_DSTBN0# | C30      | H_A_D13#    |
| A27      | H_A_D15#  | B30      | VSS         | C31      | H_A_D2#     |
| A28      | VSS       | B31      | H_A_D5#     | C32      | VSS         |
| A29      | H_A_D11#  | B32      | H_A_D3#     | C33      | H_A_D7#     |
| A30      | H_A_D10#  | B33      | VTT         | C34      | H_A_DBI0#   |
| A31      | VSS       | B34      | H_A_D1#     | C35      | VSS         |
| A32      | H_A_D6#   | B35      | H_A_DEP0#   | C36      | H_A_DBI1#   |
| A33      | H_A_D0#   | B36      | H_A_D26#    | C37      | H_A_D23#    |
| A34      | VSS       | B37      | VSS         | C38      | VSS         |
| A35      | H_A_DEP1# | C1       | VSS         | D1       | H_B_D59#    |
| A36      | VSS       | C2       | H_B_D56#    | D2       | H_B_D57#    |
| B2       | VSS       | C3       | H_B_DBI3#   | D3       | H_B_D61#    |
| B3       | H_B_D62#  | C4       | H_B_DEP5#   | D4       | VSS         |
| B4       | H_B_DEP4# | C5       | VSS         | D5       | H_B_D46#    |
| B5       | H_B_D47#  | C6       | H_B_D42#    | D6       | H_B_D45#    |



**Table 7-1. NB Pin List (by Ball Number) (Sheet 2 of 13)**

| Ball No. | Signal    | Ball No. | Signal      | Ball No. | Signal      |
|----------|-----------|----------|-------------|----------|-------------|
| D7       | VTT       | E7       | H_B_D52#    | F7       | H_B_D48#    |
| D8       | H_B_D41#  | E8       | H_B_D50#    | F8       | VSS         |
| D9       | H_B_D33#  | E9       | VSS         | F9       | H_B_DEP3#   |
| D10      | VSS       | E10      | H_B_DSTBP1# | F10      | H_B_D31#    |
| D11      | H_B_D36#  | E11      | H_B_DSTBN1# | F11      | VTT         |
| D12      | H_B_D12#  | E12      | VSS         | F12      | H_B_D30#    |
| D13      | VTT       | E13      | H_B_D25#    | F13      | H_B_D28#    |
| D14      | H_B_D13#  | E14      | H_B_D26#    | F14      | VSS         |
| D15      | H_B_D2#   | E15      | VSS         | F15      | H_B_D27#    |
| D16      | VSS       | E16      | H_B_D22#    | F16      | H_B_D23#    |
| D17      | H_B_D7#   | E17      | H_B_D21#    | F17      | VTT         |
| D18      | H_B_DBI0# | E18      | VSS         | F18      | H_B_D18#    |
| D19      | VTT       | E19      | H_B_D17#    | F19      | H_B_D16#    |
| D20      | H_A_DEP5# | E20      | H_A_DEP7#   | F20      | VSS         |
| D21      | H_A_D47#  | E21      | VSS         | F21      | H_A_D60#    |
| D22      | VSS       | E22      | H_A_D59#    | F22      | H_A_D58#    |
| D23      | H_A_D40#  | E23      | H_A_D57#    | F23      | VTT         |
| D24      | H_A_D38#  | E24      | VSS         | F24      | H_A_D61#    |
| D25      | VTT       | E25      | H_A_D62#    | F25      | H_A_D54#    |
| D26      | H_A_D35#  | E26      | H_A_D55#    | F26      | VSS         |
| D27      | H_A_D34#  | E27      | VSS         | F27      | H_A_DSTBP3# |
| D28      | VSS       | E28      | H_A_D51#    | F28      | H_A_DSTBN3# |
| D29      | H_A_D14#  | E29      | H_A_D52#    | F29      | VTT         |
| D30      | H_A_D9#   | E30      | VSS         | F30      | H_A_D50#    |
| D31      | VTT       | E31      | H_A_DEP3#   | F31      | H_A_DEP2#   |
| D32      | H_A_D8#   | E32      | H_A_D31#    | F32      | VSS         |
| D33      | H_A_D4#   | E33      | VSS         | F33      | H_A_D24#    |
| D34      | VSS       | E34      | H_A_D28#    | F34      | H_A_D30#    |
| D35      | Reserved  | E35      | H_A_D25#    | F35      | VTT         |
| D36      | H_A_D27#  | E36      | VSS         | F36      | H_A_D18#    |
| D37      | H_A_D22#  | E37      | H_A_D20#    | F37      | H_A_D16#    |
| D38      | H_A_D21#  | E38      | H_A_D19#    | F38      | VSS         |
| E1       | H_B_D63#  | F1       | H_B_DEP6#   | G1       | VSS         |
| E2       | H_B_D58#  | F2       | VSS         | G2       | H_B_ID7#    |
| E3       | VSS       | F3       | H_B_D60#    | G3       | H_B_DEP7#   |
| E4       | H_B_D55#  | F4       | H_B_D54#    | G4       | VSS         |
| E5       | H_B_D53#  | F5       | VTT         | G5       | H_B_DSTBP3# |
| E6       | VSS       | F6       | H_B_D51#    | G6       | H_B_DSTBN3# |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 3 of 13)**

| Ball No. | Signal      | Ball No. | Signal    | Ball No. | Signal    |
|----------|-------------|----------|-----------|----------|-----------|
| G7       | VSS         | H7       | H_B_VREF1 | J7       | H_B_REQ1# |
| G8       | H_B_D49#    | H8       | Reserved  | J8       | VSS       |
| G9       | RESERVED    | H9       | VTT       | J9       | H_B_A18#  |
| G10      | VSS         | H10      | Reserved  | J10      | H_B_A19#  |
| G11      | H_B_DEP2#   | H11      | Reserved  | J11      | VSS       |
| G12      | H_B_D24#    | H12      | VSS       | J12      | H_B_IDS#  |
| G13      | VSS         | H13      | H_B_ID6#  | J13      | H_B_OOD#  |
| G14      | H_B_D29#    | H14      | H_B_DP1#  | J14      | VSS       |
| G15      | H_B_DBI1#   | H15      | VTT       | J15      | H_B_DP2#  |
| G16      | VSS         | H16      | H_B_DP0#  | J16      | H_B_DP3#  |
| G17      | H_B_D20#    | H17      | H_B_VREF2 | J17      | VSS       |
| G18      | H_B_D19#    | H18      | VSS       | J18      | TESTLO4   |
| G19      | VSS         | H19      | Reserved  | J19      | P1V5      |
| G20      | H_A_DEP6#   | H20      | Reserved  | J20      | VSS       |
| G21      | H_A_D63#    | H21      | VTT       | J21      | HCLKINN   |
| G22      | VSS         | H22      | H_A_VREF1 | J22      | HCLKINP   |
| G23      | H_A_D56#    | H23      | H_A_DP0#  | J23      | VSS       |
| G24      | H_A_DBI3#   | H24      | VSS       | J24      | H_A_DP2#  |
| G25      | VSS         | H25      | H_A_DP1#  | J25      | H_A_BPM5# |
| G26      | H_A_D53#    | H26      | Reserved  | J26      | VSS       |
| G27      | H_A_D48#    | H27      | VTT       | J27      | H_A_RSP#  |
| G28      | VSS         | H28      | Reserved  | J28      | H_A_A38#  |
| G29      | H_A_D49#    | H29      | Reserved  | J29      | VSS       |
| G30      | Reserved    | H30      | VSS       | J30      | H_A_A31#  |
| G31      | VSS         | H31      | H_A_VREF2 | J31      | H_A_A33#  |
| G32      | H_A_DSTBP1# | H32      | Reserved  | J32      | VSS       |
| G33      | H_A_DSTBN1# | H33      | VTT       | J33      | H_A_A10#  |
| G34      | VSS         | H34      | H_A_VREF0 | J34      | H_A_A13#  |
| G35      | H_A_D29#    | H35      | H_A_A14#  | J35      | VSS       |
| G36      | H_A_D17#    | H36      | VSS       | J36      | H_A_TRDY# |
| G37      | VSS         | H37      | H_A_DRDY# | J37      | H_A_ADS#  |
| G38      | H_A_LOCK#   | H38      | H_A_DBSY# | J38      | VSS       |
| H1       | H_B_ID4#    | J1       | H_B_ID1#  | K1       | VTT       |
| H2       | H_B_ID5#    | J2       | VSS       | K2       | H_B_BPRI# |
| H3       | VTT         | J3       | H_B_ID0#  | K3       | H_B_ID2#  |
| H4       | H_B_A37#    | J4       | H_B_REQ4# | K4       | VSS       |
| H5       | H_B_VREF0   | J5       | VSS       | K5       | H_B_REQ2# |
| H6       | VSS         | J6       | H_B_A3#   | K6       | H_B_REQ3# |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 4 of 13)**

| Ball No. | Signal      | Ball No. | Signal      | Ball No. | Signal      |
|----------|-------------|----------|-------------|----------|-------------|
| K7       | VTT         | L7       | H_B_REQ0#   | M7       | H_B_A8#     |
| K8       | H_B_A24#    | L8       | H_B_A28#    | M8       | VSS         |
| K9       | H_B_ADSTB1# | L9       | VSS         | M9       | H_B_A29#    |
| K10      | VSS         | L10      | H_B_A25#    | M10      | H_B_A23#    |
| K11      | H_B_A39#    | L11      | H_B_A17#    | M11      | VTT         |
| K12      | Reserved    | L12      | VSS         | M12      | H_B_BINIT#  |
| K13      | VTT         | L13      | H_B_HITM#   | M13      | H_B_AP0#    |
| K14      | EXP1_WIDTH0 | L14      | H_B_BREQ1#  | M14      | VSS         |
| K15      | H_B_ID3#    | L15      | VSS         | M15      | H_B_BPM4#   |
| K16      | VSS         | L16      | H_SLWCRES   | M16      | H_ODTCRES   |
| K17      | H_VSSA      | L17      | H_CRES      | M17      | VTT         |
| K18      | H_VCCA      | L18      | VSS         | M18      | TESTLO1     |
| K19      | VTT         | L19      | Reserved    | M19      | Reserved    |
| K20      | VSSA        | L20      | TESTLO3     | M20      | VSS         |
| K21      | VCCA        | L21      | VSS         | M21      | H_A_PRSNT#  |
| K22      | VSS         | L22      | TESTHI1     | M22      | H_B_PRSNT#  |
| K23      | H_A_DP3#    | L23      | TESTLO2     | M23      | VTT         |
| K24      | H_A_BPM4#   | L24      | VSS         | M24      | TESTLO5     |
| K25      | VTT         | L25      | H_A_AP1#    | M25      | H_A_BREQ1#  |
| K26      | H_A_MCERR#  | L26      | H_A_AP0#    | M26      | VSS         |
| K27      | H_A_RST#    | L27      | VSS         | M27      | H_A_BINIT#  |
| K28      | VSS         | L28      | H_A_A32#    | M28      | H_A_A20#    |
| K29      | H_A_A35#    | L29      | H_A_A26#    | M29      | VTT         |
| K30      | H_A_A27#    | L30      | VSS         | M30      | H_A_A21#    |
| K31      | VTT         | L31      | H_A_A34#    | M31      | H_A_A30#    |
| K32      | H_A_A12#    | L32      | H_A_ADSTB0# | M32      | VSS         |
| K33      | H_A_A15#    | L33      | VSS         | M33      | H_A_A8#     |
| K34      | VSS         | L34      | H_A_A11#    | M34      | H_A_A9#     |
| K35      | H_A_A16#    | L35      | H_A_A36#    | M35      | VTT         |
| K36      | H_A_BREQ0#  | L36      | VSS         | M36      | H_A_HIT#    |
| K37      | VTT         | L37      | H_A_RS2#    | M37      | H_A_RS1#    |
| K38      | H_A_BNR#    | L38      | H_A_RS0#    | M38      | VSS         |
| L1       | H_B_HIT#    | M1       | H_B_RS1#    | N1       | VSS         |
| L2       | H_B_DEFER#  | M2       | VSS         | N2       | H_B_BNR#    |
| L3       | VSS         | M3       | H_B_RS2#    | N3       | H_B_RS0#    |
| L4       | H_B_A7#     | M4       | H_B_A6#     | N4       | VSS         |
| L5       | H_B_A4#     | M5       | VTT         | N5       | H_B_A9#     |
| L6       | VSS         | M6       | H_B_A5#     | N6       | H_B_ADSTB0# |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 5 of 13)**

