Intel® E7500 Chipset

Datasheet

Intel® E7500 Memory Controller Hub (MCH)

February 2002

Document Number: 290730-001

Contents

Figures

Tables

Revision History

Rev.	Description	Date
-001	Initial Release	February 2002

Intel® E7500 MCH Features

- Processor/Host Bus Support
  - —Intel® Xeon™ processor with 512-KB L2 cache
  - —400 MHz system bus (2x address, 4x data)
  - —Symmetric Multiprocessing Protocol (SMP) for up to two processors at 400 MT/s
  - —System bus Dynamic Bus Inversion (DBI)
  - —36-bit system bus addressing
  - —12-deep in-order queue
  - —AGTL+ bus driver technology with on-die termination resistors
  - —Parity protection on system bus data, address/request, and response signals
- Memory System
  - —One 144-bit wide DDR memory port (with Chipkill* technology ECC)
  - —Peak memory bandwidth of 3.2 GB/s
  - —Supports 64 Mb, 128 Mb, 256 Mb, 512 Mb DRAM densities
  - —Supports a maximum of 16 GB of memory using (x4) double-sided DIMM
  - —Supports x72, Registered, ECC DDR DIMMs (in pairs)
- Hub Interface_A to Intel® ICH3-S
  - —Supports connection to ICH3-S via hub interface 1.5
  - —266 MB/s point-to-point hub interface 1.5 interface to ICH3-S
  - —Parity protected
  - —66 MHz base clock running 4x (533 MB/s) data transfer
  - —Isochronous support
  - —Parallel termination mode only
  - —64-bit addressing on inbound transactions (maximum 16 GB memory decode space)
- Hub Interface_B, Hub Interface_C, and Hub Interface_D
  - —Supports connection to Intel® P64H2 via HI 2.0
  - —Each hub interface is an independent 1 GB/s point-to-point 16-bit connection
  - —ECC protected
  - —66 MHz base clock running 8x (1 GB/s) data transfers
  - —Supports snooped and non-snooped inbound accesses
  - —Parallel termination mode
  - —64-bit inbound addressing
  - —32-bit outbound addressing supported for PCI-X
- PCI / PCI-X
  - —Supports 33 MHz PCI on ICH3-S
  - —Supports 33 MHz and 66 MHz PCI on P64H2
  - —Supports 66 MHz, 100 MHz or 133 MHz PCI-X on P64H2
- RASUM
  - —Supports S4EC/D4ED ECC
  - —Provides x4 Chipkill technology ECC support
  - —Correct any number of errors contained in a 4-bit nibble
  - —Detect all errors contained entirely within two 4-bit nibbles
  - —Hub Interface_A protected by parity
  - —Hub Interface_B–D protected by ECC
  - —Memory auto-initialization by hardware implemented to allow main memory to be initialized with valid ECC
  - —Memory scrubbing supported
  - —SMBus target interface access to MCH error registers
  - —P64H2 and ICH3-S have SMBus target interface for access to registers
  - —ICH3-S master SMBus interface reads serial presence detect (SPD) on DIMMs
- Package
  - —1005-ball, 42.5 mm FC-BGA package

Introduction 1

The Intel® E7500 chipset is targeted for the server market, both front-end and general purpose low- to mid-range. It is intended to be used with the Intel® Xeon™ processor with 512-KB L2 cache. The E7500 chipset consists of three major components: the Intel® E7500 Memory Controller Hub (MCH), the Intel® I/O Controller Hub 3 (ICH3-S), and the PCI/PCI-X 64-bit Hub 2.0 (P64H2). The MCH provides the system bus interface, memory controller, hub interface for legacy I/O, and three high-performance hub interfaces for PCI/PCI-X bus expansion.

This document describes the E7500 Memory Controller Hub (MCH). Section 1.3, “Intel® E7500 Chipset System Architecture” on page 1-12 provides an overview of each of the components of the E7500 chipset. For details on other components of the chipset, refer to that component’s datasheet.

1.1 Glossary of Terms

Term	Description
DBI	Dynamic Bus Inversion.
DDR	Double Data Rate memory technology.
DP	Dual Processor.
Full Reset	The term “a full MCH reset” is used in this document when RSTIN# is asserted.
HI	Hub Interface. The proprietary hub interconnect that ties the MCH to the ICH3-S and P64H2. In this document HI cycles originating from or destined for the primary PCI interface on the ICH3-S are generally referred to as HI/PCI_A or simply HI_A cycles. Cycles originating from or destined for any target on the second, third or fourth HI interfaces are described as HI_B, HI_C, and HI_D cycles respectively. Note that there are two versions of HI used on the Intel® E7500 MCH: an 8-bit HI 1.5 protocol is implemented on HI_A and a 16-bit HI 2.0 protocol is used for the HI_B, HI_C and HI_D.
Host	This term is used synonymously with processor.
IB	Inbound, refers to traffic moving from PCI or other I/O toward DRAM or the system bus.
ICH3-S	The I/O Controller Hub 3-S component that contains the primary PCI interface, LPC interface, USB, ATA-100, and other legacy functions. It communicates with the MCH over a proprietary interconnect called the hub interface.
Intel® Xeon™ processor with 512-KB L2 cache	The processor supported by the Intel® E7500 chipset. This processor is the second generation of processors based on the Intel® NetBurst™ microarchitecture. This processor delivers performance levels that are significantly higher than previous generations of IA-32 processors. This processor supports 1-2 processors on a single system bus and has a 512 KB integrated L2 cache.
MCH	The Memory Controller Hub component that contains the processor interface and DRAM interface. It communicates with the I/O Controller Hub 3-S (ICH3-S) and P64H2 over a proprietary interconnect called the Hub Interface (HI).
OB	Outbound, refers to traffic moving from the system bus to PCI or other I/O.
Intel® P64H2	PCI/PCI-X 64-bit Hub 2.0 component. The Bus Controller Hub component has a 16-bit hub interconnect 2.0 on its primary side and two, 64-bit PCI-X bus segments on the secondary side.

Term	Description
Primary PCI or PCI_A	The physical PCI bus that is driven directly by the ICH3-S component. It supports 5 V, 32-bit, 33 MHz PCI 2.2 compliant components. Communication between PCI_A and the MCH occurs over HI_A. Note that even though the Primary PCI bus is referred to as PCI_A it is not PCI Bus #0 from a configuration standpoint.
RASUM	Reliability, Availability, Serviceability, Usability and Manageability.

1.2 Reference Documents

Document	Document Number
Intel® Xeon™ Processor with 512 KB L2 Cache and Intel® E7500 Chipset Platform Design Guide	298649
Intel® 82801CA I/O Controller Hub 3-S (ICH3-S) Datasheet	290733
Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) Datasheet	290732
Intel® E7500 Chipset: E7500 Memory Controller Hub (MCH) Thermal and Mechanical Design Guidelines	298647
Intel® PCI/PCI-X 64-bit Hub 2 (P64H2) Thermal and Mechanical Design Guidelines	298648
Intel® 82802B/AC Firmware Hub (FWH) Datasheet	290658
Intel® Xeon™ Processor with 512-KB L2 Cache Datasheet	

NOTE: Refer to the *Intel® Xeon™ Processor with 512-KB L2 Cache and Intel® E7500 Chipset Platform Design Guide* for an expanded set of reference documents.

1.3 Intel® E7500 Chipset System Architecture

The E7500 chipset is optimized for the Intel Xeon processor with 512-KB L2 cache. The architecture of the chipset provides the performance and feature-set required for dual-processor based severs in the entry-level and mid-range, front-end and general-purpose server market segments. A new chipset component interconnect, the hub interface 2.0 (HI2.0), is designed into the E7500 chipset to provide more efficient communication between chipset components for high-speed I/O. Each HI2.0 provides 1.066 GB/s I/O bandwidth. The E7500 chipset has three HI2.0 connections, delivering 3.2 GB/s bandwidth for high-speed I/O, which can be used for PCI-X. The system bus, used to connect the processor with the E7500 chipset, utilizes a 400 MT/s transfer rate for data transfers, delivering a bandwidth of 3.2 GB/s. The E7500 chipset architecture supports a 144-bit wide, 200 MHz Double Data Rate (DDR) memory interface also capable of transferring data at 3.2 GB/s.

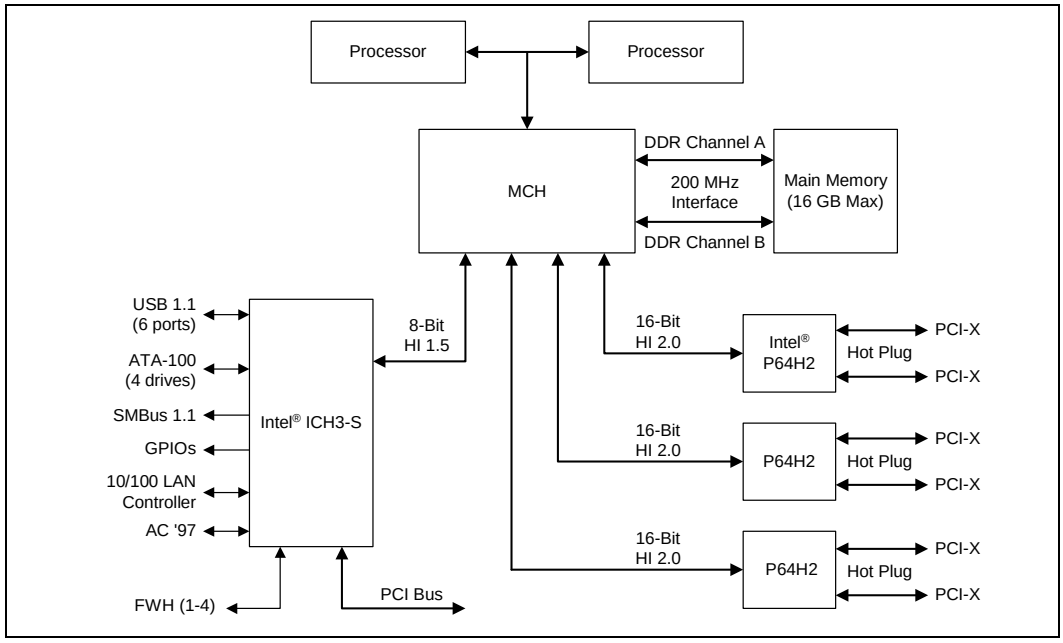
In addition to these performance features, E7500 chipset-based platforms also provide the RASUM (Reliability, Availability, Serviceability, Usability, and Manageability) features required for entry-level and mid-range servers. These features include: Chipkill* technology ECC for memory, ECC for all high-performance I/O, out-of-bound manageability through SMBus target interfaces on all major components, memory scrubbing and auto-initialization, processor thermal monitoring, and hot-plug PCI/PCI-X.

The E7500 chipset consists of three major components: the Memory Controller Hub (MCH), the I/O Controller Hub 3-S (ICH3-S), and the PCI/PCI-X 64-bit Hub 2.0 (P64H2). The chipset components communicate via hub interfaces (HIs). The MCH provides four hub interface connections: one for the ICH3-S and three for high-speed I/O using P64H2 bridges. The hub interfaces are point-to-point and therefore only support two agents (the MCH plus one I/O device), providing connections for up to 3 P64H2 bridges. The P64H2 provides bridging functions between hub interface_B–D and the PCI/PCI-X bus. Up to six PCI-X busses are supported. Each PCI-X bus is 66 MHz, 100 MHz, and 133 MHz PCI-X capable.

Additional platform features supported by the E7500 chipset include four ATA/100 IDE drives, Low Pin Count interface (LPC), integrated LAN Controller, Audio Codec, and Universal Serial Bus (USB).

The E7500 chipset is also ACPI compliant and supports Full-on, Stop Grant, Suspend to Disk, and Soft-off power management states. Through the use of an appropriate LAN device, the E7500 chipset also supports wake-on-LAN* for remote administration and troubleshooting.

Figure 1-1. Intel® E7500 Chipset Platform Block Diagram



1.3.1 Intel® 82801CA I/O Controller Hub 3-S (ICH3-S)

The ICH3-S is a highly-integrated, multi-functional I/O Controller Hub that provides the interface to the PCI bus and integrates many of the functions needed in today's PC platforms. The MCH and ICH3-S communicate over a dedicated hub interface. Intel 82801CA ICH3-S functions and capabilities include:

- *PCI Local Bus Specification*, Revision 2.2-compliant with support for 33 MHz PCI operations.
- PCI slots (supports up to 6 Req/Gnt pairs)
- ACPI Power Management Logic Support
- Enhanced DMA Controller, Interrupt Controller, and Timer Functions
- Integrated IDE controller supports Ultra ATA100/66/33

- USB host interface with support for 6 USB ports; 3 UHCI host controllers
- Integrated LAN Controller
- *System Management Bus (SMBus) Specification*, Version 1.1 with additional support for I^2C devices
- *Audio Codec '97, Revision 2.2 Specification* (a.k.a., *AC '97 Component Specification*, Rev. 2.2) Compliant Link for Audio and Telephony codecs (up to 6 channels)
- Low Pin Count (LPC) interface
- Firmware Hub (FWH) interface support
- Alert On LAN* (AOL) and Alert On LAN 2* (AOL2)

1.3.2 Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2)

The 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) is a peripheral chip that performs PCI bridging functions between the MCH hub interface and the PCI -X busses. The P64H2 interfaces to the MCH via a 16-bit hub interface. Each P64H2 has two independent 64-bit PCI bus interfaces that can be configured to operate in PCI or PCI-X mode. Each PCI bus interface contains an I/OAPIC with 24 interrupts and a hot-plug controller. Functions and capabilities include:

- 16-Bit hub interface to MCH
- Two PCI bus interfaces
  - *PCI Specification, Revision 2.2* compliant
  - *PCI-PCI Bridge Specification, Revision 1.1* compliant
  - *PCI-X Specification, Revision 1.0* compliant
  - PCI hot plug 1.0 compliant
- SMBus interface
- Hot-plug controller for each PCI bus segment
- I/OAPIC for each PCI bus segment

1.4 Intel® E7500 MCH Overview

The MCH provides the processor interface, main memory interface, and hub interfaces in an E7500 chipset-based server platform. It supports Intel Xeon processor with 512 KB L2 cache processor. The MCH is offered in a 1005-ball, 42.5 mm FC-BGA package and has the following functionality:

- Supports single or dual processor configurations at 400 MT/s
- AGTL+ host bus with integrated termination supporting 36-bit host addressing
- 144-bit wide DDR channel supporting 200 MHz dual data rate operation
- 16 GB DDR DRAM (512 Mb devices) support
- 8-bit, 66 MHz 4x hub interface A to ICH3-S
- Three 16-bit, 66 MHz 8x hub interface
- Distributed arbitration for highly concurrent operation

1.4.1 Processor System Interface

The E7500 MCH is optimized for use with processors based on the Intel® NetBurst™ microarchitecture. It supports the following features:

- 400 MHz system bus (2x address, 4x data)
- Symmetric multiprocessing protocol (SMP) for up to two processors at 400 MT/s
- System bus dynamic bus inversion (DBI)
- 36-bit system bus addressing
- 12-deep in-order queue
- AGTL+bus driver technology with on die termination resistors
- Parity protection on system bus data, address/ request, and response signals

1.4.2 Main Memory Interface

The MCH directly supports two channels of DDR DRAM operating in lock-step. These channels are organized to provide minimum latency for the critical segment of data. The MCH DDR channels run at 200 MHz. The MCH supports 64-Mb, 128-Mb, 256-Mb, or 512-Mb memory technology. The MCH provides ECC error checking with Chipkill technology, on x4 DIMMS to ensure DRAM data integrity. The MCH supports x72, registered, ECC DDR DIMMs. The MCH memory interface supports the following operations:

- Provides x4 Chipkill technology ECC support
- Corrects any number of errors contained in a 4-bit nibble
- Detects all errors contained entirely within two 4-bit nibbles
- 8 KB–64 KB page sizes support 64 Mb to 512 Mb DRAM Devices

The supported DIMM configurations are listed in Table 1-1.