| Ball No. | Signal     | Ball No. | Signal     | Ball No. | Signal      |
|----------|------------|----------|------------|----------|-------------|
| N7       | VSS        | P7       | H_B_A15#   | R7       | H_B_A13#    |
| N8       | H_B_A21#   | P8       | H_B_A34#   | R8       | VSS         |
| N9       | H_B_A30#   | P9       | VTT        | R9       | H_B_A27#    |
| N10      | VSS        | P10      | H_B_A20#   | R10      | H_B_A35#    |
| N11      | H_B_A22#   | P11      | H_B_A26#   | R11      | VSS         |
| N12      | H_B_AP1#   | P12      | VSS        | R12      | H_B_RSP#    |
| N13      | VSS        | P13      | H_B_MCERR# | R13      | Reserved    |
| N14      | H_B_RST#   | P14      | VSS        | R14      | P1V5        |
| N15      | H_B_BPM5#  | P15      | P1V5       | R15      | VSS         |
| N16      | VSS        | P16      | VSS        | R16      | P1V5        |
| N17      | VSS        | P17      | P1V5       | R17      | VSS         |
| N18      | P1V5       | P18      | VSS        | R18      | P1V5        |
| N19      | VSS        | P19      | P1V5       | R19      | VSS         |
| N20      | P1V5       | P20      | VSS        | R20      | P1V5        |
| N21      | VSS        | P21      | P1V5       | R21      | VSS         |
| N22      | P1V5       | P22      | VSS        | R22      | P1V5        |
| N23      | VSS        | P23      | P1V5       | R23      | VSS         |
| N24      | H_A_OOD#   | P24      | VSS        | R24      | P1V5        |
| N25      | VSS        | P25      | P1V5       | R25      | VSS         |
| N26      | H_A_HITM#  | P26      | Reserved   | R26      | VSS         |
| N27      | H_A_ID3#   | P27      | VTT        | R27      | H_A_IDS#    |
| N28      | VSS        | P28      | H_A_A25#   | R28      | H_A_A17#    |
| N29      | H_A_A22#   | P29      | H_A_A23#   | R29      | VSS         |
| N30      | H_A_A29#   | P30      | VSS        | R30      | H_A_ADSTB1# |
| N31      | VSS        | P31      | H_A_A28#   | R31      | H_A_A24#    |
| N32      | H_A_REQ0#  | P32      | H_A_REQ3#  | R32      | VSS         |
| N33      | H_A_A5#    | P33      | VTT        | R33      | H_A_REQ1#   |
| N34      | VSS        | P34      | H_A_A4#    | R34      | H_A_REQ2#   |
| N35      | H_A_A6#    | P35      | H_A_A7#    | R35      | VSS         |
| N36      | H_A_DEFER# | P36      | VSS        | R36      | H_A_ID4#    |
| N37      | VSS        | P37      | H_A_ID0#   | R37      | H_A_ID1#    |
| N38      | H_A_BPRI#  | P38      | H_A_ID2#   | R38      | VSS         |
| P1       | H_B_TRDY#  | R1       | H_B_ADS#   | T1       | VTT         |
| P2       | H_B_BREQ0# | R2       | VSS        | T2       | H_B_LOCK#   |
| P3       | VTT        | R3       | H_B_DRDY#  | T3       | H_B_DBSY#   |
| P4       | H_B_A36#   | R4       | H_B_A16#   | T4       | VSS         |
| P5       | H_B_A11#   | R5       | VSS        | T5       | H_B_A10#    |
| P6       | VSS        | R6       | H_B_A12#   | T6       | H_B_A14#    |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 6 of 13)**

| Ball No. | Signal       | Ball No. | Signal       | Ball No. | Signal       |
|----------|--------------|----------|--------------|----------|--------------|
| T7       | VTT          | U7       | IMI_C_RXN8   | V7       | IMI_C_RXP8   |
| T8       | H_B_A33#     | U8       | Reserved     | V8       | VSS          |
| T9       | H_B_A31#     | U9       | VSS          | V9       | IMI_C_TXN8   |
| T10      | VSS          | U10      | IMI_C_RXN9   | V10      | IMI_C_RXP9   |
| T11      | H_B_A32#     | U11      | IMI_C_FRAME  | V11      | P1V5         |
| T12      | H_B_A38#     | U12      | VSS          | V12      | IMI_C_TXN9   |
| T13      | VTT          | U13      | IMI_C_VCCBG  | V13      | IMI_C_VSSBG  |
| T14      | IMI_C_CLKP   | U14      | IMI_C_CLKN   | V14      | VSS          |
| T15      | P1V5         | U15      | VSS          | V15      | P1V5         |
| T16      | VSS          | U16      | P1V5         | V16      | VSS          |
| T17      | P1V5         | U17      | VSS          | V17      | P1V5         |
| T18      | VSS          | U18      | P1V5         | V18      | VSS          |
| T19      | P1V5         | U19      | VSS          | V19      | P1V5         |
| T20      | VSS          | U20      | P1V5         | V20      | VSS          |
| T21      | P1V5         | U21      | VSS          | V21      | P1V5         |
| T22      | VSS          | U22      | P1V5         | V22      | VSS          |
| T23      | P1V5         | U23      | VSS          | V23      | P1V5         |
| T24      | VSS          | U24      | P1V5         | V24      | VSS          |
| T25      | P1V5         | U25      | IMI_A_CLKP   | V25      | IMI_A_VCCA   |
| T26      | H_A_ID6#     | U26      | IMI_A_CLKN   | V26      | VSS          |
| T27      | H_A_A39#     | U27      | VSS          | V27      | IMI_A_LINKP0 |
| T28      | VSS          | U28      | IMI_A_LINKP2 | V28      | IMI_A_LINKN2 |
| T29      | H_A_A19#     | U29      | Reserved     | V29      | P1V5         |
| T30      | H_A_A18#     | U30      | VSS          | V30      | IMI_A_RXP17  |
| T31      | VTT          | U31      | IMI_A_LINKP1 | V31      | IMI_A_LINKN1 |
| T32      | H_A_A37#     | U32      | IMI_A_RST#   | V32      | VSS          |
| T33      | H_A_A3#      | U33      | VSS          | V33      | IMI_A_RXP7   |
| T34      | VSS          | U34      | IMI_A_TXP7   | V34      | IMI_A_TXN7   |
| T35      | H_A_REQ4#    | U35      | IMI_A_ICOMPI | V35      | P1V5         |
| T36      | H_A_ID5#     | U36      | VSS          | V36      | IMI_A_RXP6   |
| T37      | VTT          | U37      | IMI_A_TXP6   | V37      | IMI_A_TXN6   |
| T38      | H_A_ID7#     | U38      | IMI_A_ICOMPO | V38      | VSS          |
| U1       | IMI_C_RXN0   | V1       | IMI_C_RXP0   | W1       | VSS          |
| U2       | IMI_C_ICOMPI | V2       | VSS          | W2       | IMI_C_RXN2   |
| U3       | VSS          | V3       | IMI_C_TXN0   | W3       | IMI_C_TXP0   |
| U4       | IMI_C_RXN1   | V4       | IMI_C_RXP1   | W4       | VSS          |
| U5       | IMI_C_ICOMPO | V5       | P1V5         | W5       | IMI_C_RXN3   |
| U6       | VSS          | V6       | IMI_C_TXN1   | W6       | IMI_C_TXP1   |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 7 of 13)**

| Ball No. | Signal       | Ball No. | Signal      | Ball No. | Signal      |
|----------|--------------|----------|-------------|----------|-------------|
| W7       | VSS          | Y7       | IMI_C_RXN12 | AA7      | IMI_C_RXP12 |
| W8       | IMI_C_RXN10  | Y8       | IMI_C_RXP10 | AA8      | VSS         |
| W9       | IMI_C_TXP8   | Y9       | P1V5        | AA9      | IMI_C_RXN14 |
| W10      | VSS          | Y10      | IMI_C_RXN13 | AA10     | IMI_C_RXP13 |
| W11      | IMI_C_RXN11  | Y11      | IMI_C_RXP11 | AA11     | VSS         |
| W12      | IMI_C_TXP9   | Y12      | VSS         | AA12     | IMI_C_RXN15 |
| W13      | VSS          | Y13      | Reserved    | AA13     | Reserved    |
| W14      | IMI_C_VSSA   | Y14      | IMI_C_VCCA  | AA14     | IMI_D_CLKP  |
| W15      | VSS          | Y15      | P1V5        | AA15     | VSS         |
| W16      | P1V5         | Y16      | VSS         | AA16     | P1V5        |
| W17      | VSS          | Y17      | P1V5        | AA17     | VSS         |
| W18      | P1V5         | Y18      | VSS         | AA18     | P1V5        |
| W19      | VSS          | Y19      | P1V5        | AA19     | VSS         |
| W20      | P1V5         | Y20      | VSS         | AA20     | P1V5        |
| W21      | VSS          | Y21      | P1V5        | AA21     | VSS         |
| W22      | P1V5         | Y22      | VSS         | AA22     | P1V5        |
| W23      | VSS          | Y23      | P1V5        | AA23     | VSS         |
| W24      | P1V5         | Y24      | VSS         | AA24     | P1V5        |
| W25      | IMI_A_VSSA   | Y25      | IMI_A_VSSBG | AA25     | IMI_A_VCCBG |
| W26      | Reserved     | Y26      | Reserved    | AA26     | VSS         |
| W27      | IMI_A_LINKN0 | Y27      | P1V5        | AA27     | IMI_A_RXP12 |
| W28      | VSS          | Y28      | IMI_A_RXP14 | AA28     | IMI_A_RXN14 |
| W29      | IMI_A_RXP16  | Y29      | IMI_A_RXN16 | AA29     | VSS         |
| W30      | IMI_A_RXN17  | Y30      | VSS         | AA30     | IMI_A_RXP11 |
| W31      | VSS          | Y31      | IMI_A_RXP13 | AA31     | IMI_A_RXN13 |
| W32      | IMI_A_RXP15  | Y32      | IMI_A_RXN15 | AA32     | VSS         |
| W33      | IMI_A_RXN7   | Y33      | P1V5        | AA33     | IMI_A_TXP3  |
| W34      | VSS          | Y34      | IMI_A_RXP5  | AA34     | IMI_A_RXN5  |
| W35      | IMI_A_TXP5   | Y35      | IMI_A_TXN5  | AA35     | VSS         |
| W36      | IMI_A_RXN6   | Y36      | VSS         | AA36     | IMI_A_TXP2  |
| W37      | VSS          | Y37      | IMI_A_RXP4  | AA37     | IMI_A_RXN4  |
| W38      | IMI_A_TXP4   | Y38      | IMI_A_TXN4  | AA38     | VSS         |
| Y1       | IMI_C_TXN2   | AA1      | IMI_C_TXP2  | AB1      | P1V5        |
| Y2       | IMI_C_RXP2   | AA2      | VSS         | AB2      | IMI_C_TXN4  |
| Y3       | P1V5         | AA3      | IMI_C_RXN4  | AB3      | IMI_C_RXP4  |
| Y4       | IMI_C_TXN3   | AA4      | IMI_C_TXP3  | AB4      | VSS         |
| Y5       | IMI_C_RXP3   | AA5      | VSS         | AB5      | IMI_C_TXN5  |
| Y6       | VSS          | AA6      | IMI_C_RXN5  | AB6      | IMI_C_RXP5  |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 8 of 13)**

| Ball No. | Signal      | Ball No. | Signal       | Ball No. | Signal       |
|----------|-------------|----------|--------------|----------|--------------|
| AB7      | P1V5        | AC7      | IMI_C_LINKN0 | AD7      | IMI_C_LINKP0 |
| AB8      | IMI_C_RXN16 | AC8      | IMI_C_RXP16  | AD8      | VSS          |
| AB9      | IMI_C_RXP14 | AC9      | VSS          | AD9      | IMI_D_RXN10  |
| AB10     | VSS         | AC10     | IMI_C_LINKN1 | AD10     | IMI_C_LINKP1 |
| AB11     | IMI_C_RXN17 | AC11     | IMI_C_RXP17  | AD11     | P1V5         |
| AB12     | IMI_C_RXP15 | AC12     | VSS          | AD12     | IMI_C_LINKN2 |
| AB13     | P1V5        | AC13     | IMI_D_VCCBG  | AD13     | IMI_D_VSSBG  |
| AB14     | IMI_D_CLKN  | AC14     | IMI_D_VSSA   | AD14     | IMI_D_VCCA   |
| AB15     | P1V5        | AC15     | VSS          | AD15     | P1V5         |
| AB16     | VSS         | AC16     | P1V5         | AD16     | VSS          |
| AB17     | P1V5        | AC17     | VSS          | AD17     | P1V5         |
| AB18     | VSS         | AC18     | P1V5         | AD18     | VSS          |
| AB19     | P1V5        | AC19     | VSS          | AD19     | P1V5         |
| AB20     | VSS         | AC20     | P1V5         | AD20     | VSS          |
| AB21     | P1V5        | AC21     | VSS          | AD21     | P1V5         |
| AB22     | VSS         | AC22     | P1V5         | AD22     | VSS          |
| AB23     | P1V5        | AC23     | VSS          | AD23     | P1V5         |
| AB24     | VSS         | AC24     | P1V5         | AD24     | VSS          |
| AB25     | IMI_B_VCCA  | AC25     | IMI_B_VSSA   | AD25     | IMI_B_CLKN   |
| AB26     | Reserved    | AC26     | Reserved     | AD26     | VSS          |
| AB27     | IMI_A_RXN12 | AC27     | VSS          | AD27     | IMI_A_RXP9   |
| AB28     | VSS         | AC28     | IMI_A_TXP9   | AD28     | IMI_A_TXN9   |
| AB29     | IMI_A_RXP10 | AC29     | IMI_A_RXN10  | AD29     | P1V5         |
| AB30     | IMI_A_RXN11 | AC30     | VSS          | AD30     | IMI_B_LINKP2 |
| AB31     | P1V5        | AC31     | IMI_A_RXP8   | AD31     | IMI_A_RXN8   |
| AB32     | IMI_A_TXP8  | AC32     | IMI_A_TXN8   | AD32     | VSS          |
| AB33     | IMI_A_TXN3  | AC33     | VSS          | AD33     | IMI_A_RXP1   |
| AB34     | VSS         | AC34     | IMI_A_TXP1   | AD34     | IMI_A_TXN1   |
| AB35     | IMI_A_RXP3  | AC35     | IMI_A_RXN3   | AD35     | P1V5         |
| AB36     | IMI_A_TXN2  | AC36     | VSS          | AD36     | IMI_A_RXP0   |
| AB37     | P1V5        | AC37     | IMI_A_TXP0   | AD37     | IMI_A_TXN0   |
| AB38     | IMI_A_RXP2  | AC38     | IMI_A_RXN2   | AD38     | VSS          |
| AC1      | IMI_C_RXN6  | AD1      | IMI_C_RXP6   | AE1      | VSS          |
| AC2      | IMI_C_TXP4  | AD2      | VSS          | AE2      | IMI_D_RXN0   |
| AC3      | VSS         | AD3      | IMI_C_TXN6   | AE3      | IMI_C_TXP6   |
| AC4      | IMI_C_RXN7  | AD4      | IMI_C_RXP7   | AE4      | VSS          |
| AC5      | IMI_C_TXP5  | AD5      | P1V5         | AE5      | IMI_D_RXN1   |
| AC6      | VSS         | AD6      | IMI_C_TXN7   | AE6      | IMI_C_TXP7   |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 9 of 13)**

| Ball No. | Signal       | Ball No. | Signal       | Ball No. | Signal                  |
|----------|--------------|----------|--------------|----------|-------------------------|
| AE7      | VSS          | AF7      | IMI_D_RXN12  | AG7      | IMI_D_RXP12             |
| AE8      | IMI_D_RXN11  | AF8      | IMI_D_RXP11  | AG8      | VSS                     |
| AE9      | IMI_D_RXP10  | AF9      | P1V5         | AG9      | IMI_D_RXN13             |
| AE10     | VSS          | AF10     | ICHRST#      | AG10     | PME_OUT/<br>EXP1_WIDTH2 |
| AE11     | IMI_C_RST#   | AF11     | IMI_D_FRAME  | AG11     | VSS                     |
| AE12     | IMI_C_LINKP2 | AF12     | VSS          | AG12     | Reserved                |
| AE13     | VSS          | AF13     | Reserved     | AG13     | Reserved                |
| AE14     | Reserved     | AF14     | Reserved     | AG14     | VSS                     |
| AE15     | VSS          | AF15     | Reserved     | AG15     | EXP_C0_TXP0             |
| AE16     | P1V5         | AF16     | CLK66        | AG16     | Reserved                |
| AE17     | VSS          | AF17     | HI_VCCA      | AG17     | VSS                     |
| AE18     | P1V5         | AF18     | HI_VSSA      | AG18     | EXP_C1_RXN3             |
| AE19     | VSS          | AF19     | EXP_VSSBG    | AG19     | EXP_VCCBG               |
| AE20     | P1V5         | AF20     | EXP_CLKP     | AG20     | VSS                     |
| AE21     | VSS          | AF21     | EXP_CLKN     | AG21     | EXP_B1_RXN3             |
| AE22     | P1V5         | AF22     | EXP_VCCA     | AG22     | EXP_VSSA                |
| AE23     | VSS          | AF23     | IMI_B_VSSBG  | AG23     | VSS                     |
| AE24     | EXP0_WIDTH0  | AF24     | IMI_B_VCCBG  | AG24     | EXP_A0_TXP0             |
| AE25     | IMI_B_CLKP   | AF25     | SMBCLK       | AG25     | GP_SMBDATA              |
| AE26     | GP_SMBCLK    | AF26     | V3REF0       | AG26     | VSS                     |
| AE27     | IMI_A_RXN9   | AF27     | ITP_TCK      | AG27     | EXP_A1_RXN3             |
| AE28     | VSS          | AF28     | ITP_TDI      | AG28     | PWRGOOD                 |
| AE29     | IMI_B_RST#   | AF29     | IMI_A_FRAME  | AG29     | VSS                     |
| AE30     | IMI_B_LINKN2 | AF30     | VSS          | AG30     | IMI_B_RXP17             |
| AE31     | VSS          | AF31     | IMI_B_LINKP0 | AG31     | IMI_B_LINKN0            |
| AE32     | IMI_B_LINKP1 | AF32     | IMI_B_LINKN1 | AG32     | VSS                     |
| AE33     | IMI_A_RXN1   | AF33     | P1V5         | AG33     | IMI_B_TXP7              |
| AE34     | VSS          | AF34     | IMI_B_RXP9   | AG34     | IMI_B_RXN9              |
| AE35     | IMI_B_TXP9   | AF35     | IMI_B_TXN9   | AG35     | VSS                     |
| AE36     | IMI_A_RXN0   | AF36     | VSS          | AG36     | IMI_B_TXP6              |
| AE37     | VSS          | AF37     | IMI_B_RXP8   | AG37     | IMI_B_RXN8              |
| AE38     | IMI_B_TXP8   | AF38     | IMI_B_TXN8   | AG38     | VSS                     |
| AF1      | IMI_D_TXN0   | AG1      | IMI_D_TXP0   | AH1      | P1V5                    |
| AF2      | IMI_D_RXP0   | AG2      | VSS          | AH2      | IMI_D_TXN2              |
| AF3      | P1V5         | AG3      | IMI_D_RXN2   | AH3      | IMI_D_RXP2              |
| AF4      | IMI_D_TXN1   | AG4      | IMI_D_TXP1   | AH4      | VSS                     |
| AF5      | IMI_D_RXP1   | AG5      | VSS          | AH5      | IMI_D_TXN3              |



**Table 7-1. NB Pin List (by Ball Number) (Sheet 10 of 13)**

| Ball No. | Signal                | Ball No. | Signal      | Ball No. | Signal        |
|----------|-----------------------|----------|-------------|----------|---------------|
| AH6      | VSS                   | AG6      | IMI_D_RXN3  | AH6      | IMI_D_RXP3    |
| AH7      | P1V5                  | AJ7      | IMI_D_RXN15 | AK7      | IMI_D_RXP15   |
| AH8      | IMI_D_RXN14           | AJ8      | IMI_D_RXP14 | AK8      | VSS           |
| AH9      | IMI_D_RXP13           | AJ9      | VSS         | AK9      | IMI_D_RXN16   |
| AH10     | VSS                   | AJ10     | V3REF1      | AK10     | Reserved      |
| AH11     | EXP_HPINT/EXP1_WIDTH1 | AJ11     | Reserved    | AK11     | P1V5          |
| AH12     | IMI_HPINT             | AJ12     | VSS         | AK12     | EXP1_SPE C10A |
| AH13     | P1V5                  | AJ13     | EXP_D_RXP0  | AK13     | EXP_D_RXN0    |
| AH14     | EXP_D_TXP0            | AJ14     | EXP_D_TXN0  | AK14     | VSS           |
| AH15     | EXP_C0_TXN0           | AJ15     | VSS         | AK15     | EXP_C0_RXP1   |
| AH16     | VSS                   | AJ16     | EXP_C0_TXP1 | AK16     | EXP_C0_TXN1   |
| AH17     | EXP_C0_RXP0           | AJ17     | EXP_C0_RXN0 | AK17     | P1V5          |
| AH18     | EXP_C1_RXP3           | AJ18     | VSS         | AK18     | EXP_C1_TXN3   |
| AH19     | P1V5                  | AJ19     | EXP_B0_RXP0 | AK19     | EXP_B0_RXN0   |
| AH20     | EXP_B0_TXP0           | AJ20     | EXP_B0_TXN0 | AK20     | VSS           |
| AH21     | EXP_B1_RXP3           | AJ21     | VSS         | AK21     | EXP_B0_TXP1   |
| AH22     | VSS                   | AJ22     | EXP_B1_TXN3 | AK22     | EXP_B1_TXP3   |
| AH23     | EXP_A0_RXP0           | AJ23     | EXP_A0_RXN0 | AK23     | P1V5          |
| AH24     | EXP_A0_TXN0           | AJ24     | VSS         | AK24     | EXP_A0_RXP1   |
| AH25     | P1V5                  | AJ25     | EXP_A0_TXP1 | AK25     | EXP_A0_TXN1   |
| AH26     | EXP_A1_TXN3           | AJ26     | EXP_A1_TXP3 | AK26     | VSS           |
| AH27     | EXP_A1_RXP3           | AJ27     | VSS         | AK27     | EXP_A1_RXN2   |
| AH28     | ITP_TMS               | AJ28     | Reserved    | AK28     | ERR0#         |
| AH29     | RSTIN#                | AJ29     | Reserved    | AK29     | P1V5          |
| AH30     | IMI_B_RXN17           | AJ30     | VSS         | AK30     | IMI_B_RXP14   |
| AH31     | P1V5                  | AJ31     | IMI_B_RXP15 | AK31     | IMI_B_RXN15   |
| AH32     | IMI_B_RXP16           | AJ32     | IMI_B_RXN16 | AK32     | VSS           |
| AH33     | IMI_B_TXN7            | AJ33     | VSS         | AK33     | IMI_B_RXP5    |
| AH34     | VSS                   | AJ34     | IMI_B_TXP5  | AK34     | IMI_B_TXN5    |
| AH35     | IMI_B_RXP7            | AJ35     | IMI_B_RXN7  | AK35     | P1V5          |
| AH36     | IMI_B_TXN6            | AJ36     | VSS         | AK36     | IMI_B_RXP4    |
| AH37     | P1V5                  | AJ37     | IMI_B_TXP4  | AK37     | IMI_B_TXN4    |
| AH38     | IMI_B_RXP6            | AJ38     | IMI_B_RXN6  | AK38     | VSS           |
| AJ1      | IMI_D_RXN4            | AK1      | IMI_D_RXP4  | AL1      | VSS           |
| AJ2      | IMI_D_TXP2            | AK2      | VSS         | AL2      | IMI_D_RXN6    |
| AJ3      | VSS                   | AK3      | IMI_D_TXN4  | AL3      | IMI_D_TXP4    |
| AJ4      | IMI_D_RXN5            | AK4      | IMI_D_RXP5  | AL4      | VSS           |
| AJ5      | IMI_D_TXP3            | AK5      | P1V5        | AL5      | IMI_D_RXN7    |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 11 of 13)**

| Ball No. | Signal      | Ball No. | Signal       | Ball No. | Signal       |
|----------|-------------|----------|--------------|----------|--------------|
| AJ6      | VSS         | AK6      | IMI_D_TXN5   | AL6      | IMI_D_TXP5   |
| AL7      | VSS         | AM7      | IMI_D_LINKN0 | AN7      | IMI_D_LINKP0 |
| AL8      | IMI_D_RXN17 | AM8      | IMI_D_RXP17  | AN8      | VSS          |
| AL9      | IMI_D_RXP16 | AM9      | P1V5         | AN9      | IMI_D_LINKN1 |
| AL10     | VSS         | AM10     | Reserved     | AN10     | Reserved     |
| AL11     | Reserved    | AM11     | Reserved     | AN11     | VSS          |
| AL12     | Reserved    | AM12     | VSS          | AN12     | EXP_D_TXP2   |
| AL13     | VSS         | AM13     | EXP_D_RXP1   | AN13     | EXP_D_RXN1   |
| AL14     | EXP_D_TXP1  | AM14     | EXP_D_TXN1   | AN14     | VSS          |
| AL15     | EXP_C0_RXN1 | AM15     | P1V5         | AN15     | EXP_C0_RXP2  |
| AL16     | VSS         | AM16     | EXP_C0_TXP2  | AN16     | EXP_C0_TXN2  |
| AL17     | EXP_C1_RXN2 | AM17     | EXP_C1_RXP2  | AN17     | VSS          |
| AL18     | EXP_C1_TXP3 | AM18     | VSS          | AN18     | EXP_C1_TXN2  |
| AL19     | VSS         | AM19     | EXP_B0_TXP2  | AN19     | EXP_B0_TXN2  |
| AL20     | EXP_B0_RXP1 | AM20     | EXP_B0_RXN1  | AN20     | VSS          |
| AL21     | EXP_B0_TXN1 | AM21     | P1V5         | AN21     | EXP_B1_RXN1  |
| AL22     | VSS         | AM22     | EXP_B1_TXN2  | AN22     | EXP_B1_TXP2  |
| AL23     | EXP_B1_RXN2 | AM23     | EXP_B1_RXP2  | AN23     | VSS          |
| AL24     | EXP_A0_RXN1 | AM24     | VSS          | AN24     | EXP_A0_RXP2  |
| AL25     | VSS         | AM25     | EXP_A0_TXP2  | AN25     | EXP_A0_TXN2  |
| AL26     | EXP_A1_TXN2 | AM26     | EXP_A1_TXP2  | AN26     | VSS          |
| AL27     | EXP_A1_RXP2 | AM27     | P1V5         | AN27     | EXP_A1_RXN1  |
| AL28     | VSS         | AM28     | EXP0_SPEC10A | AN28     | XDP_ODTCRES  |
| AL29     | ERR1#       | AM29     | ERR2#        | AN29     | VSS          |
| AL30     | IMI_B_RXN14 | AM30     | VSS          | AN30     | IMI_B_RXP11  |
| AL31     | VSS         | AM31     | IMI_B_RXP12  | AN31     | IMI_B_RXN12  |
| AL32     | IMI_B_RXP13 | AM32     | IMI_B_RXN13  | AN32     | VSS          |
| AL33     | IMI_B_RXN5  | AM33     | P1V5         | AN33     | IMI_B_TXP1   |
| AL34     | VSS         | AM34     | IMI_B_RXP3   | AN34     | IMI_B_RXN3   |
| AL35     | IMI_B_TXP3  | AM35     | IMI_B_TXN3   | AN35     | VSS          |
| AL36     | IMI_B_RXN4  | AM36     | VSS          | AN36     | IMI_B_TXP0   |
| AL37     | VSS         | AM37     | IMI_B_RXP2   | AN37     | IMI_B_RXN2   |
| AL38     | IMI_B_TXP2  | AM38     | IMI_B_TXN2   | AN38     | VSS          |
| AM1      | IMI_D_TXN6  | AN1      | IMI_D_TXP6   | AP1      | P1V5         |
| AM2      | IMI_D_RXP6  | AN2      | VSS          | AP2      | IMI_D_TXN8   |
| AM3      | P1V5        | AN3      | IMI_D_RXN8   | AP3      | IMI_D_RXP8   |
| AM4      | IMI_D_TXN7  | AN4      | IMI_D_TXP7   | AP4      | VSS          |
| AM5      | IMI_D_RXP7  | AN5      | VSS          | AP5      | IMI_D_TXN9   |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 12 of 13)**