Table 1-1. Supported DIMM Configuration

Density	64 Mbit		128 Mbit		256 Mbit		512 Mbit	
Device Width	X4	X8	X4	X8	X4	X8	X4	X8
Single / Double	SS / DS	SS / DS	SS / DS	SS / DS	SS / DS	SS / DS	SS / DS	SS / DS
184 Pin DDR DIMM Capacity	128 MB / 256 MB	64 MB/ 128 MB	256 MB / 512 MB	128 MB / 256 MB	512 MB / 1024 MB	256 MB / 512 MB	1024MB/ 2048MB	512MB/ 1024 MB

NOTE: DIMMs must be populated in pairs, and the DIMMs in a pair must be identical.

1.4.3 Hub Interface_A (HI_A)

The 8-bit HI_A connects the MCH to the ICH3-S. All communication between the MCH and the ICH3-S occurs over HI_A, running at 66 MHz base clock 4x (266 MB/s). HI_A supports upstream 64-bit addressing and downstream 32-bit addressing. All incoming accesses on HI_A are snooped. HI_A provides preferential treatment for isochronous transfers. The interface supports parallel termination only.

1.4.4 Hub Interface_B–D (HI_B–D)

The MCH supports three 16-bit hub interfaces that run at 66 MHz 8x (1 GB/s). The 16-bit HI 2.0 interfaces support 32-bit downstream addressing and 64-bit upstream addressing. For Hub Interface_B–D to main memory accesses, memory read and write accesses are supported. For processor to Hub Interface_B–D accesses, memory reads, memory writes, I/O reads, and I/O writes are supported.

The 16-bit hub interfaces 2.0 support parallel termination only. The 16-bit HI 2.0 may or may not be connected to a device. The MCH detects the presence of a device on each 16-bit hub. If a hub interface is not connected to a valid hub interface device, the bridge configuration register space for that interface is disabled.

1.4.5 MCH Clocking

The MCH has the following clock input pins:

- Differential HCLKINP/HCLKINN for the host interface
- 66 MHz clock input for the HI_A, HI_B, HI_C, HI_D interfaces

Clock synthesizer chip(s) generate the system bus clock and hub interface clock. The system bus interface clock speed is 100 MHz. The MCH does not require any relationship between the HCLKIN host clock and the 66 MHz clock generated for hub interfaces. The HI_A, HI_B, HI_C and HI_D interfaces run at a 66 MHz base clock frequency. HI_A runs at 4x, HI_B, HI_C, and HI_D run at 8x.

The DDR clocks generated by the MCH have a 1:1 relationship with the system bus.

1.4.6 SMBus Interface

The SMBus address for the MCH is 011_0000. This interface has no configuration registers associated with it. The SMBus controller has access to all internal MCH registers. It does not allow access to devices on the hub interface or PCI buses. The SMBus port can read all MCH error registers. It can only write a special set of “shadowed” error registers. These error registers are an exact copy of what the processor has access to. This allows the processor to read and clear its set of error registers independently from the set the SMBus port controls. The SMBus port can only write the error registers to clear them; the only supported write operation is a byte write. Reads are always performed as 4-byte accesses.

Signal Description 2

This section provides a detailed description of MCH signals. The signals are arranged in functional groups according to their associated interface.

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.

The following notations are used to describe the signal type:

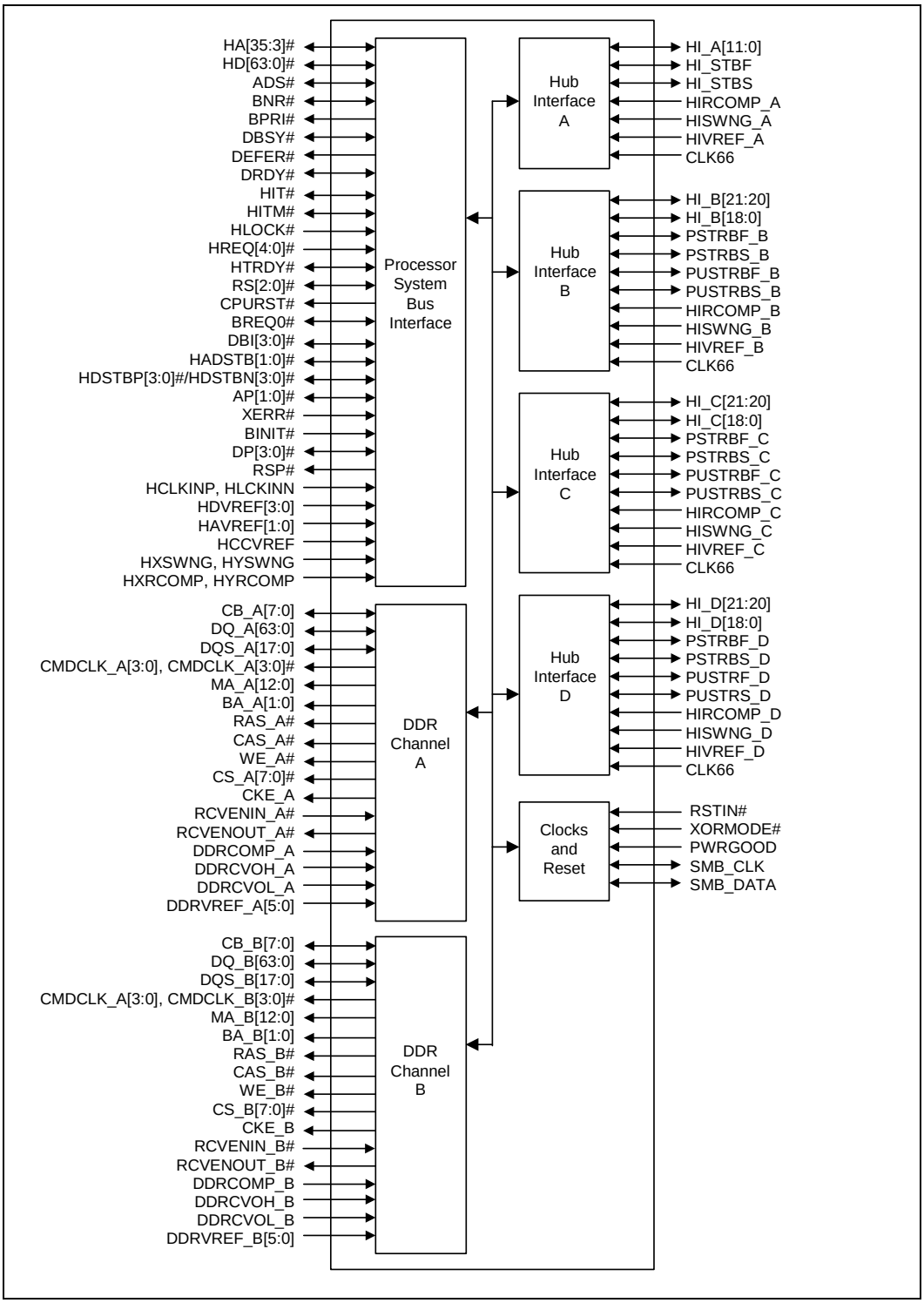
I	Input pin
O	Output pin
I/O	Bidirectional Input/Output pin
as/t/s	Active Sustained tristate. This applies to some of the hub interface (HI) signals. This pin is weakly driven to its last driven value
2x	Double-pump clocking. Addressing at 2x of HCLKINx
4x	Quad-pump clocking. Data transfer at 4x of HCLKINx
SSTL-2	Stub series terminated logic for 2.5 Volts. Refer to the JEDEC specification D8-9A for complete details

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

AGTL+	Open drain AGTL+ interface signal. Refer to the AGTL+ I/O Specification for complete details. The MCH integrates AGTL+ termination resistors
CMOS	CMOS buffers

Note: Certain signals are logically inverted signals. The logical values are the inversion of the electrical values on the system bus.

Figure 2-1. MCH Interface Signals



2.1 System Bus Interface Signals

Table 2-1. System Bus Interface Signals (Sheet 1 of 3)

Signal Name	Type	Description
ADS#	I/O AGTL+	**Address Strobe:** The system bus owner asserts ADS# to indicate the first of two cycles of a request phase.
AP[1:0]#	I/O AGTL+	**Address Parity:** The AP[1:0]# lines are driven by the request initiator and provide parity protection for the Request Phase signals. AP[1:0]# are common clock signals and are driven one common clock after the request phase. Address parity is correct if there are an even number of electrically low signals (low voltage) in the set consisting of the covered signals plus the parity signal. Note that the MCH only connects to HA[35:3]#.
XERR#	I AGTL+	**Bus Error:** This signal may be connected to the MCERR# signal or IERR# signal, depending on system usage. The MCH detects an electrical high to low transition on this input and set the correct error bit. The MCH will take no other action except setting that bit.
BINIT#	I AGTL+	**Bus Initialize:** This signal indicates an unrecoverable error occurred and can be driven by the processor. It is latched by the MCH.
BNR#	I/O AGTL+	**Block Next Request:** BNR# is used to block the current request bus owner from issuing a new requests. This signal is used to dynamically control the system bus pipeline depth.
BPRI#	O AGTL+	**Priority Agent Bus Request:** The MCH is the only Priority Agent on the system bus. It asserts this signal to obtain ownership of the address bus. The MCH has priority over symmetric bus requests and will cause the current symmetric owner to stop issuing new transactions unless the HLOCK# signal is asserted.
BREQ0#	I/O AGTL+	**Bus Request 0:** The MCH pulls the processor bus BREQ0# signal low during CPURST#. The signal is sampled by the processors on the active-to-inactive transition of CPURST#. The minimum setup time for this signal is four HCLKs. The minimum hold time is two HCLKs and the maximum hold time is 20 HCLKs. BREQ0# should be Tristate after the hold time requirement has been satisfied.
CPURST#	O AGTL+	**CPU Reset:** The MCH asserts CPURST# while RSTIN# (PCIRST# from ICH3-S) is asserted and for approximately 1 ms after RSTIN# is deasserted. CPURST# allows the processors to begin execution in a known state.
DBSY#	I/O AGTL+	**Data Bus Busy:** This signal is used by the data bus owner to hold the data bus for transfers requiring more than one cycle.
DEFER#	O AGTL+	**Defer:** When asserted, the MCH will terminate the transaction currently being snooped with either a deferred response or with a retry response.
DP[3:0]#	I/O AGTL+	**Host Data Parity:** The DP[3:0]# signals provide parity protection for HD[63:0]#. The DP[3:0]# signals are common clock signals and are driven one common clock after the data phases they cover. DP[3:0]# are driven by the same agent driving HD[63:0]#. Data parity is correct if there are an even number of electrically low signals (low voltage) in the set consisting of the covered signals plus the parity signal.
DBI[3:0]#	I/O AGTL+ 4x	**Dynamic Bus Inversion:** The DBI[3:0]# signals are driven along with the HD[63:0]# signals. They indicate when the associated signals are inverted. DBI[3:0]# are asserted such that the number of data bits driven electrically low (low voltage) within the corresponding 16 bit group never exceeds 8.
DRDY#	I/O AGTL+	**Data Ready:** This signal is asserted for each cycle that data is transferred.

Table 2-1. System Bus Interface Signals (Sheet 2 of 3)

Signal Name	Type	Description
HA[35:3]#	I/O GTL+ 2x	**Host Address Bus:** HA[35:3]# connect to the system address bus. During processor cycles, HA[35:3]# are inputs. The MCH drives HA[35:3]# during snoop cycles on behalf of hub interface initiators.
HADSTB[1:0]#	I/O AGTL+ 2x	**Host Address Strobe:** The source synchronous strobes are used to latch HA[35:3]# and HREQ[4:0]#.
HD[63:0]#	I/O AGTL+ 4x	**Host Data:** These signals are connected to the system data bus.
HDSTBP[3:0]# HDSTBN[3:0]#	I/O AGTL+ 4x	**Differential Host Data Strobes:** The differential source synchronous strobes are used to latch HD[63:0]# and DBI[3:0]#. **Strobe Data Bits Associated** HDSTBP3#, HDSTBN3# HD[63:48]#, DBI3# HDSTBP2#, HDSTBN2# HD[47:32]#, DBI2# HDSTBP1#, HDSTBN1# HD[31:16]#, DBI1# HDSTBP0#, HDSTBN0# HD[15:0]#, DBI0#
HIT#	I/O AGTL+	**Hit:** HIT# indicates that a caching agent holds an unmodified version of the requested line. This signal is also driven in conjunction with HITM# by the target to extend the snoop window.
HITM#	I/O AGTL+	**Hit Modified:** HITM# indicates that a caching agent holds a modified version of the requested line and that this agent assumes responsibility for providing the line. HITM# is driven in conjunction with HIT# to extend the snoop window.
HLOCK#	I AGTL+	**Host Lock:** All system bus cycles are sampled with the assertion of HLOCK# and ADS#, until the negation of HLOCK#. This operation is atomic.
HREQ[4:0]#	I/O AGTL+ 2x	**Host Request Command:** HREQ[4:0]# defines the attributes of the request. These signals are asserted by the requesting agent during both halves of a request phase. In the first half the signals define the transaction type to a level of detail that is sufficient to begin a snoop request. In the second half the signals carry additional information to define the complete transaction type.
HTRDY#	O AGTL+	**Host Target Ready:** HTRDY# indicates that the target of the processor transaction is able to enter the data transfer phase.
RS[2:0]#	O AGTL+	**Response Signals:** RS[2:0]# indicate the type of response according to the following table: **RS[2:0] Response Type** 000 Idle state 001 Retry response 010 Deferred response 011 Reserved (not driven by MCH) 100 Hard Failure (not driven by MCH) 101 No data response 110 Implicit Writeback 111 Normal data response
RSP#	O AGTL+	**Response Parity:** RSP# provides parity protection for the RS[2:0]# signals. RSP# is always driven by the MCH and must be valid on all clocks. Response parity is correct when there are an even number of low signals (low voltage) in the set consisting of the RS[2:0]# signals and the RSP# signal itself.
HCLKINP, HLCKINN	I CMOS	**Differential Host Clock In:** These input pins receive a differential host clock from the external clock synthesizer. The clock is used by all the MCH logic in the host clock domain.
HDVREF[3:0]	I Analog	**Host Data Reference Voltage:** RHDVREF[3:0] are the reference voltage inputs for the 4x data signals of the Host GTL interface.