| Ball No. | Signal       | Ball No. | Signal       | Ball No. | Signal       |
|----------|--------------|----------|--------------|----------|--------------|
| AM6      | VSS          | AN6      | IMI_D_RXN9   | AP6      | IMI_D_RXP9   |
| AP7      | P1V5         | AR7      | IMI_D_RST#   | AT7      | HI5          |
| AP8      | IMI_D_LINKN2 | AR8      | IMI_D_LINKP2 | AT8      | VSS          |
| AP9      | IMI_D_LINKP1 | AR9      | VSS          | AT9      | HIRCOMP      |
| AP10     | VSS          | AR10     | Reserved     | AT10     | Reserved     |
| AP11     | Reserved     | AR11     | Reserved     | AT11     | P1V5         |
| AP12     | EXP_D_TXN2   | AR12     | VSS          | AT12     | EXP_D_TXP3   |
| AP13     | P1V5         | AR13     | Reserved     | AT13     | EXP_D_TXN3   |
| AP14     | EXP_D_RXP2   | AR14     | EXP_D_RXN2   | AT14     | VSS          |
| AP15     | EXP_C0_RXN2  | AR15     | VSS          | AT15     | EXP_C0_RXP3  |
| AP16     | VSS          | AR16     | EXP_ICOMPI   | AT16     | EXP_C0_RXN3  |
| AP17     | EXP_C1_TXN1  | AR17     | EXP_C1_TXP1  | AT17     | P1V5         |
| AP18     | EXP_C1_TXP2  | AR18     | VSS          | AT18     | Reserved     |
| AP19     | P1V5         | AR19     | EXP_C1_RXN1  | AT19     | EXP_C1_RXP1  |
| AP20     | EXP_B0_RXP2  | AR20     | EXP_B0_RXN2  | AT20     | VSS          |
| AP21     | EXP_B1_RXP1  | AR21     | VSS          | AT21     | EXP_B1_TXP0  |
| AP22     | VSS          | AR22     | EXP_RCOMP    | AT22     | EXP_B1_TXN0  |
| AP23     | EXP_B1_TXN1  | AR23     | EXP_B1_TXP1  | AT23     | P1V5         |
| AP24     | EXP_A0_RXN2  | AR24     | VSS          | AT24     | EXP_A0_RXP3  |
| AP25     | P1V5         | AR25     | ITP_TRST#    | AT25     | EXP_A0_RXN3  |
| AP26     | EXP_A1_TXN1  | AR26     | EXP_A1_TXP1  | AT26     | VSS          |
| AP27     | EXP_A1_RXP1  | AR27     | VSS          | AT27     | EXP0_WIDTHH1 |
| AP28     | VSS          | AR28     | SMBDATA      | AT28     | XDP_D15#     |
| AP29     | XDP_SLWCRES  | AR29     | XDP_CRES     | AT29     | P1V5         |
| AP30     | IMI_B_RXN11  | AR30     | VSS          | AT30     | XDP_D13#     |
| AP31     | P1V5         | AR31     | IMI_B_FRAME  | AT31     | XDP_D12#     |
| AP32     | IMI_B_RXP10  | AR32     | IMI_B_RXN10  | AT32     | VSS          |
| AP33     | IMI_B_TXN1   | AR33     | VSS          | AT33     | XDP_D10#     |
| AP34     | VSS          | AR34     | IMI_B_ICOMPI | AT34     | XDP_D9#      |
| AP35     | IMI_B_RXP1   | AR35     | IMI_B_RXN1   | AT35     | VSS          |
| AP36     | IMI_B_TXN0   | AR36     | VSS          | AT36     | XDP_DSTBP    |
| AP37     | P1V5         | AR37     | IMI_B_ICOMPO | AT37     | XDP_DSTBN    |
| AP38     | IMI_B_RXP0   | AR38     | IMI_B_RXN0   | AT38     | VSS          |
| AR1      | IMI_D_ICOMPI | AT1      | VSS          | AU2      | VSS          |
| AR2      | IMI_D_TXP8   | AT2      | HI11         | AU3      | HI1          |
| AR3      | VSS          | AT3      | HI0          | AU4      | HI2          |
| AR4      | IMI_D_ICOMPO | AT4      | HI3          | AU5      | HI8          |
| AR5      | IMI_D_TXP9   | AT5      | P1V5         | AU6      | HI9          |

**Table 7-1. NB Pin List (by Ball Number) (Sheet 13 of 13)**

| Ball No. | Signal      | Ball No. | Signal      | Ball No. | Signal      |
|----------|-------------|----------|-------------|----------|-------------|
| AR6      | VSS         | AT6      | HI10        | AU7      | VSS         |
| AU8      | HI7         | AU30     | XDP_D5#     | AV17     | EXP_C1_TXN0 |
| AU9      | HIVSWING    | AU31     | P1V5        | AV18     | VSS         |
| AU10     | VSS         | AU32     | XDP_D11#    | AV19     | EXP_B0_TXP3 |
| AU11     | Reserved    | AU33     | XDP_D2#     | AV20     | EXP_B0_TXN3 |
| AU12     | Reserved    | AU34     | P1V5        | AV21     | P1V5        |
| AU13     | VSS         | AU35     | XDP_D8#     | AV22     | EXP_B1_RXP0 |
| AU14     | EXP_C0_TXP3 | AU36     | XDP_RDY#    | AV23     | EXP_B1_RXN0 |
| AU15     | EXP_C0_TXN3 | AU37     | VSS         | AV24     | VSS         |
| AU16     | VSS         | AV3      | VSS         | AV25     | EXP_A1_TXP0 |
| AU17     | EXP_C1_RXP0 | AV4      | HI_STBS     | AV26     | EXP_A1_TXN0 |
| AU18     | EXP_C1_RXN0 | AV5      | HI_STBF     | AV27     | P1V5        |
| AU19     | VSS         | AV6      | VSS         | AV28     | XDP_D7#     |
| AU20     | EXP_B0_RXP3 | AV7      | HI4         | AV29     | XDP_D6#     |
| AU21     | EXP_B0_RXN3 | AV8      | HI6         | AV30     | VSS         |
| AU22     | VSS         | AV9      | P1V5        | AV31     | XDP_D4#     |
| AU23     | EXP_A0_TXP3 | AV10     | HIVREF      | AV32     | XDP_D3#     |
| AU24     | EXP_A0_TXN3 | AV11     | Reserved    | AV33     | VSS         |
| AU25     | VSS         | AV12     | VSS         | AV34     | XDP_D1#     |
| AU26     | EXP_A1_RXP0 | AV13     | EXP_D_RXP3  | AV35     | XDP_D0#     |
| AU27     | EXP_A1_RXN0 | AV14     | EXP_D_RXN3  | AV36     | VSS         |
| AU28     | ITP_TDO     | AV15     | P1V5        |          |             |
| AU29     | XDP_D14#    | AV16     | EXP_C1_TXP0 |          |             |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 1 of 13)**

| Ball No. | Signal      | Ball No. | Signal      | Ball No. | Signal      |
|----------|-------------|----------|-------------|----------|-------------|
| AF16     | CLK66       | AR20     | EXP_B0_RXN2 | AH15     | EXP_C0_TXN0 |
| AK28     | ERR0#       | AU21     | EXP_B0_RXN3 | AK16     | EXP_C0_TXN1 |
| AL29     | ERR1#       | AJ19     | EXP_B0_RXP0 | AN16     | EXP_C0_TXN2 |
| AM29     | ERR2#       | AL20     | EXP_B0_RXP1 | AU15     | EXP_C0_TXN3 |
| AJ23     | EXP_A0_RXN0 | AP20     | EXP_B0_RXP2 | AG15     | EXP_C0_TXP0 |
| AL24     | EXP_A0_RXN1 | AU20     | EXP_B0_RXP3 | AJ16     | EXP_C0_TXP1 |
| AP24     | EXP_A0_RXN2 | AJ20     | EXP_B0_TXN0 | AM16     | EXP_C0_TXP2 |
| AT25     | EXP_A0_RXN3 | AL21     | EXP_B0_TXN1 | AU14     | EXP_C0_TXP3 |
| AH23     | EXP_A0_RXP0 | AN19     | EXP_B0_TXN2 | AU18     | EXP_C1_RXN0 |
| AK24     | EXP_A0_RXP1 | AV20     | EXP_B0_TXN3 | AR19     | EXP_C1_RXN1 |
| AN24     | EXP_A0_RXP2 | AH20     | EXP_B0_TXP0 | AL17     | EXP_C1_RXN2 |
| AT24     | EXP_A0_RXP3 | AK21     | EXP_B0_TXP1 | AG18     | EXP_C1_RXN3 |
| AH24     | EXP_A0_TXN0 | AM19     | EXP_B0_TXP2 | AU17     | EXP_C1_RXP0 |
| AK25     | EXP_A0_TXN1 | AV19     | EXP_B0_TXP3 | AT19     | EXP_C1_RXP1 |
| AN25     | EXP_A0_TXN2 | AV23     | EXP_B1_RXN0 | AM17     | EXP_C1_RXP2 |
| AU24     | EXP_A0_TXN3 | AN21     | EXP_B1_RXN1 | AH18     | EXP_C1_RXP3 |
| AG24     | EXP_A0_TXP0 | AL23     | EXP_B1_RXN2 | AV17     | EXP_C1_TXN0 |
| AJ25     | EXP_A0_TXP1 | AG21     | EXP_B1_RXN3 | AP17     | EXP_C1_TXN1 |
| AM25     | EXP_A0_TXP2 | AV22     | EXP_B1_RXP0 | AN18     | EXP_C1_TXN2 |
| AU23     | EXP_A0_TXP3 | AP21     | EXP_B1_RXP1 | AK18     | EXP_C1_TXN3 |
| AU27     | EXP_A1_RXN0 | AM23     | EXP_B1_RXP2 | AV16     | EXP_C1_TXP0 |
| AN27     | EXP_A1_RXN1 | AH21     | EXP_B1_RXP3 | AR17     | EXP_C1_TXP1 |
| AK27     | EXP_A1_RXN2 | AT22     | EXP_B1_TXN0 | AP18     | EXP_C1_TXP2 |
| AG27     | EXP_A1_RXN3 | AP23     | EXP_B1_TXN1 | AL18     | EXP_C1_TXP3 |
| AU26     | EXP_A1_RXP0 | AM22     | EXP_B1_TXN2 | AF21     | EXP_CLKN    |
| AP27     | EXP_A1_RXP1 | AJ22     | EXP_B1_TXN3 | AF20     | EXP_CLKP    |
| AL27     | EXP_A1_RXP2 | AT21     | EXP_B1_TXP0 | AK13     | EXP_D_RXN0  |
| AH27     | EXP_A1_RXP3 | AR23     | EXP_B1_TXP1 | AN13     | EXP_D_RXN1  |
| AV26     | EXP_A1_TXN0 | AN22     | EXP_B1_TXP2 | AR14     | EXP_D_RXN2  |
| AP26     | EXP_A1_TXN1 | AK22     | EXP_B1_TXP3 | AV14     | EXP_D_RXN3  |
| AL26     | EXP_A1_TXN2 | AJ17     | EXP_C0_RXN0 | AJ13     | EXP_D_RXP0  |
| AH26     | EXP_A1_TXN3 | AL15     | EXP_C0_RXN1 | AM13     | EXP_D_RXP1  |
| AV25     | EXP_A1_TXP0 | AP15     | EXP_C0_RXN2 | AP14     | EXP_D_RXP2  |
| AR26     | EXP_A1_TXP1 | AT16     | EXP_C0_RXN3 | AV13     | EXP_D_RXP3  |
| AM26     | EXP_A1_TXP2 | AH17     | EXP_C0_RXP0 | AJ14     | EXP_D_TXN0  |
| AJ26     | EXP_A1_TXP3 | AK15     | EXP_C0_RXP1 | AM14     | EXP_D_TXN1  |
| AK19     | EXP_B0_RXN0 | AN15     | EXP_C0_RXP2 | AP12     | EXP_D_TXN2  |
| AM20     | EXP_B0_RXN1 | AT15     | EXP_C0_RXP3 | AT13     | EXP_D_TXN3  |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 2 of 13)**