Table 2-1. System Bus Interface Signals (Sheet 3 of 3)

Signal Name	Type	Description
HAVREF[1:0]	I Analog	**Host Address Reference Voltage:** HAVREF[1:0] are the reference voltage inputs for the 2x address signals of the Host GTL interface.
HCCVREF	I Analog	**Host Common Clock Reference Voltage:** HCCVREF is the reference voltage input for the common clock signals of the Host GTL interface
HXSWNG, HYSWNG	I Analog	**Host Voltage Swing:** These signals provide a reference voltage used by the system bus RCOMP circuit.
HXRCOMP, HYRCOMP	I Analog	**Host RCOMP:** These signals are used to calibrate the Host AGTL+ I/O buffers.

2.2 DDR Channel A Signals

Table 2-2. DDR Channel_A Interface Signals

Signal Name	Type	Description
CB_A[7:0]	I/O SSTL-2	**DDR Channel A Check bits:** These check bits are required to provide ECC support.
DQ_A[63:0]	I/O SSTL-2	**DDR Channel A Data Bus:** The DDR data bus provides the data interface for the DRAM devices.
DQS_A[17:0]	I/O SSTL-2	**DDR Channel A Data Strobes:** DQS_A[17:0] are the DDR data strobes. Each data strobe is used to strobe a set of 4 or 8 data signals.
CMDCLK_A[3:0], CMDCLK_A[3:0]#	O CMOS	**DDR Channel A Command CLOCK:** These signals are the DDR command clocks used by the DDR DRAMs to latch MA[12:0], BA[1:0], RAS#, CAS#, WE#, CKE#, and CS# signals.
MA_A[12:0]	O SSTL-2	**DDR Channel A Memory Address:** MA_A[12:0] are the DDR memory address signals.
BA_A[1:0]	O SSTL-2	**DDR Channel A Bank Address:** BA_A[1:0] are the DDR bank address signals. These bits select the bank within the DDR DRAM.
RAS_A#	O SSTL-2	**DDR Channel A Row Address Strobe:** RAS_A# is used to indicate a valid row address and open a row.
CAS_A#	O SSTL-2	**DDR Channel A Column Address Strobe:** CAS_A# is used to indicate a valid column address and initiate a transaction.
WE_A#	O SSTL-2	**DDR Channel A Write Enable:** WE_A# is used to indicate a write cycle.
CS_A[7:0]#	O SSTL-2	**DDR Channel A Chipselect:** The chip select signals are used to indicate which DRAM device cycles are targeted.
CKE_A	O SSTL-2	**DDR Channel a Clock Enable:** CKE_A is the DDR clock enable signal.
RCVENIN_A#	I SSTL-2	**Receive Enable Input:** RCVENIN_A# is used for DRAM timing.
RCVENOUT_A#	O SSTL-2	**Receive Enable Output:** RCVENOUT_A# is used for DRAM timing.
DDRCOMP_A	I CMOS	**Compensation for DDR A:** This signal is used to calibrate the DDR buffers.
DDRCVOH_A	I Analog	**Compensation for DDR A:** This signal is used to calibrate the DDR buffers.
DDRCVOL_A	I Analog	**Compensation for DDR A:** This signal is used to calibrate the DDR buffers.
DDRVREF_A[5:0]	I Analog	**DDR Channel A Voltage Reference:** DDR reference voltage input.

2.3 DDR Channel B Signals

Table 2-3. DDR Channel_B Interface Signals

Signal Name	Type	Description
CB_B[7:0]	I/O SSTL-2	**DDR Channel B Check bits:** These check bits are required to provide ECC support.
DQ_B[63:0]	I/O SSTL-2	**DDR Channel B Data Bus:** The DDR data bus provides the data interface for the DRAM devices.
DQS_B[17:0]	I/O SSTL-2	**DDR Channel B Data Strobes:** DQS_B[17:0] are the DDR data strobes. Each data strobe is used to strobe a set of 4 or 8 data signals.
CMDCLK_B[3:0], CMDCLK_B[3:0]#	O CMOS	**DDR Channel B Command CLOCK:** These signals are the DDR command clocks used by the DDR DRAMs to latch MA[12:0], BA[1:0], RAS#, CAS#, WE#, CKE#, and CS# signals.
MA_B[12:0]	O SSTL-2	**DDR Channel B Memory Address:** MA_B[12:0] are the DDR memory address signals.
BA_B[1:0]	O SSTL-2	**DDR Channel B Bank Address:** BA_B[1:0] are the DDR bank address signals. These bits select the bank within the DDR DRAM.
RAS_B#	O SSTL-2	**DDR Channel B Row Address Strobe:** RAS_B# is used to indicate a valid row address and open a row.
CAS_B#	O SSTL-2	**DDR Channel B Column Address Strobe:** CAS_B# is used to indicate a valid column address and initiate a transaction.
WE_B#	O SSTL-2	**DDR Channel B Write Enable:** WE_B# is used to indicate a write cycle.
CS_B[7:0]#	O SSTL-2	**DDR Channel B Chipselect:** The chip select signals are used to indicate which DRAM device cycles are targeted.
CKE_B	O SSTL-2	**DDR Channel B Clock Enable:** CKE_B is the DDR clock enable signal.
RCVENIN_B#	I SSTL-2	**Receive Enable Input:** RCVENIN_B# is used for DRAM timing.
RCVENOUT_B#	O SSTL-2	**Receive Enable Output:** RCVENOUT_B# is used for DRAM timing.
DDRCOMP_B	I/O CMOS	**Compensation for DDR B:** This signal is used to calibrate the DDR buffers.
DDRCVOH_B	I Analog	**Compensation for DDR A:** This signal is used to calibrate the DDR buffers.
DDRCVOL_B	I Analog	**Compensation for DDR A:** This signal is used to calibrate the DDR buffers.
DDRVREF_B[5:0]	I Analog	**DDR Channel B Voltage Reference:** DDR reference voltage input.

2.4 Hub Interface_A Signals

Table 2-4. HI _A Signals

Signal Name	Type	Description
HI_A[11:0]	I/O (as/t/s) CMOS	**HI_A Signals:** HI_A[11:0] are the signals used for the hub interface between the ICH3-S and the MCH.
HI_STBF	I/O (as/t/s) CMOS	**HI_A Strobe:** HI_STBF is one of the two strobe signals used to transmit and receive packet data over HI_A. **Note**:In Normal Buffer Mode (HI 1.0) the HI_STBF signal is called HI_STB#. Refer to the platform design guide and the MCH documentation for appropriate hub interface strobe signals.
HI_STBS	I/O (as/t/s) CMOS	**HI_A Strobe Compliment:** HI_STBS is one of the two strobes signals used to transmit or receive packet data over HI_A. **Note**: In Normal Buffer Mode (HI 1.0) the HI_STB# signal is called HI_STB. Refer to the platform design guide and the MCH documentation for appropriate hub interface strobe signals.
HIRCOMP_A	I Analog	**Compensation for HI_A:** This signal is used to calibrate the HI_A I/O buffers.
HISWNG_A	I Analog	**HI_A Voltage Swing:** This signal provides a reference voltage used by the HI_A RCOMP circuit.
HIVREF_A	I Analog	**HI_A Reference:** HIVREF_A is a reference voltage input for the HI_A interface.
CLK66[1]	I CMOS	**66 MHz Clock In:**. This pin receives a 66 MHz clock from the clock synthesizer. This clock is shared by the HI_A, HI_B, HI_C, and HI_D.

NOTES:
1. Clk66 is being shared by HI_A-D. Physically there is one CLK 66 pin on the MCH.

2.5 Hub Interface_B Signals

Table 2-5. HI_B Signals

Signal Name	Type	Description
HI_B[21:20]	I/O (as/t/s) CMOS	**HI_B Signals:** HI_B[21:20] are the ECC signals used for connection between the 16-bit hub and the MCH.
HI_B[18:0]	I/O (as/t/s) CMOS	**HI_B Signals:** The HI_B[18:0] signals are used for connection between the 16-bit hub and the MCH.
PSTRBF_B	I/O (as/t/s) CMOS	**HI_B Strobe First:** PSTRBF_B is one of two strobes signal pairs used to transmit or receive lower 8-bit data over HI_B.
PSTRBS_B	I/O (as/t/s) CMOS	**HI_B Strobe Second:** PSTRBS_B is one of two strobes signal pairs used to transmit or receive lower 8-bit packet data over HI_B.
PUSTRBF_B	I/O (as/t/s) CMOS	**HI_B Upper Strobe First:** PUSTRBF_B is one of two strobes signal pairs used to transmit or receive upper 8-bit packet data over HI_B.
PUSTRBS_B	I/O (as/t/s) CMOS	**HI_B Upper Strobe Second:** PUSTRBS_B is one of two strobes signal pairs used to transmit or receive upper 8-bit packet data over HI_B.
HIRCOMP_B	I/O CMOS	**Compensation for HI_B:** This signal is used to calibrate the HI_B I/O buffers.
HISWNG_B	I Analog	**HI_B Voltage Swing:** This signal provides a reference voltage used by the HI_B RCOMP circuit.
HIVREF_B	I Analog	**HI_B Reference:** HIVREF_B is a reference voltage input for the HI_B interface.
CLK66[1]	I CMOS	**66 MHz Clock In:** This pin receives a 66 MHz clock from the clock synthesizer. This clock is shared by the HI_A, HI_B, HI_C and HI_D.

NOTES:
1. Clk66 is being shared by HI_A-D. Physically there is one CLK 66 pin on the MCH.

2.6 Hub Interface_C Signals

Table 2-6. HI_C Signals

Signal Name	Type	Description
HI_C[21:20]	I/O (as/t/s) CMOS	**HI_C Signals:** HI_C[21:20] are the ECC signals used for connection between the 16-bit hub and the MCH.
HI_C[18:0]	I/O (as/t/s) CMOS	**HI_C Signals:** HI_C[18:0] are the signals used for the connection between the 16-bit hub and the MCH.
PSTRBF_C	I/O (as/t/s) CMOS	**HI_C Strobe First:** PSTRBF_C is one of two strobe signal pairs used to transmit or receive lower 8-bit data over HI_C.
PSTRBS_C	I/O (as/t/s) CMOS	**HI_C Strobe second:** PSTRBS_C is one of two strobe signals pairs used to transmit or receive lower 8-bit data over HI_C.
PUSTRBF_C	I/O (as/t/s) CMOS	**HI_C Upper Strobe First:** PUSTRBF_C is one of two strobe signals pairs used to transmit or receive upper 8-bit data over HI_C.
PUSTRBS_C	I/O (as/t/s) CMOS	**HI_C Upper Strobe Second:** PUSTRBS_C is one of two strobe signals pairs used to transmit or receive upper 8-bit data over HI_C.
HIRCOMP_C	I/O CMOS	**Compensation for HI_C:** This signal is used to calibrate the HI_C I/O buffers.
HISWNG_C	I Analog	**HI_C Voltage Swing:** This signal provides a reference voltage used by the HI_C RCOMP circuit.
HIVREF_C	I Analog	**HI_C Reference:** HIVREF_C is a reference voltage input for the HI_C interface.
CLK66[1]	I CMOS	**66 MHz Clock In:**. This pin receives a 66 MHz clock from the clock synthesizer. This clock is shared by the HI_A, HI_B, HI_C and HI_D.

NOTES:
1. Clk66 is being shared by HI_A-D. Physically there is one CLK 66 pin on the MCH.

2.7 Hub Interface_D Signals

Table 2-7. HI_D Signals

Signal Name	Type	Description
HI_D[21:20]	I/O (as/t/s) CMOS	**HI_D Signals:** HI_D[21:20] are ECC signals used for connection between the 16-bit hub and the MCH.
HI_D[18:0]	I/O (as/t/s) CMOS	**HI_D Signals:** HI_D[18:0] are the signals used for the connection between the 16-bit hub and the MCH.
PSTRBF_D	I/O (as/t/s) CMOS	**HI_D Strobe First:** PSTRBF_D is one of two strobe signal pairs used to transmit or receive lower 8-bit data over HI_D.
PSTRBS_D	I/O (as/t/s) CMOS	**HI_D Strobe Second:** PSTRBS_D is one of two strobe signal pairs used to transmit or receive lower 8-bit data over HI_D.
PUSTRF_D	I/O (as/t/s) CMOS	**HI_D Upper Strobe First:** PUSTRF_D is one of two strobe signal pairs used to transmit or receive upper 8-bit data over HI_D.
PUSTRS_D	I/O (as/t/s) CMOS	**HI_D Upper Strobe Second:** PUSTRS_D is one of two strobe signal pairs used to transmit or receive upper 8-bit data over HI_D.
HIRCOMP_D	I/O CMOS	**Compensation for HI_D:** This signal is used to calibrate the HI_D I/O buffers.
HISWNG_D	I Analog	**HI_D Voltage Swing:** This signal provides a reference voltage used by the HI_DRCOMP circuit.
HIVREF_D	I Analog	**HI_D Reference:** HIVREF_D is the reference voltage input for the HI_D interface.
CLK66[1]	I CMOS	**66 MHz Clock In:**. This pin receives a 66 MHz clock from the clock synthesizer. This clock is shared by the HI_A, HI_B, HI_C and HI_D.

NOTES:
1. Clk66 is being shared by HI_A-D. Physically there is one CLK 66 pin on the MCH.

2.8 Clocks, Reset, Power, and Miscellaneous Signals

The voltage reference pins are described in the signal description sections for the associated interface.

Table 2-8. Clocks, Reset, Power, and Miscellaneous Signals

Signal Name	Type	Description
RSTIN#	I CMOS	**Reset In:** When asserted, RSTIN# asynchronously resets the MCH logic. This signal is connected to the PCIRST# output of the ICH3-S.
XORMODE#	I CMOS	**Test Input:** When XORMODE# is asserted, the MCH places all outputs in XOR mode for board-level testing.
PWRGOOD	I	**Power Good:** This signal resets the MCH component, including “sticky” logic. It is driven by external logic to indicate all power rails are present.
SMB_CLK	I/O	**SMBus Clock:** This is the clock pin for the SMBus interface.
SMB_DATA	I/O	**SMBus Data:** This is the data pin for the SMBus interface.
VCC1_2		**Power:** These pins are 1.2 V power input pins for HI_A–D, and the MCH core.
VCCA1_2		**Power:** These pins are 1.2 V analog power input pins.
VCCAHI1_2		**Power:** This pin is a 1.2 V analog power input pin.
VCCACPU1_2		**Power:** This pin is a 1.2 V analog power input pin.
VCC_CPU		**Power:** For the system bus interface.
VCC2_5		**Power:** These pins are 2.5 V power input pins for DDR.
VSS		**Ground:** Ground pin.

2.9 Pin States During and After Reset

This section provides the signal states during reset (assertion of RSTIN#) and immediately following reset (deassertion of RSTIN#).