| Ball No. | Signal                | Ball No. | Signal      | Ball No. | Signal   |
|----------|-----------------------|----------|-------------|----------|----------|
| AH14     | EXP_D_TXP0            | P29      | H_A_A23#    | D30      | H_A_D9#  |
| AL14     | EXP_D_TXP1            | R31      | H_A_A24#    | A30      | H_A_D10# |
| AN12     | EXP_D_TXP2            | P28      | H_A_A25#    | A29      | H_A_D11# |
| AT12     | EXP_D_TXP3            | L29      | H_A_A26#    | C28      | H_A_D12# |
| AH11     | EXP_HPINT/EXP1_WIDTH1 | K30      | H_A_A27#    | C30      | H_A_D13# |
| AR16     | EXP_ICOMPI            | P31      | H_A_A28#    | D29      | H_A_D14# |
| AR22     | EXP_RCOMP             | N30      | H_A_A29#    | A27      | H_A_D15# |
| AF22     | EXP_VCCA              | M31      | H_A_A30#    | F37      | H_A_D16# |
| AG19     | EXP_VCCBG             | J30      | H_A_A31#    | G36      | H_A_D17# |
| AG22     | EXP_VSSA              | L28      | H_A_A32#    | F36      | H_A_D18# |
| AF19     | EXP_VSSBG             | J31      | H_A_A33#    | E38      | H_A_D19# |
| AM28     | EXP0_SPEC10A          | L31      | H_A_A34#    | E37      | H_A_D20# |
| AE24     | EXP0_WIDTH0           | K29      | H_A_A35#    | D38      | H_A_D21# |
| AT27     | EXP0_WIDTH1           | L35      | H_A_A36#    | D37      | H_A_D22# |
| AK12     | EXP1_SPE C10A         | T32      | H_A_A37#    | C37      | H_A_D23# |
| K14      | EXP1_WIDTH0           | J28      | H_A_A38#    | F33      | H_A_D24# |
| AE26     | GP_SMBCLK             | T27      | H_A_A39#    | E35      | H_A_D25# |
| AG25     | GP_SMBDATA            | J37      | H_A_ADS#    | B36      | H_A_D26# |
| T33      | H_A_A3#               | L32      | H_A_ADSTB0# | D36      | H_A_D27# |
| P34      | H_A_A4#               | R30      | H_A_ADSTB1# | E34      | H_A_D28# |
| N33      | H_A_A5#               | L26      | H_A_AP0#    | G35      | H_A_D29# |
| N35      | H_A_A6#               | L25      | H_A_AP1#    | F34      | H_A_D30# |
| P35      | H_A_A7#               | M27      | H_A_BINIT#  | E32      | H_A_D31# |
| M33      | H_A_A8#               | K38      | H_A_BNR#    | A26      | H_A_D32# |
| M34      | H_A_A9#               | K24      | H_A_BPM4#   | B26      | H_A_D33# |
| J33      | H_A_A10#              | J25      | H_A_BPM5#   | D27      | H_A_D34# |
| L34      | H_A_A11#              | N38      | H_A_BPRI#   | D26      | H_A_D35# |
| K32      | H_A_A12#              | K36      | H_A_BREQ0#  | C27      | H_A_D36# |
| J34      | H_A_A13#              | M25      | H_A_BREQ1#  | B25      | H_A_D37# |
| H35      | H_A_A14#              | A33      | H_A_D0#     | D24      | H_A_D38# |
| K33      | H_A_A15#              | B34      | H_A_D1#     | A24      | H_A_D39# |
| K35      | H_A_A16#              | C31      | H_A_D2#     | D23      | H_A_D40# |
| R28      | H_A_A17#              | B32      | H_A_D3#     | A23      | H_A_D41# |
| T30      | H_A_A18#              | D33      | H_A_D4#     | C22      | H_A_D42# |
| T29      | H_A_A19#              | B31      | H_A_D5#     | B22      | H_A_D43# |
| M28      | H_A_A20#              | A32      | H_A_D6#     | C21      | H_A_D44# |
| M30      | H_A_A21#              | C33      | H_A_D7#     | A21      | H_A_D45# |
| N29      | H_A_A22#              | D32      | H_A_D8#     | A20      | H_A_D46# |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 3 of 13)**

| Ball No. | Signal      | Ball No. | Signal      | Ball No. | Signal      |
|----------|-------------|----------|-------------|----------|-------------|
| D21      | H_A_D47#    | C25      | H_A_DSTBN2# | M4       | H_B_A6#     |
| G27      | H_A_D48#    | F28      | H_A_DSTBN3# | L4       | H_B_A7#     |
| G29      | H_A_D49#    | B28      | H_A_DSTBP0# | M7       | H_B_A8#     |
| F30      | H_A_D50#    | G32      | H_A_DSTBP1# | N5       | H_B_A9#     |
| E28      | H_A_D51#    | C24      | H_A_DSTBP2# | T5       | H_B_A10#    |
| E29      | H_A_D52#    | F27      | H_A_DSTBP3# | P5       | H_B_A11#    |
| G26      | H_A_D53#    | M36      | H_A_HIT#    | R6       | H_B_A12#    |
| F25      | H_A_D54#    | N26      | H_A_HITM#   | R7       | H_B_A13#    |
| E26      | H_A_D55#    | P37      | H_A_ID0#    | T6       | H_B_A14#    |
| G23      | H_A_D56#    | R37      | H_A_ID1#    | P7       | H_B_A15#    |
| E23      | H_A_D57#    | P38      | H_A_ID2#    | R4       | H_B_A16#    |
| F22      | H_A_D58#    | N27      | H_A_ID3#    | L11      | H_B_A17#    |
| E22      | H_A_D59#    | R36      | H_A_ID4#    | J9       | H_B_A18#    |
| F21      | H_A_D60#    | T36      | H_A_ID5#    | J10      | H_B_A19#    |
| F24      | H_A_D61#    | T26      | H_A_ID6#    | P10      | H_B_A20#    |
| E25      | H_A_D62#    | T38      | H_A_ID7#    | N8       | H_B_A21#    |
| G21      | H_A_D63#    | R27      | H_A_IDS#    | N11      | H_B_A22#    |
| C34      | H_A_DBI0#   | G38      | H_A_LOCK#   | M10      | H_B_A23#    |
| C36      | H_A_DBI1#   | K26      | H_A_MCERR#  | K8       | H_B_A24#    |
| B23      | H_A_DBI2#   | N24      | H_A_OOD#    | L10      | H_B_A25#    |
| G24      | H_A_DBI3#   | M21      | H_A_PRSENT# | P11      | H_B_A26#    |
| H38      | H_A_DBSY#   | N32      | H_A_REQ0#   | R9       | H_B_A27#    |
| N36      | H_A_DEFER#  | R33      | H_A_REQ1#   | L8       | H_B_A28#    |
| B35      | H_A_DEP0#   | R34      | H_A_REQ2#   | M9       | H_B_A29#    |
| A35      | H_A_DEP1#   | P32      | H_A_REQ3#   | N9       | H_B_A30#    |
| F31      | H_A_DEP2#   | T35      | H_A_REQ4#   | T9       | H_B_A31#    |
| E31      | H_A_DEP3#   | L38      | H_A_RS0#    | T11      | H_B_A32#    |
| B20      | H_A_DEP4#   | M37      | H_A_RS1#    | T8       | H_B_A33#    |
| D20      | H_A_DEP5#   | L37      | H_A_RS2#    | P8       | H_B_A34#    |
| G20      | H_A_DEP6#   | J27      | H_A_RSP#    | R10      | H_B_A35#    |
| E20      | H_A_DEP7#   | K27      | H_A_RST#    | P4       | H_B_A36#    |
| H23      | H_A_DP0#    | J36      | H_A_TRDY#   | H4       | H_B_A37#    |
| H25      | H_A_DP1#    | H34      | H_A_VREF0   | T12      | H_B_A38#    |
| J24      | H_A_DP2#    | H22      | H_A_VREF1   | K11      | H_B_A39#    |
| K23      | H_A_DP3#    | H31      | H_A_VREF2   | R1       | H_B_ADS#    |
| H37      | H_A_DRDY#   | J6       | H_B_A3#     | N6       | H_B_ADSTB0# |
| B29      | H_A_DSTBN0# | L5       | H_B_A4#     | K9       | H_B_ADSTB1# |
| G33      | H_A_DSTBN1# | M6       | H_B_A5#     | M13      | H_B_AP0#    |

Table 7-2. NB Pin List (by Signal Name) (Sheet 4 of 13)

| Ball No. | Signal     | Ball No. | Signal    | Ball No. | Signal      |
|----------|------------|----------|-----------|----------|-------------|
| N12      | H_B_AP1#   | F12      | H_B_D30#  | T3       | H_B_DBSY#   |
| M12      | H_B_BINIT# | F10      | H_B_D31#  | L2       | H_B_DEFER#  |
| N2       | H_B_BNR#   | A11      | H_B_D32#  | C19      | H_B_DEP0#   |
| M15      | H_B_BPM4#  | D9       | H_B_D33#  | B19      | H_B_DEP1#   |
| N15      | H_B_BPM5#  | B11      | H_B_D34#  | G11      | H_B_DEP2#   |
| K2       | H_B_BPRI#  | A8       | H_B_D35#  | F9       | H_B_DEP3#   |
| P2       | H_B_BREQ0# | D11      | H_B_D36#  | B4       | H_B_DEP4#   |
| L14      | H_B_BREQ1# | B10      | H_B_D37#  | C4       | H_B_DEP5#   |
| B17      | H_B_D0#    | B8       | H_B_D38#  | F1       | H_B_DEP6#   |
| C18      | H_B_D1#    | A9       | H_B_D39#  | G3       | H_B_DEP7#   |
| D15      | H_B_D2#    | C7       | H_B_D40#  | H16      | H_B_DP0#    |
| C16      | H_B_D3#    | D8       | H_B_D41#  | H14      | H_B_DP1#    |
| A18      | H_B_D4#    | C6       | H_B_D42#  | J15      | H_B_DP2#    |
| C15      | H_B_D5#    | A6       | H_B_D43#  | J16      | H_B_DP3#    |
| B16      | H_B_D6#    | A5       | H_B_D44#  | R3       | H_B_DRDY#   |
| D17      | H_B_D7#    | D6       | H_B_D45#  | B14      | H_B_DSTBN0# |
| A17      | H_B_D8#    | D5       | H_B_D46#  | E11      | H_B_DSTBN1# |
| A15      | H_B_D9#    | B5       | H_B_D47#  | C10      | H_B_DSTBN2# |
| C13      | H_B_D10#   | F7       | H_B_D48#  | G6       | H_B_DSTBN3# |
| A14      | H_B_D11#   | G8       | H_B_D49#  | B13      | H_B_DSTBP0# |
| D12      | H_B_D12#   | E8       | H_B_D50#  | E10      | H_B_DSTBP1# |
| D14      | H_B_D13#   | F6       | H_B_D51#  | C9       | H_B_DSTBP2# |
| C12      | H_B_D14#   | E7       | H_B_D52#  | G5       | H_B_DSTBP3# |
| A12      | H_B_D15#   | E5       | H_B_D53#  | L1       | H_B_HIT#    |
| F19      | H_B_D16#   | F4       | H_B_D54#  | L13      | H_B_HITM#   |
| E19      | H_B_D17#   | E4       | H_B_D55#  | J3       | H_B_ID0#    |
| F18      | H_B_D18#   | C2       | H_B_D56#  | J1       | H_B_ID1#    |
| G18      | H_B_D19#   | D2       | H_B_D57#  | K3       | H_B_ID2#    |
| G17      | H_B_D20#   | E2       | H_B_D58#  | K15      | H_B_ID3#    |
| E17      | H_B_D21#   | D1       | H_B_D59#  | H1       | H_B_ID4#    |
| E16      | H_B_D22#   | F3       | H_B_D60#  | H2       | H_B_ID5#    |
| F16      | H_B_D23#   | D3       | H_B_D61#  | H13      | H_B_ID6#    |
| G12      | H_B_D24#   | B3       | H_B_D62#  | G2       | H_B_ID7#    |
| E13      | H_B_D25#   | E1       | H_B_D63#  | J12      | H_B_IDS#    |
| E14      | H_B_D26#   | D18      | H_B_DBI0# | T2       | H_B_LOCK#   |
| F15      | H_B_D27#   | G15      | H_B_DBI1# | P13      | H_B_MCERR#  |
| F13      | H_B_D28#   | B7       | H_B_DBI2# | J13      | H_B_OOD#    |
| G14      | H_B_D29#   | C3       | H_B_DBI3# | M22      | H_B_PRSENT# |



**Table 7-2. NB Pin List (by Signal Name) (Sheet 5 of 13)**

| Ball No. | Signal    | Ball No. | Signal       | Ball No. | Signal      |
|----------|-----------|----------|--------------|----------|-------------|
| L7       | H_B_REQ0# | AU9      | HISWING      | Y34      | IMI_A_RXP5  |
| J7       | H_B_REQ1# | AV10     | HIVREF       | V36      | IMI_A_RXP6  |
| K5       | H_B_REQ2# | AF10     | ICHRST#      | V33      | IMI_A_RXP7  |
| K6       | H_B_REQ3# | U26      | IMI_A_CLKN   | AC31     | IMI_A_RXP8  |
| J4       | H_B_REQ4# | U25      | IMI_A_CLKP   | AD27     | IMI_A_RXP9  |
| N3       | H_B_RS0#  | AF29     | IMI_A_FRAME  | AB29     | IMI_A_RXP10 |
| M1       | H_B_RS1#  | U35      | IMI_A_ICOMPI | AA30     | IMI_A_RXP11 |
| M3       | H_B_RS2#  | U38      | IMI_A_ICOMPO | AA27     | IMI_A_RXP12 |
| R12      | H_B_RSP#  | W27      | IMI_A_LINKN0 | Y31      | IMI_A_RXP13 |
| N14      | H_B_RST#  | V31      | IMI_A_LINKN1 | Y28      | IMI_A_RXP14 |
| P1       | H_B_TRDY# | V28      | IMI_A_LINKN2 | W32      | IMI_A_RXP15 |
| H5       | H_B_VREF0 | V27      | IMI_A_LINKP0 | W29      | IMI_A_RXP16 |
| H7       | H_B_VREF1 | U31      | IMI_A_LINKP1 | V30      | IMI_A_RXP17 |
| H17      | H_B_VREF2 | U28      | IMI_A_LINKP2 | AD37     | IMI_A_TXN0  |
| L17      | H_CRES    | U32      | IMI_A_RST#   | AD34     | IMI_A_TXN1  |
| M16      | H_ODTCRES | AE36     | IMI_A_RXN0   | AB36     | IMI_A_TXN2  |
| L16      | H_SLWCRES | AE33     | IMI_A_RXN1   | AB33     | IMI_A_TXN3  |
| K18      | H_VCCA    | AC38     | IMI_A_RXN2   | Y38      | IMI_A_TXN4  |
| K17      | H_VSSA    | AC35     | IMI_A_RXN3   | Y35      | IMI_A_TXN5  |
| J21      | HCLKINN   | AA37     | IMI_A_RXN4   | V37      | IMI_A_TXN6  |
| J22      | HCLKINP   | AA34     | IMI_A_RXN5   | V34      | IMI_A_TXN7  |
| AV5      | HI_STBF   | W36      | IMI_A_RXN6   | AC32     | IMI_A_TXN8  |
| AV4      | HI_STBS   | W33      | IMI_A_RXN7   | AD28     | IMI_A_TXN9  |
| AF17     | HI_VCCA   | AD31     | IMI_A_RXN8   | AC37     | IMI_A_TXP0  |
| AF18     | HI_VSSA   | AE27     | IMI_A_RXN9   | AC34     | IMI_A_TXP1  |
| AT3      | HI0       | AC29     | IMI_A_RXN10  | AA36     | IMI_A_TXP2  |
| AU3      | HI1       | AB30     | IMI_A_RXN11  | AA33     | IMI_A_TXP3  |
| AU4      | HI2       | AB27     | IMI_A_RXN12  | W38      | IMI_A_TXP4  |
| AT4      | HI3       | AA31     | IMI_A_RXN13  | W35      | IMI_A_TXP5  |
| AV7      | HI4       | AA28     | IMI_A_RXN14  | U37      | IMI_A_TXP6  |
| AT7      | HI5       | Y32      | IMI_A_RXN15  | U34      | IMI_A_TXP7  |
| AV8      | HI6       | Y29      | IMI_A_RXN16  | AB32     | IMI_A_TXP8  |
| AU8      | HI7       | W30      | IMI_A_RXN17  | AC28     | IMI_A_TXP9  |
| AU5      | HI8       | AD36     | IMI_A_RXP0   | V25      | IMI_A_VCCA  |
| AU6      | HI9       | AD33     | IMI_A_RXP1   | AA25     | IMI_A_VCCBG |
| AT6      | HI10      | AB38     | IMI_A_RXP2   | W25      | IMI_A_VSSA  |
| AT2      | HI11      | AB35     | IMI_A_RXP3   | Y25      | IMI_A_VSSBG |
| AT9      | HIRCOMP   | Y37      | IMI_A_RXP4   | AD25     | IMI_B_CLKN  |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 6 of 13)**

| Ball No. | Signal       | Ball No. | Signal       | Ball No. | Signal       |
|----------|--------------|----------|--------------|----------|--------------|
| AE25     | IMI_B_CLKP   | AF34     | IMI_B_RXP9   | AC7      | IMI_C_LINKN0 |
| AR31     | IMI_B_FRAME  | AP32     | IMI_B_RXP10  | AC10     | IMI_C_LINKN1 |
| AR34     | IMI_B_ICOMPI | AN30     | IMI_B_RXP11  | AD12     | IMI_C_LINKN2 |
| AR37     | IMI_B_ICOMPO | AM31     | IMI_B_RXP12  | AD7      | IMI_C_LINKP0 |
| AG31     | IMI_B_LINKN0 | AL32     | IMI_B_RXP13  | AD10     | IMI_C_LINKP1 |
| AF32     | IMI_B_LINKN1 | AK30     | IMI_B_RXP14  | AE12     | IMI_C_LINKP2 |
| AE30     | IMI_B_LINKN2 | AJ31     | IMI_B_RXP15  | AE11     | IMI_C_RST#   |
| AF31     | IMI_B_LINKP0 | AH32     | IMI_B_RXP16  | U1       | IMI_C_RXN0   |
| AE32     | IMI_B_LINKP1 | AG30     | IMI_B_RXP17  | U4       | IMI_C_RXN1   |
| AD30     | IMI_B_LINKP2 | AP36     | IMI_B_TXN0   | W2       | IMI_C_RXN2   |
| AE29     | IMI_B_RST#   | AP33     | IMI_B_TXN1   | W5       | IMI_C_RXN3   |
| AR38     | IMI_B_RXN0   | AM38     | IMI_B_TXN2   | AA3      | IMI_C_RXN4   |
| AR35     | IMI_B_RXN1   | AM35     | IMI_B_TXN3   | AA6      | IMI_C_RXN5   |
| AN37     | IMI_B_RXN2   | AK37     | IMI_B_TXN4   | AC1      | IMI_C_RXN6   |
| AN34     | IMI_B_RXN3   | AK34     | IMI_B_TXN5   | AC4      | IMI_C_RXN7   |
| AL36     | IMI_B_RXN4   | AH36     | IMI_B_TXN6   | U7       | IMI_C_RXN8   |
| AL33     | IMI_B_RXN5   | AH33     | IMI_B_TXN7   | U10      | IMI_C_RXN9   |
| AJ38     | IMI_B_RXN6   | AF38     | IMI_B_TXN8   | W8       | IMI_C_RXN10  |
| AJ35     | IMI_B_RXN7   | AF35     | IMI_B_TXN9   | W11      | IMI_C_RXN11  |
| AG37     | IMI_B_RXN8   | AN36     | IMI_B_TXP0   | Y7       | IMI_C_RXN12  |
| AG34     | IMI_B_RXN9   | AN33     | IMI_B_TXP1   | Y10      | IMI_C_RXN13  |
| AR32     | IMI_B_RXN10  | AL38     | IMI_B_TXP2   | AA9      | IMI_C_RXN14  |
| AP30     | IMI_B_RXN11  | AL35     | IMI_B_TXP3   | AA12     | IMI_C_RXN15  |
| AN31     | IMI_B_RXN12  | AJ37     | IMI_B_TXP4   | AB8      | IMI_C_RXN16  |
| AM32     | IMI_B_RXN13  | AJ34     | IMI_B_TXP5   | AB11     | IMI_C_RXN17  |
| AL30     | IMI_B_RXN14  | AG36     | IMI_B_TXP6   | V1       | IMI_C_RXP0   |
| AK31     | IMI_B_RXN15  | AG33     | IMI_B_TXP7   | V4       | IMI_C_RXP1   |
| AJ32     | IMI_B_RXN16  | AE38     | IMI_B_TXP8   | Y2       | IMI_C_RXP2   |
| AH30     | IMI_B_RXN17  | AE35     | IMI_B_TXP9   | Y5       | IMI_C_RXP3   |
| AP38     | IMI_B_RXP0   | AB25     | IMI_B_VCCA   | AB3      | IMI_C_RXP4   |
| AP35     | IMI_B_RXP1   | AF24     | IMI_B_VCCBG  | AB6      | IMI_C_RXP5   |
| AM37     | IMI_B_RXP2   | AC25     | IMI_B_VSSA   | AD1      | IMI_C_RXP6   |
| AM34     | IMI_B_RXP3   | AF23     | IMI_B_VSSBG  | AD4      | IMI_C_RXP7   |
| AK36     | IMI_B_RXP4   | U14      | IMI_C_CLKN   | V7       | IMI_C_RXP8   |
| AK33     | IMI_B_RXP5   | T14      | IMI_C_CLKP   | V10      | IMI_C_RXP9   |
| AH38     | IMI_B_RXP6   | U11      | IMI_C_FRAME  | Y8       | IMI_C_RXP10  |
| AH35     | IMI_B_RXP7   | U2       | IMI_C_ICOMPI | Y11      | IMI_C_RXP11  |
| AF37     | IMI_B_RXP8   | U5       | IMI_C_ICOMPO | AA7      | IMI_C_RXP12  |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 7 of 13)**

| Ball No. | Signal       | Ball No. | Signal       | Ball No. | Signal      |
|----------|--------------|----------|--------------|----------|-------------|
| AA10     | IMI_C_RXP13  | AP9      | IMI_D_LINKP1 | AM8      | IMI_D_RXP17 |
| AB9      | IMI_C_RXP14  | AR8      | IMI_D_LINKP2 | AF1      | IMI_D_TXN0  |
| AB12     | IMI_C_RXP15  | AR7      | IMI_D_RST#   | AF4      | IMI_D_TXN1  |
| AC8      | IMI_C_RXP16  | AE2      | IMI_D_RXN0   | AH2      | IMI_D_TXN2  |
| AC11     | IMI_C_RXP17  | AE5      | IMI_D_RXN1   | AH5      | IMI_D_TXN3  |
| V3       | IMI_C_TXN0   | AG3      | IMI_D_RXN2   | AK3      | IMI_D_TXN4  |
| V6       | IMI_C_TXN1   | AG6      | IMI_D_RXN3   | AK6      | IMI_D_TXN5  |
| Y1       | IMI_C_TXN2   | AJ1      | IMI_D_RXN4   | AM1      | IMI_D_TXN6  |
| Y4       | IMI_C_TXN3   | AJ4      | IMI_D_RXN5   | AM4      | IMI_D_TXN7  |
| AB2      | IMI_C_TXN4   | AL2      | IMI_D_RXN6   | AP2      | IMI_D_TXN8  |
| AB5      | IMI_C_TXN5   | AL5      | IMI_D_RXN7   | AP5      | IMI_D_TXN9  |
| AD3      | IMI_C_TXN6   | AN3      | IMI_D_RXN8   | AG1      | IMI_D_TXP0  |
| AD6      | IMI_C_TXN7   | AN6      | IMI_D_RXN9   | AG4      | IMI_D_TXP1  |
| V9       | IMI_C_TXN8   | AD9      | IMI_D_RXN10  | AJ2      | IMI_D_TXP2  |
| V12      | IMI_C_TXN9   | AE8      | IMI_D_RXN11  | AJ5      | IMI_D_TXP3  |
| W3       | IMI_C_TXP0   | AF7      | IMI_D_RXN12  | AL3      | IMI_D_TXP4  |
| W6       | IMI_C_TXP1   | AG9      | IMI_D_RXN13  | AL6      | IMI_D_TXP5  |
| AA1      | IMI_C_TXP2   | AH8      | IMI_D_RXN14  | AN1      | IMI_D_TXP6  |
| AA4      | IMI_C_TXP3   | AJ7      | IMI_D_RXN15  | AN4      | IMI_D_TXP7  |
| AC2      | IMI_C_TXP4   | AK9      | IMI_D_RXN16  | AR2      | IMI_D_TXP8  |
| AC5      | IMI_C_TXP5   | AL8      | IMI_D_RXN17  | AR5      | IMI_D_TXP9  |
| AE3      | IMI_C_TXP6   | AF2      | IMI_D_RXP0   | AD14     | IMI_D_VCCA  |
| AE6      | IMI_C_TXP7   | AF5      | IMI_D_RXP1   | AC13     | IMI_D_VCCBG |
| W9       | IMI_C_TXP8   | AH3      | IMI_D_RXP2   | AC14     | IMI_D_VSSA  |
| W12      | IMI_C_TXP9   | AH6      | IMI_D_RXP3   | AD13     | IMI_D_VSSBG |
| Y14      | IMI_C_VCCA   | AK1      | IMI_D_RXP4   | AH12     | IMI_HPINT   |
| U13      | IMI_C_VCCBG  | AK4      | IMI_D_RXP5   | AF27     | ITP_TCK     |
| W14      | IMI_C_VSSA   | AM2      | IMI_D_RXP6   | AF28     | ITP_TDI     |
| V13      | IMI_C_VSSBG  | AM5      | IMI_D_RXP7   | AU28     | ITP_TDO     |
| AB14     | IMI_D_CLKN   | AP3      | IMI_D_RXP8   | AH28     | ITP_TMS     |
| AA14     | IMI_D_CLKP   | AP6      | IMI_D_RXP9   | AR25     | ITP_TRST#   |
| AF11     | IMI_D_FRAME  | AE9      | IMI_D_RXP10  | J19      | P1V5        |
| AR1      | IMI_D_ICOMP1 | AF8      | IMI_D_RXP11  | N18      | P1V5        |
| AR4      | IMI_D_ICOMPO | AG7      | IMI_D_RXP12  | N20      | P1V5        |
| AM7      | IMI_D_LINKN0 | AH9      | IMI_D_RXP13  | N22      | P1V5        |
| AN9      | IMI_D_LINKN1 | AJ8      | IMI_D_RXP14  | P15      | P1V5        |
| AP8      | IMI_D_LINKN2 | AK7      | IMI_D_RXP15  | P17      | P1V5        |
| AN7      | IMI_D_LINKP0 | AL9      | IMI_D_RXP16  | P19      | P1V5        |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 8 of 13)**