Legend	Interpretation
Drive	Strong drive (to normal value supplied by core logic, if not otherwise stated
TERM	Normal termination devices on
LV	Low voltage
HV	High voltage
IN	Input buffer enabled
ISO	Isolate inputs in inactive states
TRI	Tri-state
PU	Weak pull-up
PD	Weak pull-down

Signal Name	State During RSTIN# Assertion	State After RSTIN# Deassertion
System Bus Interface		
CPURST#	DRIVE LV	TERM HV (after 1ms)
HA[35:3]#	TERM HV [1]	TERM HV [2]
HADSTB[1:0]#	TERM HV	TERM HV
AP[1:0]#	TERM HV	TERM HV
HD[63:0]#	TERM HV	TERM HV
HDSTBp[3:0]#	TERM HV	TERM HV
HDSTBn[3:0]#	TERM HV	TERM HV
DEP[3:0]#	TERM HV	TERM HV
DBI[3:0]#	TERM HV	TERM HV
ADS#	TERM HV	TERM HV
BNR#	TERM HV	TERM HV
BPRI#	TERM HV	TERM HV
DBSY#	TERM HV	TERM HV
DEFER#	TERM HV	TERM HV
DRDY#	TERM HV	TERM HV
HIT#	TERM HV	TERM HV
HITM#	TERM HV	TERM HV
HLOCK#	TERM HV	TERM HV
HREQ[4:0]#	TERM HV	TERM HV
HTRDY#	TERM HV	TERM HV
RS[2:0]#	TERM HV	TERM HV
RSP#	TERM HV	TERM HV
BERR#	TERM HV	TERM HV
BREQ0#	TERM HV	DRIVE LV [3]
HDVREF[3:0]	IN	IN
HAVREF[1:0]	IN	IN
HCCVREF	IN	IN
HXRCOMP	TRI	TRI after RCOMP
HYRCOMP	TRI	TRI after RCOMP
HXSWNG	IN	IN
HYSWNG	IN	IN

Signal Name	State During RSTIN# Assertion	State After RSTIN# Deassertion
DDR Channel A Interface		
CB_A[7:0]	TRI	TRI
DQ_A[63:0]	TRI	TRI
DQS_A[17:0]	TRI	TRI
CMDCLK_A[3:0]	LV	Starts to toggle
CMDCLK_A[3:0]#	LV	Starts to toggle
MA_A[12:0]	Note 4	Note 4
BA_A[1:0]	Note 4	Note 4
RAS_A#	LV	LV
CAS_A#	HV	HV
WE_A#	HV	HV
CS_A[7:0]#	HV	HV
CKE_A	LV	Note 6
RCVENIN_A#	IN	IN
RCVENOUT_A#	HV	HV
DDR Channel B Interface		
CB_B[7:0]	TRI	TRI
DQ_B[63:0]	TRI	TRI
DQS_B[17:0]	TRI	TRI
CMDCLK_B[3:0]	LV	Starts to toggle
CMDCLK_B[3:0]#	LV	Starts to toggle
MA_B[12:0]	Note 4	Note 4
BA_B[1:0]	Note 4	Note 4
RAS_B#	LV	LV
CAS_B#	HV	HV
WE_B#	HV	HV
CS_B[7:0]#	HV	HV
CKE_B	LV	Note 6
RCVENIN_B#	IN	IN
RCVENOUT_B#	HV	HV

Signal Name	State During RSTIN# Assertion	State After RSTIN# Deassertion
Hub Interface_A		
HI7_A	Weak PU	TERM LV
HI_A[11:8,6:0]	Weak PD	TERM LV
HI_STBF	Weak PD	TERM LV
HI_STBS	Weak PD	TERM LV
HIRCOMP_A	TRI	TRI after RCOMP
HIVREF_A	IN	IN
HISWNG_A	IN	IN
Hub Interface_B–D		
HI_x[21:17,15:0]	Weak PD	TERM LV
HI16_x	Note 5	TERM LV
PSTRBF_x, PUSTRBF_x	Weak PD	TERM LV
PSTRBS_x, PUSTRBS_x	Weak PD	TERM LV
HIRCOMP_x	TRI	TRI after RCOMP
HIVREF_x	IN	IN
HISWNG_x	IN	IN

Signal Name	State During RSTIN# Assertion	State After RSTIN# Deassertion
Clocks and Miscellaneous		
HCLKIN[N:P]	IN	IN
CLK66	IN	IN
RSTIN#	IN	IN
XORMODE#	IN	IN
PWRGOOD	IN	IN

NOTES:
1. DRIVE LV if POC or Straps are set
2. Any signals driven LV from POC Register go to TERM HV two clocks after CPURST# deasserts
3. Drive LV and hold until two clocks after CPURST# is deasserted, and then TERM HV.
4. Active 0 or 1, either is ok
5. Weak PU for Swizzle; Weak PD for non-Swizzle
6. Remains low and is asserted after 256 clocks

Register Description 3

The MCH contains two sets of software accessible registers, accessed via the host processor I/O address space:

- Control registers – These registers are I/O mapped into the processor I/O space, which control access to PCI configuration space (see Section 3.5, “I/O Mapped Registers” on page 3-35)
- Internal configuration registers – These registers, which reside within the MCH, are partitioned into multiple logical device register sets (“logical” since they reside within a single physical device). One register set is dedicated to Host-HI Bridge functionality (controls PCI_A, DRAM configuration, other chipset operating parameters, and optional features). Other sets of registers map to HI_B, HI_C and HI_D.

The MCH supports PCI configuration space accesses using the mechanism denoted as Configuration Mechanism #1 in the PCI specification.

The MCH internal registers (I/O mapped and configuration registers) are accessible by the host. The registers can be accessed as Byte (8-bit), Word (16-bit), or DWord (32-bit) quantities, with the exception of the CONF_ADDR Register, 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).

3.1 Register Terminology

Term	Description
RO	**Read Only.** In some cases, If a register is read only, writes to this register location have no effect. However, in other cases, two separate registers are located at the same location where a read accesses one of the registers and a write accesses the other register. See the I/O and memory map tables for details.
WO	**Write Only.** In some cases, If a register is write only, reads to this register location have no effect. However, in other cases, two separate registers are located at the same location where a read accesses one of the registers and a write accesses the other register. See the I/O and memory map tables for details.
R/W	**Read/Write.** A register with this attribute can be read and written.
R/WC	**Read/Write Clear.** A register bit with this attribute can be read and written. However, a write of 1 clears (sets to 0) the corresponding bit and a write of 0 has no effect.
R/W/L	**Read/Write/Lock.** A register with this attribute can be read, written and locked.
R/WO	**Read/Write Once.** A register (bit) with this attribute can be written only once after power up. After the first write, the register (bit) becomes read only.
L	**Lock.** A register bit with this attribute becomes read only after a lock bit is set.

Term	Description
Reserved Bits	Some of the MCH registers described in this chapter contain reserved bits. These bits are labeled Reserved (Rsvd). Software must deal correctly with fields that are reserved. On reads, software must use appropriate masks to extract the defined bits and not rely on reserved bits being any particular value. On writes, software must ensure that the values of reserved bit positions are preserved. That is, the values of reserved bit positions must first be read, merged with the new values for other bit positions and then written back. Note the software does not need to perform read, merge, and write operations for the configuration address register.
Reserved Registers	The MCH contains address locations in the configuration space of the Host-HI Bridge entity that are marked “Reserved”. Registers that are marked as “Reserved” must not be modified by system software. Writes to “Reserved” registers may cause system failure. Reads to “Reserved” registers may return a non-zero value.
Default Value upon Reset	Upon a Reset, the MCH sets its internal configuration registers to predetermined default states. At reset, some register values are determined by external strapping options. A register’s default value represents the minimum functionality feature set required to successfully bring up the system. Hence, it does not represent the optimal system configuration. It is the responsibility of the system initialization software (usually BIOS) to properly determine the DRAM configurations, operating parameters and optional system features that are applicable, and to program the MCH registers accordingly.

3.2 Platform Configuration

The MCH and the ICH3-S are physically connected by HI_A. From a configuration standpoint, HI_A is logically PCI bus 0. As a result, all devices internal to the MCH and ICH3-S appear to be on PCI bus 0. The system’s primary PCI expansion bus is physically attached to the ICH3-S and, from a configuration perspective appears to be a hierarchical PCI bus behind a PCI-to-PCI bridge and therefore has a programmable PCI Bus number.

Note: The primary PCI bus is referred to as PCI_A in this document and is **not** PCI bus 0 from a configuration standpoint.

The 16-bit hub interface ports appear to system software to be real PCI buses behind PCI-to-PCI bridges resident as devices on PCI bus 0.

The MCH decodes multiple PCI Device numbers. The configuration registers for the devices are mapped as devices residing on PCI bus 0. Each Device Number may contain multiple functions.

- **Device 0**: Host-HI_A Bridge/DRAM Controller. Logically this appears as a PCI device residing on PCI bus 0. Physically Device 0 contains the standard PCI bridge registers, DRAM registers, configuration for HI_A, and other MCH specific registers.
- **Device 2**: Host-HI_B Bridge. Logically this bridge appears to be a PCI-to-PCI bridge device residing on PCI bus 0. Physically, Device 2 contains the standard PCI bridge registers and configuration registers for HI_B.
- **Device 3**: Host-HI_C Bridge. Logically this bridge appears to be a PCI-to-PCI bridge device residing on PCI bus 0. Physically, Device 3 contains the standard PCI bridge registers and configuration registers for HI_C.
- **Device 4**: Host-HI_D Bridge. Logically this bridge appears to be a PCI-to-PCI bridge device residing on PCI bus 0. Physically, Device 4 contains the standard PCI bridge registers and configuration registers for HI_D.

Table 3-1 shows the Device # assignment for the various internal MCH devices. All of these devices are on Bus #0.

Table 3-1. Intel® E7500 MCH Logical Configuration Resources

Intel® MCH Function	Device #, Function #
DRAM Controller (8 bit HI_A)	Device 0, Function 0
DRAM Controller Error Reporting (8 bit HI_A)	Device 0, Function 1
Host-to-HI_B Bridge Controller (16 bit PCI2PCI)	Device 2, Function 0
Host-to-HI_B Bridge Error Reporting (16 bit PCI2PCI)	Device 2, Function 1
Host-to-HI_C Bridge Controller (16 bit PCI2PCI)	Device 3, Function 0
Host-to-HI_C Bridge Error Reporting (16 bit PCI2PCI)	Device 3, Function 1
Host-to-HI_D Bridge Controller (16 bit PCI2PCI)	Device 4, Function 0
Host-to-HI_D Bridge Error Reporting (16 bit PCI2PCI)	Device 4, Function 1

3.3 General Routing Configuration Accesses

The MCH supports up to four hub interfaces: HI_A, HI_B, HI_C, and HI_D. PCI configuration cycles are selectively routed to one of these interfaces. The MCH is responsible for routing PCI configuration cycles to the proper interface. PCI configuration cycles to ICH3-S internal devices and Primary PCI (including downstream devices) are routed to the ICH3-S via HI_A. PCI configuration cycles to any of the 16-bit hub interfaces are routed to HI_B, HI_C, and HI_D. Routing of configuration accesses to HI_B, HI_C, and HI_D is controlled via the standard PCI-PCI bridge mechanism using information contained within the primary bus number, the secondary bus number, and the subordinate bus number registers of the corresponding PCI-PCI bridge device.

A detailed description of the mechanism for translating processor I/O bus cycles to configuration cycles on one of the buses is described below.

Note: The MCH supports a variety of connectivity options. When any of the MCH's interfaces are disabled, the associated interface's device registers are not visible. Configuration cycles to these registers will return all 1s for a read and master abort for a write.

3.3.1 Standard PCI Configuration Mechanism

The PCI bus defines a slot-based configuration space that allows each device to contain up to eight functions; each function contains up to 256, 8-bit configuration registers. The PCI specification defines two bus cycles to access the PCI configuration space: Configuration Read and Configuration Write. Memory and I/O spaces are supported directly by the processor. Configuration space is supported by a mapping mechanism implemented within the MCH. The PCI specification defines two mechanisms to access configuration space, Mechanism 1 and Mechanism 2. **The MCH supports only Mechanism 1**.

The configuration access mechanism makes use of the CONF_ADDR Register and CONF_DATA Register. To reference a configuration register a DWord I/O write cycle is used to place a value into CONF_ADDR that specifies the PCI bus, the device on that bus, the function within the device, and a specific configuration register of the device function being accessed. CONF_ADDR[31] must be 1 to enable a configuration cycle. CONF_DATA then becomes a window into the four

bytes of configuration space specified by the contents of CONF_ADDR. Any read or write to CONF_DATA results in the MCH translating the CONF_ADDR into the appropriate configuration cycle.

The MCH is responsible for translating and routing the processor's I/O accesses to the CONF_ADDR and CONF_DATA Registers to internal MCH configuration registers for HI_A, HI_B, HI_C, and HI_D.

3.3.2 Logical PCI Bus 0 Configuration Mechanism

The MCH decodes the Bus Number (bits 23:16) and the Device Number fields of the CONF_ADDR Register. When the Bus Number field of CONF_ADDR is 0, the configuration cycle is targeting a PCI bus 0 device.

- The Host-HI_A bridge entity within the MCH is hardwired as Device 0 on PCI Bus 0.
- The Host-HI_B bridge entity within the MCH is hardwired as Device 2 on PCI Bus 0.
- The Host-HI_C bridge entity within the MCH is hardwired as Device 3 on PCI Bus 0.
- The Host-HI_D bridge entity within the MCH is hardwired as Device 4 on PCI Bus 0.

Configuration cycles to any of the MCH's enabled internal devices are confined to the MCH and not sent over HI_A. Accesses to devices 8 to 31 are forwarded over HI_A as Type 0. The ICH3-S decodes the Type 0 access and generates a configuration access to the selected internal device.

3.3.3 Primary PCI Downstream Configuration Mechanism

When the Bus Number in the CONF_ADDR is non-zero, and does not lie between the Secondary Bus Number registers and the Subordinate Bus Number registers for one of the HI_16, the MCH will generate a type 1 HI_A configuration cycle.

When the cycle is forwarded to the ICH3-S via HI_A, the ICH3-S compares the non-zero Bus Number with the Secondary Bus Number and Subordinate Bus Number registers of its PCI- PCI bridges to determine if the configuration cycle is meant for Primary PCI, or a downstream PCI bus.

3.3.4 HI_B, HI_C, HI_D Bus Configuration Mechanism

From the chipset configuration perspective, HI_B, HI_C and HI_D are seen as PCI bus interfaces residing on a Secondary Bus side of the "virtual" PCI-PCI bridges referred to as the MCH Host-HI_B, HI_C and HI_D bridge.

Note: There is no requirement that the secondary and subordinate bus number values from one Hub Interface be contiguous with any other Hub Interfaces. It is possible that HI_B will decode buses 2 through 5, HI_C will decode buses 8 through 12, and HI_D will decode buses 13 through 15. In this case there is a gap where buses 6 and 7 are subtractively decoded to HI_A.

When the bus number is non-zero, greater than the value programmed into the Secondary Bus Number Register, and less than or equal to the value programmed into the corresponding Subordinate Bus Number Register, the configuration cycle is targeting a PCI bus downstream of the targeted hub interface. The MCH generates a Type 1configuration cycle on the appropriate hub interface.

3.4 Sticky Registers

Certain registers in the MCH are sticky through a hard-reset. They will only be reset on a power-good reset. These registers in general are the error logging registers and a few special cases. The error command registers are not sticky. The following registers are sticky:

- Device 0, Function 1 error registers
- Device 2, Function 1 error registers
- Device 3, Function 1 error registers
- Device 4, Function 1 error registers
- Others that are determined to need to hold state through reset for function or test purposes

3.5 I/O Mapped Registers

The MCH contains two registers that reside in the processor I/O address space; the Configuration Address (CONF_ADDR) Register and the Configuration Data (CONF_DATA) Register. The Configuration Address Register enables/disables the configuration space and determines what portion of configuration space is visible through the Configuration Data window.