| Ball No. | Signal | Ball No. | Signal | Ball No. | Signal |
|----------|--------|----------|--------|----------|--------|
| P21      | P1V5   | Y19      | P1V5   | AF3      | P1V5   |
| P23      | P1V5   | Y21      | P1V5   | AF9      | P1V5   |
| P25      | P1V5   | Y23      | P1V5   | AF33     | P1V5   |
| R14      | P1V5   | Y27      | P1V5   | AH1      | P1V5   |
| R16      | P1V5   | Y33      | P1V5   | AH7      | P1V5   |
| R18      | P1V5   | AA16     | P1V5   | AH13     | P1V5   |
| R20      | P1V5   | AA18     | P1V5   | AH19     | P1V5   |
| R22      | P1V5   | AA20     | P1V5   | AH25     | P1V5   |
| R24      | P1V5   | AA22     | P1V5   | AH31     | P1V5   |
| T15      | P1V5   | AA24     | P1V5   | AH37     | P1V5   |
| T17      | P1V5   | AB1      | P1V5   | AK5      | P1V5   |
| T19      | P1V5   | AB7      | P1V5   | AK11     | P1V5   |
| T21      | P1V5   | AB13     | P1V5   | AK17     | P1V5   |
| T23      | P1V5   | AB15     | P1V5   | AK23     | P1V5   |
| T25      | P1V5   | AB17     | P1V5   | AK29     | P1V5   |
| U16      | P1V5   | AB19     | P1V5   | AK35     | P1V5   |
| U18      | P1V5   | AB21     | P1V5   | AM3      | P1V5   |
| U20      | P1V5   | AB23     | P1V5   | AM9      | P1V5   |
| U22      | P1V5   | AB31     | P1V5   | AM15     | P1V5   |
| U24      | P1V5   | AB37     | P1V5   | AM21     | P1V5   |
| V5       | P1V5   | AC16     | P1V5   | AM27     | P1V5   |
| V11      | P1V5   | AC18     | P1V5   | AM33     | P1V5   |
| V15      | P1V5   | AC20     | P1V5   | AP1      | P1V5   |
| V17      | P1V5   | AC22     | P1V5   | AP7      | P1V5   |
| V19      | P1V5   | AC24     | P1V5   | AP13     | P1V5   |
| V21      | P1V5   | AD5      | P1V5   | AP19     | P1V5   |
| V23      | P1V5   | AD11     | P1V5   | AP25     | P1V5   |
| V29      | P1V5   | AD15     | P1V5   | AP31     | P1V5   |
| V35      | P1V5   | AD17     | P1V5   | AP37     | P1V5   |
| W16      | P1V5   | AD19     | P1V5   | AT5      | P1V5   |
| W18      | P1V5   | AD21     | P1V5   | AT11     | P1V5   |
| W20      | P1V5   | AD23     | P1V5   | AT17     | P1V5   |
| W22      | P1V5   | AD29     | P1V5   | AT23     | P1V5   |
| W24      | P1V5   | AD35     | P1V5   | AT29     | P1V5   |
| Y3       | P1V5   | AE16     | P1V5   | AU31     | P1V5   |
| Y9       | P1V5   | AE18     | P1V5   | AU34     | P1V5   |
| Y15      | P1V5   | AE20     | P1V5   | AV9      | P1V5   |
| Y17      | P1V5   | AE22     | P1V5   | AV15     | P1V5   |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 9 of 13)**

| Ball No. | Signal              | Ball No. | Signal   | Ball No. | Signal |
|----------|---------------------|----------|----------|----------|--------|
| AV21     | P1V5                | AJ29     | RESERVED | A31      | VSS    |
| AV27     | P1V5                | AK10     | RESERVED | A34      | VSS    |
| AG10     | PME_OUT/EXP1_WIDTH2 | AL11     | RESERVED | A36      | VSS    |
| AG28     | PWRGOOD             | AL12     | RESERVED | B2       | VSS    |
| D35      | RESERVED            | AM10     | RESERVED | B6       | VSS    |
| G9       | RESERVED            | AM11     | RESERVED | B12      | VSS    |
| G30      | RESERVED            | AN10     | RESERVED | B18      | VSS    |
| H8       | RESERVED            | AP11     | RESERVED | B24      | VSS    |
| H10      | RESERVED            | AR10     | RESERVED | B30      | VSS    |
| H11      | RESERVED            | AR11     | RESERVED | B37      | VSS    |
| H19      | RESERVED            | AR13     | RESERVED | C1       | VSS    |
| H20      | RESERVED            | AT10     | RESERVED | C5       | VSS    |
| H26      | RESERVED            | AT18     | RESERVED | C8       | VSS    |
| H28      | RESERVED            | AU11     | RESERVED | C11      | VSS    |
| H29      | RESERVED            | AU12     | RESERVED | C14      | VSS    |
| H32      | RESERVED            | AV11     | RESERVED | C17      | VSS    |
| K12      | RESERVED            | AH29     | RSTIN#   | C20      | VSS    |
| L19      | RESERVED            | AF25     | SMBCLK   | C23      | VSS    |
| M19      | RESERVED            | AR28     | SMBDATA  | C26      | VSS    |
| P26      | RESERVED            | L22      | TESTHI1  | C29      | VSS    |
| R13      | RESERVED            | M18      | TESTLO1  | C32      | VSS    |
| U8       | RESERVED            | L23      | TESTLO2  | C35      | VSS    |
| U29      | RESERVED            | L20      | TESTLO3  | C38      | VSS    |
| W26      | RESERVED            | J18      | TESTLO4  | D4       | VSS    |
| Y13      | RESERVED            | M24      | TESTLO5  | D10      | VSS    |
| Y26      | RESERVED            | AF26     | V3REF0   | D16      | VSS    |
| AA13     | RESERVED            | AJ10     | V3REF1   | D22      | VSS    |
| AB26     | RESERVED            | K21      | VCCA     | D28      | VSS    |
| AC26     | RESERVED            | A3       | VSS      | D34      | VSS    |
| AE14     | RESERVED            | A4       | VSS      | E3       | VSS    |
| AF13     | RESERVED            | A7       | VSS      | E6       | VSS    |
| AF14     | RESERVED            | A10      | VSS      | E9       | VSS    |
| AF15     | RESERVED            | A13      | VSS      | E12      | VSS    |
| AG12     | RESERVED            | A16      | VSS      | E15      | VSS    |
| AG13     | RESERVED            | A19      | VSS      | E18      | VSS    |
| AG16     | RESERVED            | A22      | VSS      | E21      | VSS    |
| AJ11     | RESERVED            | A25      | VSS      | E24      | VSS    |
| AJ28     | RESERVED            | A28      | VSS      | E27      | VSS    |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 10 of 13)**

| Ball No. | Signal | Ball No. | Signal | Ball No. | Signal |
|----------|--------|----------|--------|----------|--------|
| E30      | VSS    | J29      | VSS    | N23      | VSS    |
| E33      | VSS    | J32      | VSS    | N25      | VSS    |
| E36      | VSS    | J35      | VSS    | N28      | VSS    |
| F2       | VSS    | J38      | VSS    | N31      | VSS    |
| F8       | VSS    | K4       | VSS    | N34      | VSS    |
| F14      | VSS    | K10      | VSS    | N37      | VSS    |
| F20      | VSS    | K16      | VSS    | P6       | VSS    |
| F26      | VSS    | K22      | VSS    | P12      | VSS    |
| F32      | VSS    | K28      | VSS    | P14      | VSS    |
| F38      | VSS    | K34      | VSS    | P16      | VSS    |
| G1       | VSS    | L3       | VSS    | P18      | VSS    |
| G4       | VSS    | L6       | VSS    | P20      | VSS    |
| G7       | VSS    | L9       | VSS    | P22      | VSS    |
| G10      | VSS    | L12      | VSS    | P24      | VSS    |
| G13      | VSS    | L15      | VSS    | P30      | VSS    |
| G16      | VSS    | L18      | VSS    | P36      | VSS    |
| G19      | VSS    | L21      | VSS    | R2       | VSS    |
| G22      | VSS    | L24      | VSS    | R5       | VSS    |
| G25      | VSS    | L27      | VSS    | R8       | VSS    |
| G28      | VSS    | L30      | VSS    | R11      | VSS    |
| G31      | VSS    | L33      | VSS    | R15      | VSS    |
| G34      | VSS    | L36      | VSS    | R17      | VSS    |
| G37      | VSS    | M2       | VSS    | R19      | VSS    |
| H6       | VSS    | M8       | VSS    | R21      | VSS    |
| H12      | VSS    | M14      | VSS    | R23      | VSS    |
| H18      | VSS    | M20      | VSS    | R25      | VSS    |
| H24      | VSS    | M26      | VSS    | R26      | VSS    |
| H30      | VSS    | M32      | VSS    | R29      | VSS    |
| H36      | VSS    | M38      | VSS    | R32      | VSS    |
| J2       | VSS    | N1       | VSS    | R35      | VSS    |
| J5       | VSS    | N4       | VSS    | R38      | VSS    |
| J8       | VSS    | N7       | VSS    | T4       | VSS    |
| J11      | VSS    | N10      | VSS    | T10      | VSS    |
| J14      | VSS    | N13      | VSS    | T16      | VSS    |
| J17      | VSS    | N16      | VSS    | T18      | VSS    |
| J20      | VSS    | N17      | VSS    | T20      | VSS    |
| J23      | VSS    | N19      | VSS    | T22      | VSS    |
| J26      | VSS    | N21      | VSS    | T24      | VSS    |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 11 of 13)**

| Ball No. | Signal | Ball No. | Signal | Ball No. | Signal |
|----------|--------|----------|--------|----------|--------|
| T28      | VSS    | W34      | VSS    | AC15     | VSS    |
| T34      | VSS    | W37      | VSS    | AC17     | VSS    |
| U3       | VSS    | Y6       | VSS    | AC19     | VSS    |
| U6       | VSS    | Y12      | VSS    | AC21     | VSS    |
| U9       | VSS    | Y16      | VSS    | AC23     | VSS    |
| U12      | VSS    | Y18      | VSS    | AC27     | VSS    |
| U15      | VSS    | Y20      | VSS    | AC30     | VSS    |
| U17      | VSS    | Y22      | VSS    | AC33     | VSS    |
| U19      | VSS    | Y24      | VSS    | AC36     | VSS    |
| U21      | VSS    | Y30      | VSS    | AD2      | VSS    |
| U23      | VSS    | Y36      | VSS    | AD8      | VSS    |
| U27      | VSS    | AA2      | VSS    | AD16     | VSS    |
| U30      | VSS    | AA5      | VSS    | AD18     | VSS    |
| U33      | VSS    | AA8      | VSS    | AD20     | VSS    |
| U36      | VSS    | AA11     | VSS    | AD22     | VSS    |
| V2       | VSS    | AA15     | VSS    | AD24     | VSS    |
| V8       | VSS    | AA17     | VSS    | AD26     | VSS    |
| V14      | VSS    | AA19     | VSS    | AD32     | VSS    |
| V16      | VSS    | AA21     | VSS    | AD38     | VSS    |
| V18      | VSS    | AA23     | VSS    | AE1      | VSS    |
| V20      | VSS    | AA26     | VSS    | AE4      | VSS    |
| V22      | VSS    | AA29     | VSS    | AE7      | VSS    |
| V24      | VSS    | AA32     | VSS    | AE10     | VSS    |
| V26      | VSS    | AA35     | VSS    | AE13     | VSS    |
| V32      | VSS    | AA38     | VSS    | AE15     | VSS    |
| V38      | VSS    | AB4      | VSS    | AE17     | VSS    |
| W1       | VSS    | AB10     | VSS    | AE19     | VSS    |
| W4       | VSS    | AB16     | VSS    | AE21     | VSS    |
| W7       | VSS    | AB18     | VSS    | AE23     | VSS    |
| W10      | VSS    | AB20     | VSS    | AE28     | VSS    |
| W13      | VSS    | AB22     | VSS    | AE31     | VSS    |
| W15      | VSS    | AB24     | VSS    | AE34     | VSS    |
| W17      | VSS    | AB28     | VSS    | AE37     | VSS    |
| W19      | VSS    | AB34     | VSS    | AF6      | VSS    |
| W21      | VSS    | AC3      | VSS    | AF12     | VSS    |
| W23      | VSS    | AC6      | VSS    | AF30     | VSS    |
| W28      | VSS    | AC9      | VSS    | AF36     | VSS    |
| W31      | VSS    | AC12     | VSS    | AG2      | VSS    |

**Table 7-2. NB Pin List (by Signal Name) (Sheet 12 of 13)**

| Ball No. | Signal | Ball No. | Signal | Ball No. | Signal |
|----------|--------|----------|--------|----------|--------|
| AG5      | VSS    | AL7      | VSS    | AR9      | VSS    |
| AG8      | VSS    | AL10     | VSS    | AR12     | VSS    |
| AG11     | VSS    | AL13     | VSS    | AR15     | VSS    |
| AG14     | VSS    | AL16     | VSS    | AR18     | VSS    |
| AG17     | VSS    | AL19     | VSS    | AR21     | VSS    |
| AG20     | VSS    | AL22     | VSS    | AR24     | VSS    |
| AG23     | VSS    | AL25     | VSS    | AR27     | VSS    |
| AG26     | VSS    | AL28     | VSS    | AR30     | VSS    |
| AG29     | VSS    | AL31     | VSS    | AR33     | VSS    |
| AG32     | VSS    | AL34     | VSS    | AR36     | VSS    |
| AG35     | VSS    | AL37     | VSS    | AT1      | VSS    |
| AG38     | VSS    | AM6      | VSS    | AT8      | VSS    |
| AH4      | VSS    | AM12     | VSS    | AT14     | VSS    |
| AH10     | VSS    | AM18     | VSS    | AT20     | VSS    |
| AH16     | VSS    | AM24     | VSS    | AT26     | VSS    |
| AH22     | VSS    | AM30     | VSS    | AT32     | VSS    |
| AH34     | VSS    | AM36     | VSS    | AT35     | VSS    |
| AJ3      | VSS    | AN2      | VSS    | AT38     | VSS    |
| AJ6      | VSS    | AN5      | VSS    | AU2      | VSS    |
| AJ9      | VSS    | AN8      | VSS    | AU7      | VSS    |
| AJ12     | VSS    | AN11     | VSS    | AU10     | VSS    |
| AJ15     | VSS    | AN14     | VSS    | AU13     | VSS    |
| AJ18     | VSS    | AN17     | VSS    | AU16     | VSS    |
| AJ21     | VSS    | AN20     | VSS    | AU19     | VSS    |
| AJ24     | VSS    | AN23     | VSS    | AU22     | VSS    |
| AJ27     | VSS    | AN26     | VSS    | AU25     | VSS    |
| AJ30     | VSS    | AN29     | VSS    | AU37     | VSS    |
| AJ33     | VSS    | AN32     | VSS    | AV3      | VSS    |
| AJ36     | VSS    | AN35     | VSS    | AV6      | VSS    |
| AK2      | VSS    | AN38     | VSS    | AV12     | VSS    |
| AK8      | VSS    | AP4      | VSS    | AV18     | VSS    |
| AK14     | VSS    | AP10     | VSS    | AV24     | VSS    |
| AK20     | VSS    | AP16     | VSS    | AV30     | VSS    |
| AK26     | VSS    | AP22     | VSS    | AV33     | VSS    |
| AK32     | VSS    | AP28     | VSS    | AV36     | VSS    |
| AK38     | VSS    | AP34     | VSS    | K20      | VSSA   |
| AL1      | VSS    | AR3      | VSS    | B9       | VTT    |
| AL4      | VSS    | AR6      | VSS    | B15      | VTT    |