3.5.1 CONF_ADDR—Configuration Address Register

I/O Address: 0CF8h Accessed as a DWord
Default Value: 00000000h
Access: R/W
Size: 32 bits

CONF_ADDR is a 32-bit register that can be accessed only as a DWord. A Byte or Word reference will pass through the Configuration Address Register and HI_A onto the PCI_A bus as an I/O cycle. The CONF_ADDR Register contains the Bus Number, Device Number, Function Number, and Register Number that a subsequent configuration access is intended.

Bit	Descriptions
31	**Configuration Enable (CFGE).** 0 = Disable 1 = Enable
30:24	Reserved (These bits are read only and have a value of 0).
23:16	**Bus Number.** Contains the bus number being targeted by the config cycle.
15:11	**Device Number.** Selects one of the 32 possible devices per bus.
10:8	**Function Number.** Selects one of 8 possible functions within a device.
7:2	**Register Number:** This field selects one register within a particular Bus, Device, and Function as specified by the other fields in the Configuration Address Register. This field is mapped to A[7:2] during HI_A–D Configuration cycles.
1:0	Reserved.

3.5.2 CONF_DATA—Configuration Data Register

I/O Address: 0CFCh
Default Value: 00000000h
Access: Read/Write
Size: 32 bits

CONF_DATA is a 32-bit read/write window into configuration space. The portion of configuration space that is referenced by CONF_DATA is determined by the contents of CONF_ADDR.

Bit	Descriptions
31:0	**Configuration Data Window (CDW).** If bit 31 of CONF_ADDR is 1, any I/O access to the CONF_DATA register are mapped to configuration space using the contents of CONF_ADDR.

3.6 DRAM Controller Registers (Device 0, Function 0)

The DRAM Controller registers are in Device 0 (D0), Function 0 (F0). Table 3-2 provides the register address map for this device, function.

Warning: Address locations that are not listed the table are considered reserved register locations. Writes to "Reserved" registers may cause system failure. Reads to "Reserved" registers may return a non-zero value.

Table 3-2. DRAM Controller Register Map (HI_A—D0:F0)

Offset	Mnemonic	Register Name	Default	Type
00–01h	VID	Vendor ID	8086h	RO
02–03h	DID	Device ID	2540h	RO
04–05h	PCICMD	PCI Command	0006h	RO, R/W
06–07h	PCISTS	PCI Status	0090h	RO, R/WC
08h	RID	Revision ID	02h	RO
0Ah	SUBC	Sub Class Code	00h	RO
0Bh	BCC	Base Class Code	06h	RO
0Dh	MLT	Master Latency Timer	00h	—
0Eh	HDR	Header Type	00h	RO
2C–2Dh	SVID	Subsystem Vendor Identification	0000h	R/WO
2E–2Fh	SID	Subsystem Identification	0000h	R/WO
50–51h	MCHCFG	MCH Configuration	0004h	R/W
52–53h	MCHCFGNS	MCH Memory Scrub and Init Configuration	0000h	RO, R/W
58h	FDHC	Fixed DRAM Hole Control	00h	R/W
59–5Fh	PAM[0:6]	Programmable Attribute Map (7 registers)	00h	R/W
60–6Fh	DRB	DRAM Row Boundary	00h	R/W
70–77h	DRA	DRAM Row Attribute	00h	R/W
78–7Bh	DRT	DRAM Timing	00000010h	R/W
7C–7Fh	DRC	DRAM Controller Mode	00440009h	R/W
8Ch	CLOCK_DIS	CK/CK# Disable	00h	R/W
9Dh	SMRAM	System Management RAM Control	02h	RO, R/W, L
9Eh	ESMRAMC	Extended System Management RAM Control	38h	R/W, R/WC, R/W/L
C4–C5h	TOLM	Top of Low Memory	0800h	R/W
C6–C7h	REMAPBASE	Remap Base Address	03FFh	R/W
C8–C8h	REMAPLIMIT	Remap Limit Address	0000h	R/W
DE–DFh	SKPD	Scratchpad Data	0000h	R/W
E0–E1h	DVNP	Device Not Present	1D1Fh	R/W

3.6.1 VID—Vendor Identification Register (D0:F0)

Address Offset: 00–01h
Default: 8086h
Access: RO
Size: 16 Bits

The VID Register contains the vendor identification number. This 16-bit register combined with the Device Identification Register uniquely identify any PCI device.

Bits	Default, Access	Description
15:0	8086h RO	**Vendor Identification (VID).** This register field contains the PCI standard identification for Intel (VID=8086h).

3.6.2 DID—Device Identification Register (D0:F0)

Address Offset: 02–03h
Default: 2540h
Access: RO
Size: 16 Bits

This 16-bit register combined with the Vendor Identification register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2540h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH Host-HI Bridge Function 0.

3.6.3 PCICMD—PCI Command Register (D0:F0)

Address Offset: O4–05h
Default: 0006h
Access: RO, R/W
Size: 16 Bits

Since MCH Device 0 does not physically reside on a physical PCI bus portions of this register are not implemented.

Bits	Default, Access	Description
15:10	00h	Reserved
9	0b RO	**Fast Back-to-Back Enable (FB2B).** Hardwired to 0. This bit controls whether or not the master can do fast back-to-back writes. Since device 0 is strictly a target this bit is not implemented.
8	0b R/W	**SERR Enable (SERRE).** This is a global enable bit for Device 0 SERR messaging. The MCH does not have an SERR signal. The MCH communicates the SERR condition by sending an SERR message over HI_A to the ICH3-S. 0 = Disable. SERR message is not generated by the MCH for Device 0. 1 = Enable. The MCH is enabled to generate SERR messages over HI_A for specific Device 0 error conditions that are individually enabled in the ERRCMD register. The error status is reported in the ERRSTAT and PCISTS registers. When SERRE is cleared, the SERR message is not generated by the MCH for Device 0. **NOTE:** This bit only controls SERR messaging for the Device 0. Devices 2–4 have their own SERR bits to control error reporting for error conditions occurring on their respective devices. The control bits are used in a logical OR configuration to enable the SERR HI message mechanism.
7	0b RO	**Address/Data Stepping Enable (ADSTEP).** Hardwired to 0. Address/data stepping is not implemented in the MCH.
6	0b R/W	**Parity Error Enable (PERRE).** 0 = Disable. MCH takes no action when it detects a parity error on HI_A. 1 = Enable. MCH generates an SERR message over HI_A to the ICH3-S when an address or data parity error is detected by the MCH on HI_A (DPE set in PCISTS).
5	0b RO	**VGA Palette Snoop Enable (VGASNOOP).** Hardwired to 0. The MCH does not implement this bit.
4	0b RO	**Memory Write and Invalidate Enable (MWIE).** Hardwired to 0. The MCH will never issue memory write and invalidate commands.
3	0b RO	**Special Cycle Enable (SCE).** Hardwired to 0. The MCH does not implement this bit.
2	1b RO	**Bus Master Enable (BME).** Hardwired to 1. The MCH is always enabled as a master on HI_A.
1	1b RO	**Memory Access Enable (MAE).** Hardwired to 1. The MCH always allows access to main memory.
0	0b RO	**I/O Access Enable (IOAE).** Hardwired to 0. This bit is not implemented in the MCH.

3.6.4 PCISTS—PCI Status Register (D0:F0)

Address Offset: 06–07h
Default: 0090h
Access: RO, R/WC
Size: 16 Bits

PCISTS is a 16-bit status register that reports the occurrence of error events on Device 0's PCI interface. All other bits are Read Only. Since MCH Device 0 does not physically reside on a PCI bus, many of these bits are not implemented.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
15	0b R/WC	**Detected Parity Error (DPE).** 0 = No Parity error detected. 1 = MCH detected an address or data parity error on the HI_A interface.
14	0b R/WC	**Signaled System Error (SSE).** 0 = No SERR generated by MCH Device 0. 1 = MCH Device 0 generates an SERR message over HI_A for any enabled Device 0 error condition. Device 0 error conditions are enabled in the PCICMD and ERRCMD Registers. Device 0 error flags are read/reset from the PCISTS or ERRSTAT Registers.
13	0b RO	**Received Master Abort Status (RMAS).** Hardwired to 0. The ICH3-S never sends a Master Abort completion.
12	0b R/WC	**Received Target Abort Status (RTAS).** 0 = No received Target Abort generated by MCH. 1 = MCH generated a HI_A request that received a Target Abort.
11	0b RO	**Signaled Target Abort Status (STAS).** Hardwired to 0. The MCH will not generate a Target Abort on HI_A. This bit is not implemented.
10:9	00b RO	**DEVSEL Timing (DEVT).** These bits are hardwired to 00. Device 0 does not physically connect to PCI_A. These bits are set to 00 (fast decode) so that optimum DEVSEL timing for PCI_A is not limited by the MCH.
8	0b RO	**Master Data Parity Error Detected (DPD).** Hardwired to 0. PERR signaling and messaging are not implemented by the MCH.
7	1b RO	**Fast Back-to-Back (FB2B).** Hardwired to 1. Device 0 does not physically connect to PCI_A. This bit is set to 1 (indicating fast back-to-back capability) so that the optimum setting for PCI_A is not limited by the MCH.
6:0	00h	Reserved

3.6.5 RID—Revision Identification Register (D0:F0)

Address Offset: 08h
Default: See table below
Access: RO
Size: 8 Bits

This register contains the revision number of the MCH Device 0.

Bits	Default, Access	Description
7:0	00h RO	**Revision Identification Number (RID).** This is an 8-bit value that indicates the revision identification number for the MCH Device 0. 02h = A2 stepping

3.6.6 SUBC—Sub-Class Code Register (D0:F0)

Address Offset: 0Ah
Default: 00h
Access: RO
Size: 8 Bits

This register contains the Sub-Class Code for the MCH Device 0.

Bits	Default, Access	Description
7:0	00h RO	**Sub-Class Code (SUBC).** This is an 8-bit value that indicates the category of Bridge into which the MCH falls. 00h = Host bridge.

3.6.7 BCC—Base Class Code Register (D0:F0)

Address Offset: 0Bh
Default: 06h
Access: RO
Size: 8 Bits

This register contains the Base Class Code of the MCH Device 0.

Bits	Default, Access	Description
7:0	06h RO	**Base Class Code (BASEC).** This is an 8-bit value that indicates the Base Class Code for the MCH. 06h = Bridge device.

3.6.8 MLT—Master Latency Timer Register (D0:F0)

Address Offset: 0Dh
Default: 00h
Access: Reserved
Size: 8 Bits

Device 0 in the MCH is not a PCI master. Therefore, this register is not implemented.

Bits	Default, Access	Description
7:0	00h	Reserved

3.6.9 HDR—Header Type Register (D0:F0)

Address Offset: 0Eh
Default: 00h
Access: RO
Size: 8 Bits

This register identifies the header layout of the configuration space.

Bits	Default, Access	Description
7:0	00h RO	**PCI Header (HDR).** This register returns 00 when Device 0, Function 1 is disabled. If Device 0, Function 1 is enabled via the DVNP Register, this register (HDR) returns 80h.

3.6.10 SVID—Subsystem Vendor Identification Register (D0:F0)

Address Offset: 2C–2Dh
Default: 0000h
Access: R/WO
Size: 16 Bits

This value is used to identify the vendor of the subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem Vendor ID (SUBVID).** This field should be programmed during boot-up to indicate the vendor of the system board. After it has been written once, it becomes read only.

3.6.11 SID—Subsystem Identification Register (D0:F0)

Address Offset: 2E–2Fh
Default: 0000h
Access: R/WO
Size: 16 Bits

This value is used to identify a particular subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem ID (SUBID).** This field should be programmed during BIOS initialization. After it has been written once, it becomes read only.

3.6.12 MCHCFG—MCH Configuration Register (D0:F0)

Address Offset: 50–51h
Default: 0004h
Access: R/W
Size: 16 Bits

This register controls how the MCH tracks and routes system bus transactions.

Bits	Default, Access	Description
15:13	000b, R/W	**Number of Stop Grant Cycles (NSG).** These bits indicate the number of Stop Grant transactions expected on the system bus before a Stop Grant Acknowledge packet is sent to the ICH3-S. This field is programmed by the BIOS after it has enumerated the processors and before it has enabled Stop Clock generation in the ICH3-S. Once this field has been set, it should not be modified. 000 = HI_A Stop Grant generated after 1 Stop Grant 001 = HI_A Stop Grant generated after 2 Stop Grant 010 = HI_A Stop Grant generated after 3 Stop Grant 011 = HI_A Stop Grant generated after 4 Stop Grant Others = Reserved
12:6	000000b	Reserved

Bits	Default, Access	Description
5	0b R/W	**MDA Present (MDAP).** This bit works with the VGA Enable bits in the BCTRL Registers of devices 2–4 to control the routing of processor initiated transactions targeting MDA compatible I/O and memory address ranges. This bit should not be set if none of the VGA Enable bits are set. When none of the VGA enable bits are set, accesses to I/O address range x3BCh–x3BFh are forwarded to HI_A. When the VGA enable bit is not set, accesses to I/O address range x3BCh–x3BFh are treated just like any other I/O accesses. That is, the cycles are forwarded to HI_B–D if the address is within the corresponding IOBASE and IOLIMIT and ISA enable bit is not set; otherwise, they are forwarded to HI_A. MDA resources are defined as the following: Memory: 0B0000h – 0B7FFFh I/O: 3B4h, 3B5h, 3B8h, 3B9h, 3BAh, 3BFh, (including ISA address aliases, A[15:10] are not used in decode) Any I/O reference that includes the I/O locations listed above, or their aliases, will be forwarded to the hub interface, even if the reference includes I/O locations not listed above. The following shows the behavior for all combinations of MDA and VGA: **VGAMDABehavior** 0 0 All References to MDA and VGA go to HI_A 0 1 Illegal Combination (DO NOT USE) 1 0 All References to VGA go to device with VGA enable set. MDA-only references (I/O address 3BFh and aliases) will go to HI_A. 1 1 VGA References go to the hub interface that has its VGAEN bit set. MDA References go to HI_A
4	0b R/W	**Throttled-Write Occurred.** 0 =Writing a zero clears this bit. 1 =This bit is set when a write is throttled. This bit is set when the maximum allowed number of writes has been reached during a time-slice and there is at least one more write to be completed.
3	0b	Reserved
2	0b RO	**In-Order Queue Depth (IOQD).** This bit reflects the value sampled on HA7# on the deassertion of the CPURST#. It indicates the depth of the processor bus in-order queue. 0 = When IOQD is set to 0 (HA7# is sampled asserted; i.e., 1; or an electrical low), the depth of the IOQ is set to 1 (i.e., no pipelining support on the processor bus). HA7# may be driven low during CPURST# by an external source. 1 = When IOQD is set to 1 (HA7# sampled as 0; an electrical high), the depth of the processor bus in-order queue is configured to the maximum allowed by the processor protocol (i.e., 12).
1:0	00b	Reserved

3.6.13 MCHCFGNS—MCH Memory Scrub and Initialization Configuration Register (D0:F0)

Address Offset:	52–53h
Default:	0000h
Access:	RO, R/W
Size:	16 Bits

This register controls the mode and status of the DRAM memory scrubber.

Bits	Default, Access	Description
15:4	000h	Reserved
3	0b RO	**Valid ECC Initialization Complete.** BIOS should poll this bit after enabling auto-initialization to determine when all the ECC values have been written to DRAM. 1 = The scrub unit sets this bit to 1 after it has completed placing valid ECC data in each line of memory.
2	0b R/W	**Initialization/Scrub Mode Select.** This bit determines if the MCH is initializing memory (with valid ECC data) or running standard memory scrubbing. In the Initialization Mode, the MCH issues memory writes as quickly as possible and places valid ECC in each memory location. In Scrubbing Mode, the MCH scrubs a memory location (read a memory line and correct any ECC errors) every 32,000 clocks. This scrubs an entire 16 GB memory array in approximately 1 day. 0 = Valid ECC Init Mode 1 = ECC Scrub Mode BIOS should set this bit to 0, enable scrubbing via bit 0, wait until bit 3 (Valid ECC Init Complete) is set, and set this bit to 1 (or disable scrubbing).
1	0b	Reserved
0	0b R/W	**Memory Initialization/Scrub Enable.** This bit enables Valid ECC Init Mode or ECC Scrub Mode depending on the value in bit 2 (Init/Scrub Mode Select). 0 = Disable 1 = Enable

3.6.14 FDHC—Fixed DRAM Hole Control Register (D0:F0)

Address Offset:	58h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

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

Bit Field	Default and Access	Description
7	0b RW	**Hole Enable (HEN).** This field enables a memory hole in DRAM space. The DRAM that lies "behind" this space is not remapped. 0 = No memory hole 1 = Memory hole from 15 MB to 16 MB. Accesses to this range will be sent to HI_A.
6:0	00h	Reserved

3.6.15 PAM[0:6]—Programmable Attribute Map Registers (D0:F0)

Address Offset:	59–5Fh (PAM0–PAM6)
Default Value:	00h
Access:	R/W
Size:	8 bits each

The MCH allows programmable memory attributes on 13 *legacy* memory segments of various sizes in the 640 KB to 1 MB address range. Seven Programmable Attribute Map (PAM) Registers support these features. However, not all seven of these registers are identical. PAM 0 controls only one segment (high), while PAM 1:6 controls two segments (high and low) each. Cacheability of these areas is controlled via the MTRR Registers in the processor. Two bits are used to specify memory attributes for each memory segment. These bits only apply to host initiator access to the PAM areas. The MCH forwards to main memory any Hub Interface_A–D initiated accesses to the PAM areas. At the time that hub interface accesses to the PAM region may occur, the targeted PAM segment must be programmed to be both readable and writeable. It is illegal to issue a hub initiated transaction to a PAM region with the associated PAM register not set to 11. Each of these regions has a 2-bit field. The two bits that control each region have the same encoding.

As an example, consider BIOS that is implemented on the expansion bus. During the initialization process, BIOS can be shadowed in main memory to increase the system performance. When BIOS is shadowed in main memory, it should be copied to the same address location. To shadow the BIOS, the attributes for that address range should be set to write only. The BIOS is shadowed by first doing a read of that address. This read is forwarded to the expansion bus. The host then does a write of the same address, which is directed to main memory. After the BIOS is shadowed, the attributes for that memory area are set to read only so that all writes are forwarded to the expansion bus. Table 3-3and Figure 3-1 show the PAM Registers and the associated attribute bits:

Bits	Default, Access	Description
7:6	00b	Reserved
5:4	00b R/W	**Attribute Register (HIENABLE).** This field controls the steering of read and write cycles that address the BIOS. 00 = DRAM Disabled - All accesses are directed to HI_A 01 = Read Only - All Reads are serviced by DRAM. All Writes are forwarded to HI_A. 10 = Write Only - All writes are sent to DRAM. Reads are serviced by HI_A. 11 = Normal DRAM operation - All reads and writes are serviced by DRAM
3:2	0h	Reserved
1:0	00b R/W	**Attribute Register (LOENABLE).** This field controls the steering of read and write cycles that address the BIOS. 00 =DRAM Disabled - All accesses are directed to HI_A 01 =Read Only - All Reads are serviced by DRAM. All Writes are forwarded to HI_A. 10 =Write Only - All writes are sent to DRAM. Reads are serviced by HI_A. 1 1 =Normal DRAM operation - All reads and writes are serviced by DRAM **NOTE:** The LO Segment for PAM0 is reserved as shown in Figure 3-1.

Figure 3-1. PAM Registers

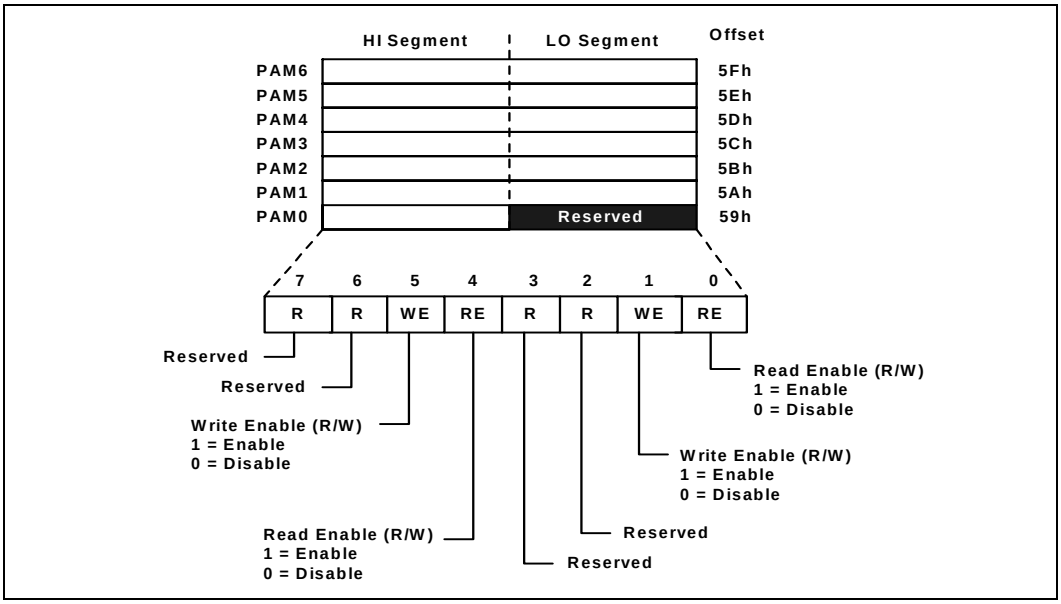


Table 3-3. PAM Associated Attribute Bits

PAM Reg	Attribute Bits				Memory Segment	Comments	Offset
PAM0 3:0, 7:6	Reserved				—	—	59h
PAM0 5:4	R	R	WE	RE	0F0000h–0FFFFFh	BIOS Area	59h
PAM1 3:2, 7:6	—	—	—	—	—	Reserved	5Ah
PAM1 1:0	R	R	WE	RE	0C0000h–0C3FFFh	BIOS Area	5Ah
PAM1 5:4	R	R	WE	RE	0C4000h–0C7FFFh	BIOS Area	5Ah
PAM2 3:2, 7:6	—	—	—	—	—	Reserved	5Bh
PAM2 1:0	R	R	WE	RE	0C8000h–0CBFFFh	BIOS Area	5Bh
PAM2 5:4	R	R	WE	RE	0CC000h–0CFFFFh	BIOS Area	5Bh
PAM3 3:2, 7:6	—	—	—	—	—	Reserved	5Ch
PAM3 1:0	R	R	WE	RE	0D0000h–0D3FFFh	BIOS Area	5Ch
PAM3 5:4	R	R	WE	RE	0D4000h–0D7FFFh	BIOS Area	5Ch
PAM4 3:2, 7:6	—	—	—	—	—	Reserved	5Dh
PAM4 1:0	R	R	WE	RE	0D8000h–0DBFFFh	BIOS Area	5Dh
PAM4 5:4	R	R	WE	RE	0DC000h–0DFFFFh	BIOS Area	5Dh
PAM5 3:2, 7:6	—	—	—	—	—	Reserved	5Eh
PAM5 1:0	R	R	WE	RE	0E0000h–0E3FFFh	BIOS Extension	5Eh
PAM5 5:4	R	R	WE	RE	0E4000h–0E7FFFh	BIOS Extension	5Eh
PAM6 3:2, 7:6	—	—	—	—	—	Reserved	5Fh
PAM6 1:0	R	R	WE	RE	0E8000h–0EBFFFh	BIOS Extension	5Fh
PAM6 5:4	R	R	WE	RE	0EC000h–0EFFFFh	BIOS Extension	5Fh

3.6.16 DRB—DRAM Row Boundary Register (D0:F0)

Address Offset:	60–6Fh
Default:	00h
Access:	R/W
Size:	8 Bits

The DRAM Row Boundary Register defines the upper boundary address of each DRAM row with a granularity of 64 MB. A row is 144 bits wide (72 bits per channel). Each row has its own single-byte DRB Register. For example, a value of 1 in DRB0 indicates that 64 MB of DRAM has been populated in the first row.

Note: The MCH DRAM Row Boundary Registers (DRB Registers) are 8-bits wide, and define the upper boundary address for each DRAM row with a granularity of 64 MB. The DRB Registers are cumulative; therefore, DRB7 will contain the total memory contained in all eight DRAM rows. By this definition, the system is only allowed to report 16 GB–64 MB of memory populated.

Bits	Default, Access	Description
7:0	00h R/W	**DRAM Row Boundary Address.** This 8-bit value defines the upper and lower addresses for each row of DRAM. This 8-bit value is compared against a set of address lines to determine the upper address limit of a particular row.

Row 0 = 60h
Row 1 = 61h
Row 2 = 62h
Row 3 = 63h
Row 4 = 64h
Row 5 = 65h
Row 6 = 66h
Row 7 = 67h
68h to 6Fh are reserved

DRB0 = Total memory in row 0 (in 64 MB increments)

DRB1 = Total memory in row 0 + row 1 (in 64 MB increments)

DRB3 = Total memory in row 0 + row 1 + row 2 + row 3 (in 64 MB increments)

The row referred to by this register is defined by the DIMM chip select used. Double-sided DIMMs use both Row 0 and Row 1 (for CS0# and CS1#), even though there is one physical slot for the DIMM. Single-sided DIMMs use only the even row number, since single-sided DIMMs only support CS0#. For single-sided DIMMs, the value BIOS places in the odd row should equal the same value as what was placed in the even row field. A row is defined as 128-bit (144 bit with ECC) wide interface consisting of two identical DIMMs.

3.6.17 DRA—DRAM Row Attribute Register (D0:F0)

Address Offset:	70–77h
Default:	R/W
Size:	8 Bits
Default:	00h

The DRAM Row Attribute Register defines the page sizes to be used for each row of memory. Each nibble of information in the DRA registers describes the page size and device width of a row. For this register, a row is defined by the chip select used by the DIMM, so that a double-sided DIMM would have both an even and an odd entry. For single-sided DIMMs, only the even side is used.

Row 0, 1 = 70h
Row 2, 3 = 71h
Row 4, 5 = 72h
Row 6, 7 = 73h

Bits	Default, Access	Description
7	0b R/W	**Device Width for Odd-numbered Row.** This bit defines whether the DDR-SDRAM devices populated in this row are 4 bits wide (x4) or 8 bits wide. 0 =8 bits wide. 1 =4 bits wide (x4).
6:4	000b R/W	**Row Attribute for Odd-numbered Row.** This 3-bit field defines the page size of the corresponding row. 010 = 8 KB 011 = 16 KB 100 = 32 KB 101 = 64 KB Others = Reserved
3	0b R/W	**Device Width for Even-numbered Row.** This bit defines whether the DDR-SDRAM devices populated in this row are 4 bits wide (x4) or 8 bits wide. 0 =8 bits wide. 1 =4 bits wide (x4).
2:0	000b R/W	**Row Attribute for Even-numbered Row.** This 3-bit field defines the page size of the corresponding row. 010 = 8 KB 011 = 16 KB 100 = 32 KB 101 = 64 KB Others = Reserved

3.6.18 DRT—DRAM Timing Register (D0:F0)

Address Offset: 78–7Bh
Access: R/W
Size: 32 Bits
Default: 00000010h

This register controls the timing of the DRAM Interface.

Bits	Default, Access	Description
31:30	00b	Reserved
29	0b R/W	**Back to Back Write-Read Turn Around.** This field determines the minimum number of CMDCLK (command clocks, at 100 MHz) between Write-Read commands. It applies to WR-RD pairs to different rows. The WR-RD pair to the same row has sufficient turnaround due to the t_{WTR} timing parameter. The purpose of this bit is to control the turnaround time on the DQ bus. 0 = 3 clocks between WR-RD commands (2 turnaround clocks on DQ) 1 = 2 clocks between WR-RD commands (1 turnaround clock on DQ)
28	0b R/W	**Back to Back Read-Write Turn Around.** This field determines the minimum number of CMDCLK (command clocks, at 100 MHz) between Read-Write commands. It applies to RD-WR pairs to any destination, in same or different rows. The purpose of this bit is to control the turnaround time on the DQ bus. 0 = 5 clocks between RD-WR commands (2 turnaround clocks on DQ) 1 = 4 clocks between RD-WR commands (1 turnaround clock on DQ)
27	0b R/W	**Back to Back Read Turn Around.** This field determines the minimum number of CMDCLK (command clocks, at 100 MHz) between two reads destined to different rows. The purpose of this bit is to control the turnaround time on the DQ bus. 0 = 4 clocks between RD commands to different rows (2 turnaround clocks on DQ) 1 = 3 clocks between RD commands to different rows (1 turnaround clock on DQ)
26:24	000b R/W	**Read Delay (t_{RD}).** This field controls the number of 100 MHz clocks elapsed from the Read Command latched on the system bus until the returned data is set to be driven on the system bus. The following t_{RD} values are supported. 000 = 7 clocks 001 = 6 clocks 010 = 5 clocks Others = Reserved
23:11	00000b	Reserved
10:9	00b R/W	**Activate to Precharge delay (t_{RAS}).** This bit controls the number of DRAM clocks for t_{RAS}. 00 = 7 Clocks 01 = 6 Clocks 10 = 5 Clocks 11 = Reserved
8:6	0000b	Reserved
5:4	01b R/W	**CAS# Latency (t_{CL}).** The number of clocks between the rising edge used by DRAM to sample the Read Command and the rising edge used by the DRAM to drive read data. 00 = 2.5 Clocks 01 = 2 Clocks 10 = 1.5 Clocks 11 = Reserved

Bits	Default, Access	Description
3	0b R/W	**Write RAS# to CAS# Delay (t_{RCD}).** This bit controls the number of clocks inserted between a row activate command and write command to that row. 0 = 3 DRAM Clocks 1 = 2 DRAM Clocks
2	0b	Reserved
1	0b R/W	**Read RAS# to CAS# Delay (t_{RCD}).** This bit controls the number of clocks inserted between a row activate command and a read command to that row. 0 = 3 DRAM Clocks 1 = 2 DRAM Clocks
0	0b R/W	**DRAM RAS# Precharge (t_{RP}).** This bit controls the number of clocks that are inserted between a row precharge command and an activate command to the same row. 0 = 3 DRAM Clocks 1 = 2 DRAM Clocks

3.6.19 DRC—DRAM Controller Mode Register (D0:F0)

Address Offset: 7C–7Fh
Default: 0044_0009h
Access: R/W
Size: 32 Bits

This register controls the mode of the DRAM Controller.