**Table 7-2. NB Pin List (by Signal Name) (Sheet 13 of 13)**

| Ball No. | Signal | Ball No. | Signal   | Ball No. | Signal      |
|----------|--------|----------|----------|----------|-------------|
| B21      | VTT    | K13      | VTT      | AV34     | XDP_D1#     |
| B27      | VTT    | K19      | VTT      | AU33     | XDP_D2#     |
| B33      | VTT    | K25      | VTT      | AV32     | XDP_D3#     |
| D7       | VTT    | K31      | VTT      | AV31     | XDP_D4#     |
| D13      | VTT    | K37      | VTT      | AU30     | XDP_D5#     |
| D19      | VTT    | M5       | VTT      | AV29     | XDP_D6#     |
| D25      | VTT    | M11      | VTT      | AV28     | XDP_D7#     |
| D31      | VTT    | M17      | VTT      | AU35     | XDP_D8#     |
| F5       | VTT    | M23      | VTT      | AT34     | XDP_D9#     |
| F11      | VTT    | M29      | VTT      | AT33     | XDP_D10#    |
| F17      | VTT    | M35      | VTT      | AU32     | XDP_D11#    |
| F23      | VTT    | P3       | VTT      | AT31     | XDP_D12#    |
| F29      | VTT    | P9       | VTT      | AT30     | XDP_D13#    |
| F35      | VTT    | P27      | VTT      | AU29     | XDP_D14#    |
| H3       | VTT    | P33      | VTT      | AT28     | XDP_D15#    |
| H9       | VTT    | T1       | VTT      | AT37     | XDP_DSTBN   |
| H15      | VTT    | T7       | VTT      | AT36     | XDP_DSTBP   |
| H21      | VTT    | T13      | VTT      | AN28     | XDP_ODTCRES |
| H27      | VTT    | T31      | VTT      | AU36     | XDP_RDY#    |
| H33      | VTT    | T37      | VTT      | AP29     | XDP_SLWCRES |
| K1       | VTT    | AR29     | XDP_CRES |          |             |
| K7       | VTT    | AV35     | XDP_D0#  |          |             |

## 7.2 Intel® E8501 Chipset North Bridge (NB) Mechanical Package Information

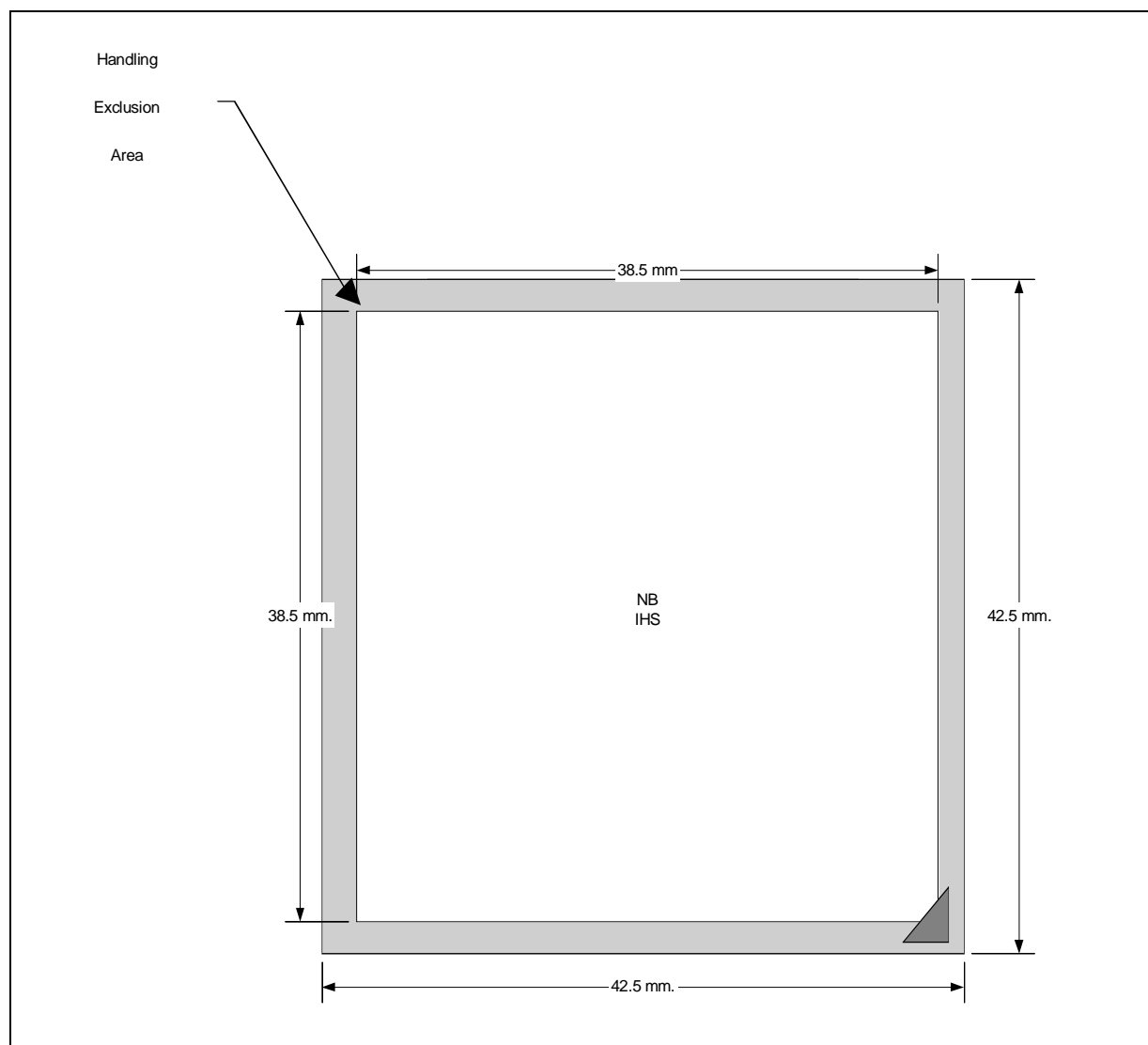
For the NB Mechanical Package drawing, refer to Figure 7-5 through Figure 7-7.

For detailed information about the XMB Mechanical specification, refer to the *Intel® E8501 Chipset eXternal Memory Bridge (XMB) Datasheet*.

For detailed information about the ICH5 mechanical specifications, refer to the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 (ICH5R) Datasheet*. The ICH5 Datasheet is available at: <http://developer.intel.com/design/chipsets/datashts>.

For detailed information about the Intel 6700PXH/6702PXH 64-bit PCI Hub ballout and pin list, refer to the *Intel® 6700PXH 64-bit PCI Hub and Intel® 6702PXH 64-bit PCI Hub Datasheet*.

**Figure 7-5. Intel® E8501 Chipset North Bridge (NB) Package Dimensions (Top View)**



**Figure 7-6. NB Package Dimensions (Side View)**

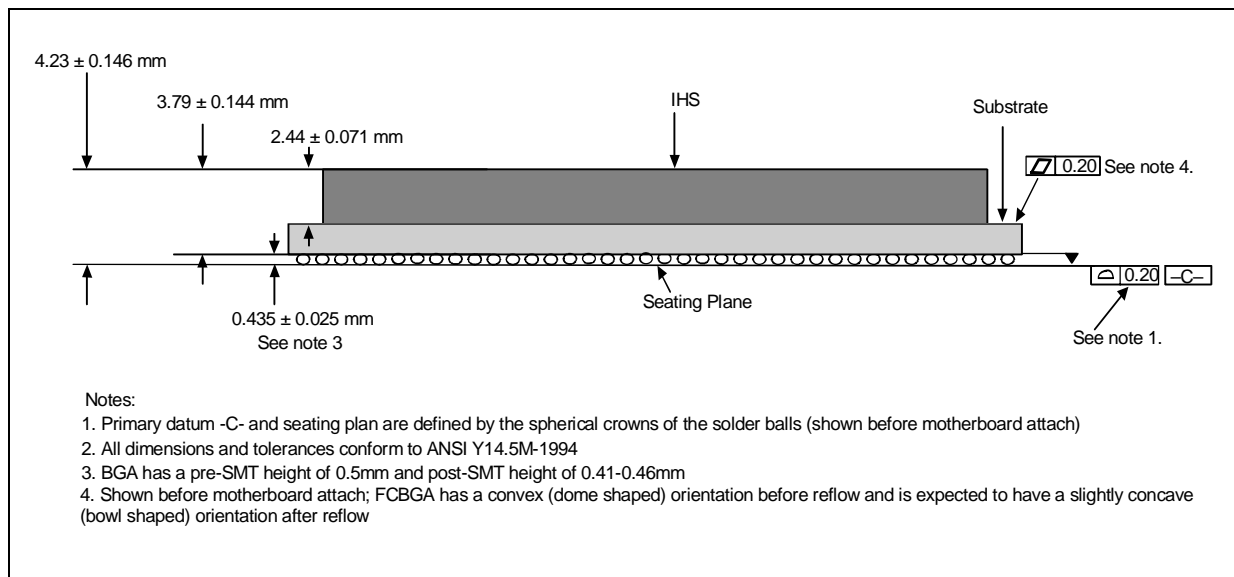
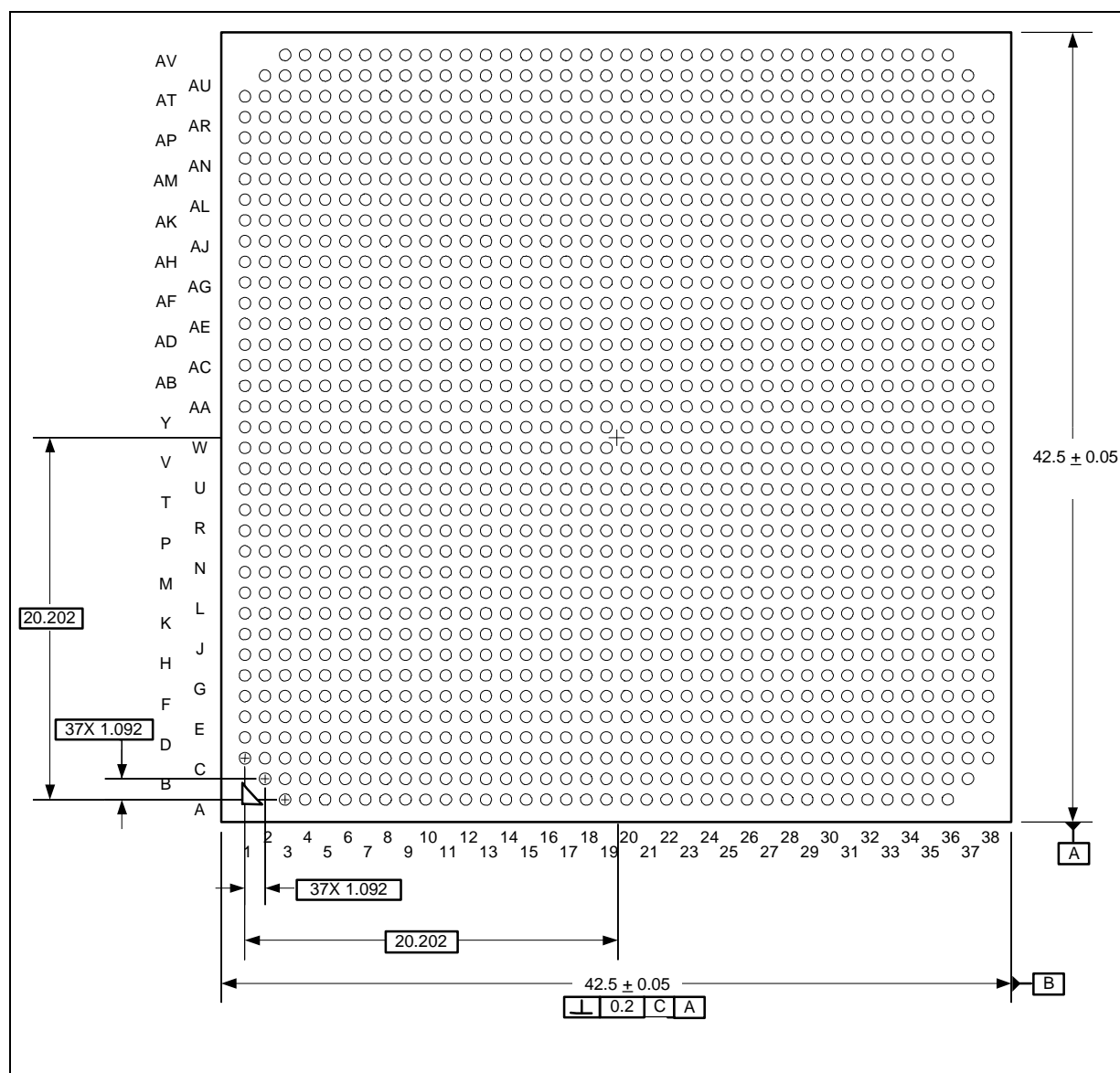


Figure 7-7. NB Package Dimensions (Bottom View)



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