Bits	Default, Access	Description
31:30	00b	Reserved
29	0b R/W	**Initialization Complete (IC).** This bit is used for communicating the software state between the memory controller and the BIOS. It indicates that the DRAM interface has been initialized. This bit must be set and the refresh mode select (DRC[9:8]) must be set to enable refresh. If this bit is clear, no refresh will occur regardless of the RMS (DRC[9:8]) setting.
28:22	00h	Reserved
21:20	00b R/W	**DRAM Data Integrity Mode (DDIM).** These bits select one of two DRAM data integrity modes. 00 =Disable. No ECC correction is performed and no errors are flagged in DRAM_FERR or DRAM_NERR. 01 =Reserved 10 =Error checking, using chip-kill, with correction 11 =Reserved
19:18	01b	Reserved
17	0b	Reserved
16	0b R/W	**Command Per Clock – Address/Control Assertion Rule (CPC).** This bit defines the number of clock cycles the MA, RAS#, CAS#, WE# are asserted. 0 = 2n rule: (MA [12:0]}, RAS#, CAS#, WE# asserted for 2 clock cycles) 1 = 1n Rule (MA [12:0]}, RAS#, CAS#, WE# asserted for 1 clock cycle)
15:10	00b	Reserved

Bits	Default, Access	Description
9:8	00b R/W	**Refresh Mode Select (RMS).** This field determines whether refresh is enabled and, if so, at what rate refreshes will be executed. 00 = Refresh Disabled 01 = Refresh Enabled. Refresh interval 15.6 µsec 10 = Refresh Enabled. Refresh interval 7.8 µsec 11 = Refresh Enabled. Refresh interval 64 µsec
7	0b	Reserved
6:4	000b R/W	**Mode Select (SMS).** These bits select the special operational mode of the DRAM interface. The special modes are intended for initialization at power up. 000 =Self refresh. In this mode CKEs are deasserted and the DRAMS are in self-refresh mode. All other combinations of SMS bits result in assertion of one or more CKEs, except when the device is in C3 or S1 state, where all devices are in self-refresh, without regard to the value in SMS. 001 =NOP Command Enable. All processor cycles to DRAM result in a NOP command on the DRAM interface. 010 =All Banks Precharge Enable. All processor cycles to DRAM result in an “all banks precharge” command on the DRAM interface. 011 =Mode register Set Enable. All processor cycles to DRAM result in a “mode register” set command on the DRAM interface. Host address lines are mapped to SDRAM address lines in order to specify the command sent. Host address lines 15:3 are typically mapped to MA[12:0]. 100 = Extended Mode Register Set Enable. All processor cycles to SDRAM result in an “extended mode register set” command on the DRAM interface (DDR only). Host address lines are mapped to SDRAM address lines in order to specify the command sent. Host address lines 15:3 are typically mapped to MA[12:0]. 101 =Reserved. 110 =CBR Refresh Enable. In this mode all processor cycles to DRAM result in a CBR cycle on the SDRAM interface 111 =Normal operation
3:0	0000b	Reserved

3.6.20 CLOCK_DIS—CK/CK# Disable Register (D0:F0)

Address Offset: 8Ch
Default: 00h
Sticky: No
Access: R/W
Size: 8 Bits

This register controls the DDR clocks for each DIMM.

Bit	Default, Access	Description
7:4	0h	Reserved
3:0	0h R/W	**CK/CK# Disable.** Each bit of this four bit field corresponds to a pair of ck/ck# pins on both channels. Bit 0 corresponds to CK0 and CK0# while bit 3 corresponds to CK3 and CK3#. 1 = These bits turn off the corresponding CK/CK# pair. CK is driven low and CK# is driven high. This feature is intended to reduce EMI due to clocks toggling to DIMMs which are not populated.

3.6.21 SMRAM—System Management RAM Control Register (D0:F0)

Address Offset:	9Dh
Default:	02h
Access:	RO, R/W, L
Size:	8 Bits

The SMRAMC Register controls how accesses to Compatible and Extended SMRAM spaces are treated. The Open, Close, and Lock bits function only when G_SMRAME bit is set to 1. The Open bit must be reset before the Lock bit is set.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SMM Space Open (D_OPEN).** 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.
5	0b R/W	**SMM Space Closed (D_CLS).** 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	0b R/W	**SMM Space Locked (D_LCK).** When D_LCK is set to 1, 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 and 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 the BIOS itself) can violate the integrity of SMM space, even if the program has knowledge of the D_OPEN function.
3	0b L	**Global SMRAM Enable (G_SMRAME).** If set to 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 must be set to 1. Refer to Section 4.3, “SMM Space” on page 4-117 for more details regarding SMM. Once D_LCK is set, this bit becomes read only.
2:0	010b RO	**Compatible SMM Space Base Segment (C_BASE_SEG).** This field indicates the location of SMM space. SMM DRAM is not remapped. It is simply made visible if the conditions are right to access SMM space, otherwise the access is forwarded to the hub interface. Since the MCH supports only the SMM space between A0000h and BFFFFh, this field is hardwired to 010.

3.6.22 ESMRAMC—Extended System Management RAM Control Register (D0:F0)

Address Offset:	9Eh
Default:	38h
Access:	R/W, R/WC, R/W/L
Size:	8 Bits

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 MB.

Bits	Default, Access	Description
7	0b R/W/L	**Enable High SMRAM (H_SMRAME).** Controls the SMM memory space location (i.e., above 1 MB or below 1 MB) When G_SMRAME is 1 and H_SMRAME is set to 1, the high SMRAM memory space is enabled. SMRAM accesses within the range 0FFEA0000h to 0FFEAFFFFh are remapped to DRAM addresses within the range 000A0000h to 000BFFFFh. Once D_LCK has been set, this bit becomes read only.
6	0b R/WC	**Invalid SMRAM Access (E_SMERR).** 1 = This bit is set when the processor 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. **Note:** Software must write a 1 to this bit to clear it.
5:3	111b	Reserved
2:1	00b R/W	**TSEG Size (TSEG_SZ).** Selects the size of the TSEG memory block if enabled. Memory from the top of main memory space (TOLM - TSEG_SZ) to TOLM is partitioned away so that it may only be accessed by the processor interface and only then when the SMM bit is set in the request packet. Non-SMM accesses to this memory region are sent to the hub interface when the TSEG memory block is enabled. **EncodingDescription** 00 (TOLM–128 KB) to TOLM 01 (TOLM–256 KB) to TOLM 10 (TOLM–512 KB) to TOLM 11 (TOLM–-1 MB) to TOLM
0	0b R/W/L	**TSEG Enable (TSEG_EN).** Enables SMRAM memory for Extended SMRAM space only. When G_SMRAME =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.

3.6.23 TOLM—Top of Low Memory Register (D0:F0)

Address Offset:	C4–C5h
Default:	0800h
Access:	R/W
Size:	16 Bits

This register contains the maximum address below 4 GB that should be treated as main memory, and is defined on a 128-MB boundary. Normally, it is set below the areas configured for the hub interface and PCI memory. Note that the memory address found in DRB7 reflects the top of total memory. In the event that the total of PCI space to main memory combined is less than 4 GB, these two registers will be set the same.

Bits	Default, Access	Description
15:11	00001b R/W	**Top of Low Memory (TOLM).** This register contains the address that corresponds to bits 31:27 of the maximum DRAM memory address that lies below 4 GB.
10:0	000h	Reserved

3.6.24 REMAPBASE—Remap Base Address Register (D0:F0)

Address Offset:	C6–C7h
Default:	03FFh
Access:	R/W
Size:	16 Bits

This register specifies the lower boundary of the remap window. Refer to Section 4.4 for more information.

Bits	Default, Access	Description
15:10	000000b	Reserved
9:0	3FFh R/W	**Remap Base Address [35:26].** The value in this register defines the lower boundary of the remap window. The remap window is inclusive of this address. A[25:0] of the remap Base Address are assumed to be 0s. Thus, the bottom of the defined memory range will be aligned to a 64-MB boundary. When the value in this register is greater than the value programmed into the Remap Limit Register, the Remap window is disabled. This field defaults to FFh.

3.6.25 REMAPLIMIT—Remap Limit Address Register (D0:F0)

Address Offset: C8–C9h
Default: 0000h
Access: R/W
Size: 16 Bits

This register specifies the upper boundary of the remap window

Bits	Default, Access	Description
15:10	000000b	Reserved
9:0	000h R/W	**Remap Base Address [35:26].** The value in this register defines the upper boundary of the remap window. The remap window is inclusive of this address. A[25:0] of the Remap Limit Address are assumed to be Fs. Thus, the top of the defined memory range will be one less than a 64-MB boundary. When the value in this register is less than the value programmed into the Remap Base Register, the remap window is disabled.

3.6.26 SKPD—Scratchpad Data Register (D0:F0)

Address Offset: DE–DFh
Default: 0000h
Access: R/W
Size: 16 Bits

This register contains bits that can be used for general purpose storage.

Bits	Default, Access	Description
15:0	0000h R/W	**Scratchpad (SCRTCH).** These bits are R/W storage bits that have no effect on the MCH functionality.

3.6.27 DVNP—Device Not Present Register (D0:F0)

Address Offset: E0–E1h
Default: 1D1Fh
Access: R/W
Size: 16 Bits

This register is used to control whether the Function 1 portions of the PCI configuration space for Devices 0, 2, 3, and 4 is visible to software. If a device's Function 1 is disabled, that device will appear to have only 1 function (Function 0).

Bits	Default, Access	Description
15:5	0E8h	Reserved
4	1b R/W	**Device 4, Function 1 Present.** 0 = Present 1 = **Not** present
3	1b R/W	**Device 3, Function 1 Present.** 0 = Present 1 = **Not** present
2	1b R/W	**Device 2, Function 1 Present.** 0 = Present 1 = **Not** present
1	1b	Reserved
0	1b R/W	**Device 0, Function 1 Present.** 0 = Present 1 = **Not** present

3.7 DRAM Controller Error Reporting Registers (Device 0, Function 1)

This section describes the DRAM Controller registers for Device 0 (D0), Function 1 (F1). Table 3-4 provides the register address map for this device, function.

Warning: Address locations that are not listed in the table are considered reserved register locations. Writes to "Reserved" registers may cause system failure. Reads to "Reserved" registers may return a non-zero value.

Table 3-4. DRAM Controller Register Map (HI_A—D0:F1)

Offset	Mnemonic	Register Name	Default	Type
00–01h	VID	Vendor ID	8086h	RO
02–03h	DID	Device ID	2541h	RO
04–05h	PCICMD	PCI Command	0000h	R/W
06–07h	PCISTS	PCI Status	0000h	R/WC
08h	RID	Revision ID	02h	RO
0Ah	SUBC	Sub Class Code	00h	RO
0Bh	BCC	Base Class Code	FFh	RO
0Dh	MLT	Master Latency Timer	00h	—
0Eh	HDR	Header Type	00h or 80h	RO
2C–2Dh	SVID	Subsystem Vendor Identification	0000h	R/WO
2E–2Fh	SID	Subsystem Identification	0000h	R/WO
40–43h	FERR_GLOBAL	Global Error	00000000h	R/WC
44–47h	NERR_GLOBAL	Global Error	00000000h	R/WC
50h	HIA_FERR	Hub Interface_A First Error	00h	R/WC
52h	HIA_NERR	Hub Interface_A Next Error	00h	R/WC
58h	SCICMD_HIA	SCI Command	00h	R/W
5Ah	SMICMD_HIA	SMI Command	00h	R/W
5Ch	SERRCMD_HIA	SERR Command	00h	R/W
60h	SYSBUS_FERR	System Bus First Error	00h	R/WC
62h	SYSBUS_NERR	System Bus Next Error	00h	R/WC
68h	SCICMD_SYSBUS	SCI Command	00h	R/W
6Ah	SMICMD_SYSBUS	SMI Command	00h	R/W
6Ch	SERRCMD_SYSBUS	SERR Command	00h	R/W
80h	DRAM_FERR	DRAM First Error	00h	R/WC
82h	DRAM_NERR	DRAM Next Error	00h	R/WC
88h	SCICMD_DRAM	SCI Command	00h	R/W
8Ah	SMICMD_DRAM	SMI Command	00h	R/W
8Ch	SERRCMD_DRAM	SERR Command	00h	R/W

Table 3-4. DRAM Controller Register Map (HI_A—D0:F1) (Continued)

Offset	Mnemonic	Register Name	Default	Type
A0–A3h	DRAM_CELOG_ADD	DRAM Firs Correctable Memory Error Address	00000000h	RO
B0–B3h	DRAM_UELOG_ADD	DRAM Firs Uncorrectable Memory Error Address	00000000h	RO
D0–D1h	DRAM_CELOG_ SYNDROME	DRAM First Correctable Memory Error	0000h	RO

3.7.1 VID—Vendor Identification Register (D0:F1)

Address Offset: 00–01h
Default: 8086h
Sticky No
Access: RO
Size: 16 Bits

The VID Register contains the vendor identification number. This 16-bit register combined with the Device Identification Register uniquely identify any PCI device.

Bits	Default, Access	Description
15:0	8086h RO	**Vendor Identification Device (VID).** This register field contains the PCI standard identification for Intel (VID=8086h).

3.7.2 DID—Device Identification Register (D0:F1)

Address Offset: 02–03h
Default: 2541h
Sticky: No
Access: RO
Size: 16 Bits

This 16-bit register combined with the Vendor Identification register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2541h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH Host-HI Bridge.

3.7.3 PCICMD—PCI Command Register (D0:F1)

Address Offset:	04-05h
Default:	0000h
Sticky:	No
Access:	R/W
Size:	16 Bits

Since MCH Device 0 does not physically reside on a physical PCI bus portions of this register are not implemented.

Bits	Default, Access	Description
15:9	00h	Reserved
8	0b R/W	**SERR Enable (SERRE).** This bit is a global enable bit for Device 0 SERR generations. 0 = Disable. SERR is not generated by the MCH for Device 0. 1 = Enable. The MCH is enabled to generate an SERR for specific Device 0 error conditions that are individually enabled in the SERRCMD register.
7:0	00h	Reserved

3.7.4 PCISTS—PCI Status Register (D0:F1)

Address Offset:	06-07h
Default:	0000h
Sticky:	No
Access:	R/WC
Size:	16 Bits

PCISTS is a 16-bit status register that reports the occurrence of error events on Device 0s PCI interface. Since MCH Device 0 does not physically reside on a PCI bus, this register is not implemented.

Bits	Default, Access	Description
15	0b	Reserved
14	0b R/WC	**Signaled System Error (SSE).** 0 = SERR Not generated by MCH Device 0 1 = MCH Device 0 generated a SERR. **Note:** Software sets this bit to 0 by writing a 1 to it.
13:0	0000h	Reserved

3.7.5 RID—Revision Identification Register (D0:F1)

Address Offset:	08h
Default:	See table below
Sticky:	No
Access:	RO
Size:	8 Bits

This register contains the revision number of the MCH Device 0.

Bits	Default, Access	Description
7:0	02h RO	**Revision Identification Number (RID).** This is an 8-bit value that indicates the revision identification number for the MCH Device 0. This number should always be the same as the RID for device 0, function 0. 02h = A2 stepping

3.7.6 SUBC—Sub-Class Code Register (D0:F1)

Address Offset:	0Ah
Default:	00h
Sticky:	No
Access:	RO
Size:	8 Bits

This register contains the Sub-Class Code for the MCH Device 0, Function 1.

Bits	Default, Access	Description
7:0	00h RO	**Sub-Class Code (SUBC).** This is an 8-bit value that indicates sub-class code for the MCH Device 0, Function 1. The code is 00h.

3.7.7 BCC—Base Class Code Register (D0:F1)

Address Offset: 0Bh
Default: FFh
Sticky: No
Access: RO
Size: 8 Bits

This register contains the Base Class Code of the MCH Device 0, Function 1.

Bits	Default, Access	Description
7:0	FFh RO	**Base Class Code (BASEC).** This is an 8-bit value that indicates the Base Class Code for the MCH. FFh =Non-defined device. Since this function is used for error conditions, it does not fall into any other class.

3.7.8 MLT—Master Latency Timer Register (D0:F1)

Address Offset: 0Dh
Default: 00h
Sticky: No
Access: Reserved
Size: 8 Bits

Device 0 in the MCH is not a PCI master. Therefore, this register is not implemented.

Bits	Default, Access	Description
7:0	00h	Reserved

3.7.9 HDR—Header Type (D0:F1)

Address Offset:	0Eh
Default:	00h or 80h
Sticky:	No
Access:	RO
Size:	8 Bits

This register identifies the header layout of the configuration space. It is hardwired to 80h to indicate a multi-function device.

Bits	Default, Access	Description
7:0	00h or 80h RO	**PCI Header (HDR).** This read only field always returns 00h or 80h (value depends on Device Not Present Register) to indicate that the MCH is a multi-function device with standard header layout.

3.7.10 SVID—Subsystem Vendor Identification Register (D0:F1)

Address Offset:	2Ch
Default:	0000h
Sticky:	No
Access:	R/WO
Size:	16 Bits

This value is used to identify the vendor of the subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem Vendor ID (SUBVID).** This field should be programmed during boot-up to indicate the vendor of the system board. After it has been written once, it becomes read only.

3.7.11 SID—Subsystem Identification Register (D0:F1)

Address Offset:	2Eh
Default:	0000h
Sticky:	No
Access:	R/WO
Size:	16 Bits

This value is used to identify a particular subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem ID (SUBID).** This field should be programmed during BIOS initialization. After it has been written once, it becomes read only.

3.7.12 FERR_GLOBAL—Global Error Register (D0:F1)

Address Offset:	40–43h
Default:	0000_0000h
Sticky:	Yes
Access:	R/WC
Size:	32 Bits

This register is used to report various error conditions. An SERR is generated on a 0-to-1 transition of any of these flags (if enabled by the ERRCMD and PCICMD registers). These bits are set regardless of whether or not the SERR is enabled and generated.

This register stores the FIRST global error. Any future errors (NEXT errors) will be set in the NERR_Global Register. No further error bits in this register will be set until the existing error bit is cleared.

Note: To prevent the same error from being logged twice in FERR_GLOBAL and NERR_GLOBAL, a FERR_GLOBAL bit being set blocks the respective bit in the NERR_GLOBAL Register from being set. In addition, bits [18:16] are grouped such that if any of these bits are set in the FERR_GLOBAL Register, none of the bits [18:16] can be set in the NERR_GLOBAL Register. For example, if HI_A causes its respective FERR_GLOBAL bit to be set, any subsequent DDR, FSB, or HI_A error will not be logged in the NERR_GLOBAL Register. Each of these three bits are part of Device 0 status and having any one of them set in FERR_GLOBAL represents a "Device 0 First Error" occurred. This implementation blocks logging in NERR_GLOBAL of any subsequent "Device 0" errors, and allows only logging of subsequent errors that are from other devices.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
31:19	0000h	Reserved
18	0b R/WC	**DRAM Interface Error Detected.** 0 = No DRAM interface error. 1 = MCH detected an error on the DRAM interface.
17	0b R/WC	**HI_A Error Detected.** 0 = No HI_A interface error. 1 = MCH detected an error on the HI_A.
16	0b R/WC	**System Bus Error Detected.** 0 = No system bus interface error. 1 = MCH detected an error on the System Bus.
15:5	000h	Reserved
4	0b R/WC	**HI_D Error Detected.** 0 = No HI_D interface error. 1 = MCH detected an error on HI_D.
3	0b R/WC	**HI_C Error Detected.** 0 = No HI_C interface error. 1 = MCH detected an error on HI_C.
2	0b R/WC	**HI_B Error Detected.** 0 = No HI_B interface error. 1 = MCH detected an error on HI_B.
1:0	00b	Reserved

3.7.13 NERR_GLOBAL—Global Error Register (D0:F1)

Address Offset:	44–47h
Default:	0000_0000h
Sticky:	Yes
Access:	R/WC
Size:	32 Bits

The FIRST global error will be stored in FERR_GLOBAL. This register stores all future global errors. Multiple bits in this register may be set.

Note: To prevent the same error from being logged twice in FERR_GLOBAL and NERR_GLOBAL, a FERR_GLOBAL bit being set blocks the respective bit in the NERR_GLOBAL Register from being set. In addition, bits [18:16] are grouped such that if any of these bits are set in the FERR_GLOBAL Register, none of the bits [18:16] can be set in the NERR_GLOBAL Register. For example, if HI_A causes its respective FERR_GLOBAL bit to be set, any subsequent DDR, FSB, or HI_A error will not be logged in the NERR_GLOBAL Register. Each of these three bits are part of Device 0 status and having any one of them set in FERR_GLOBAL represents a "Device 0 First Error" occurred. This implementation blocks logging in NERR_GLOBAL of any subsequent "Device 0" errors, and allows only logging of subsequent errors that are from other devices.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
31:19	0000h	Reserved
18	0b R/WC	**DRAM Interface Error Detected.** 0 = No DRAM interface error detected. 1 = The MCH has detected an error on the DRAM interface.
17	0b R/WC	**HI_A Error Detected.** 0 = No HI_A interface error detected. 1 = The MCH has detected an error on the HI_A.
16	0b R/WC	**System Bus Error Detected.** 0 = No system bus interface error detected. 1 = The MCH has detected an error on the System Bus.
15:5	000h	Reserved
4	0b R/WC	**HI_D Error Detected.** 0 = No HI_D interface error detected. 1 = The MCH has detected an error on HI_D.
3	0b R/WC	**HI_C Error Detected.** 0 = No HI_C interface error detected. 1 = The MCH has detected an error on HI_C.
2	0b R/WC	**HI_B Error Detected.** 0 = No HI_B interface error detected. 1 = The MCH has detected an error on HI_B.
1:0	00b	Reserved

3.7.14 HIA_FERR—Hub Interface_A First Error Register (D0:F1)

Address Offset:	50h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

This register stores the first error related to the HI_A. Only 1 error bit will be set in this register. Any future errors (NEXT errors) will be set the HIA_NERR Register. No further error bits in this register will be set until the existing error bit is cleared.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/WC	**HI_A Target Abort.** 0 = No Target Abort on MCH originated HI_A cycle detected. 1 = MCH detected that an MCH originated HI_A cycle was terminated with a Target Abort.
5	0b	Reserved
4	0b R/WC	**HI_A Data Parity Error Detected.** 0 = No data parity error detected. 1 = MCH detected a parity error on a HI_A data transfer.
3:1	000b	Reserved
0	0b R/WC	**HI_A Address/Command Error Detected.** 0 = No address or command parity error detected. 1 = MCH detected a parity error on a HI_A address or command.

3.7.15 HIA_NERR—Hub Interface_A Next Error Register (D0:F1)

Address Offset:	52h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

The first HI_A error will be stored in the HIA_FERR Register. This register stores all future HI_A errors. Multiple bits in this register may be set.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/WC	**HI_A Target Abort.** 0 = No Target Abort on MCH originated HI_A cycle terminated. 1 = MCH originated HI_A cycle was terminated with a Target Abort.
5	0b	Reserved
4	0b R/WC	**HI_A Data Parity Error Detected.** 0 = No data parity error detected. 1 = Parity error on a HI_A data transfer.
3:1	000b	Reserved
0	0b R/WC	**HI_A Data Address/Command Error Detected.** 0 = No address or command parity error detected. 1 = Parity error on a HI_A address or command.

3.7.16 SCICMD_HIA—SCI Command Register (D0:F1)

Address Offset:	58h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SCI will be generated when the associated flag is set in the HIA_FERR or HIA_NERR Register. When an error flag is set in the HIA_FERR or HIA_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SCI on HI_A Target Abort Enable.** 0 = No SCI generation 1 = Generate SCI if bit 6 is set in HIA_FERR or HIA_NERR
5	0b	Reserved
4	0b R/W	**SCI on HI_A Data Parity Error Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 4 is set in HIA_FERR or HIA_NERR
3:1	000b	Reserved
0	0b R/W	**SCI on HI_A Data Address/Comment Error Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 0 is set in HIA_FERR or HIA_NERR

3.7.17 SMICMD_HIA—SMI Command Register (D0:F1)

Address Offset:	5Ah
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determine whether SMI will be generated when the associated flag is set in either the HIA_FERR or HIA_NERR Register. When an error flag is set in the HIA_FERR or HIA_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SMI on HI_A Target Abort Enable.** 0 = No SMI generation 1 = Generate SMI if bit 6 is set in HIA_FERR or HIA_NERR
5	0b	Reserved
4	0b R/W	**SMI on HI_A Data Parity Error Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 4 is set in HIA_FERR or HIA_NERR
3:1	000b	Reserved
0	0b R/W	**SMI on HI_A Data Address/Comment Error Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 0 is set in HIA_FERR or HIA_NERR

3.7.18 SERRCMD_HIA—SERR Command Register (D0:F1)

Address Offset:	5Ch
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determine whether SERR will be generated when the associated flag is set in either the HIA_FERR or HIA_NERR Register. When an error flag is set in the HIA_FERR or HIA_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SERR on HI_A Target Abort Enable.** 0 = No SERR generation 1 = Generate SERR if bit 6 is set in HIA_FERR or HIA_NERR
5	0b	Reserved
4	0b R/W	**SERR on HI_A Data Parity Error Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 4 is set in HIA_FERR or HIA_NERR
3:1	000b	Reserved
0	0b R/W	**SEER on HI_A Data Address/Comment Error Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 0 is set in HIA_FERR or HIA_NERR

3.7.19 SYSBUS_FERR—System Bus First Error Register (D0:F1)

Address Offset:	60h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

This register stores the FIRST error related to the system bus interface. Any future errors (NEXT errors) will be set in the SYSBUS_NERR Register. No further error bits in this register will be set until the existing error bit is cleared.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b R/WC	**System Bus BINIT# Detected.** 0 = No system bus BINT# detected. 1 = This bit is set on an electrical high-to-low transition (0-to-1) of BINIT#.
6	0b R/WC	**System Bus XERR# Detected.** 0 = No system bus XERR# detected. 1 = This bit is set on an electrical high-to-low transition (0 to 1) of XERR# on the system bus.
5	0b R/WC	**Non-DRAM Lock Error (NDLOCK).** 0 = No DRAM lock error detected. 1 = MCH detected a lock operation to memory space that did not map into DRAM.
4	0b R/WC	**System Bus Address Above TOM (SBATOM).** 0 = No system bus address above TOM detected. 1 = MCH detected an address above DRB7, which is the Top of Memory and above 4 GB.
3	0b R/WC	**System Bus Data Parity Error (SBDPAR).** 0 = No system bus data parity error detected. 1 = The MCH has detected a data parity error on the system bus.
2	0b R/WC	**System Bus Address Strobe Glitch Detected (SBAGL).** 0 = No system bus address strobe glitch detected. 1 = The MCH has detected a glitch on one of the system bus address strobes.
1	0b R/WC	**System Bus Data Strobe Glitch Detected (SBDGL).** 0 = No system bus data strobe glitch detected. 1 = The MCH has detected a glitch on one of the system bus data strobes.
0	0b R/WC	**System Bus Request/Address Parity Error (SBRPAR).** 0 = No system bus request/address parity error detected. 1 = MCH detected a parity error on either the address or request signals of the system bus.

3.7.20 SYSBUS_NERR—System Bus Next Error Register (D0:F1)

Address Offset:	62h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

The FIRST system bus error will be stored in the SYSBUS_FERR Register. This register stores all future system bus errors. Multiple bits in this register may be set.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b R/WC	**System Bus BINIT# Detected.** 0 = No system bus BINIT# detected. 1 = This bit is set on an electrical high-to-low transition (0 to 1) of BINIT#.
6	0b R/WC	**System Bus XERR# Detected.** 0 = No system bus XERR# detected. 1 = This bit is set on an electrical high-to-low transition (0 to 1) of XERR# on the system bus.
5	0b R/WC	**Non-DRAM Lock Error (NDLOCK).** 0 = No non-DRAM lock error detected. 1 = The MCH has detected a lock operation to memory space that did not map into DRAM.
4	0b R/WC	**System Bus Address Above TOM (SBATOM).** 0 = No system bus address above TOM detected. 1 = MCH detected an address above DRB7, which is the Top of Memory and above 4 GB.
3	0b R/WC	**System Bus Data Parity Error (SBDPAR).** 0 = No system bus data parity error detected. 1 = MCH detected a data parity error on the system bus.
2	0b R/WC	**System Bus Address Strobe Glitch Detected (SBAGL).** 0 = No system bus address strobe glitch detected. 1 = MCH detected a glitch on one of the system bus address strobes.
1	0b R/WC	**System Bus Data Strobe Glitch Detected (SBDGL).** 0 = No System Bus Data Strobe Glitch detected. 1 = MCH detected a glitch on one of the system bus data strobes.
0	0b R/WC	**System Bus Request/Address Parity Error (SBRPAR).** 0 = No system bus request/address parity error detected. 1 = MCH detected a parity error on either the address or request signals of the system bus.

3.7.21 SCICMD_SYSBUS—SCI Command Register (D0:F1)

Address Offset:	68h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determine whether SCI will be generated when the associated flag is set in either the SYSBUS_FERR or SYSBUS_NERR Register. When an error flag is set in the SYSBUS_FERR or SYSBUS_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b R/W	**SCI on System Bus BINIT# Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 7 is set in SYSBUS_FERR or SYSBUS_NERR
6	0b R/W	**SCI on System Bus xERR# Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 6 is set in SYSBUS_FERR or SYSBUS_NERR
5	0b R/W	**SCI on Non-DRAM Lock Error Enable.** 0 = No SCI generation 1 = Generate SCI if bit 5 is set in SYSBUS_FERR or SYSBUS_NERR
4	0b R/W	**SCI on System Bus Address Above TOM Enable.** 0 = No SCI generation 1 = Generate SCI if bit 4 is set in SYSBUS_FERR or SYSBUS_NERR
3	0b R/W	**SCI on System Bus Data Parity Error Enable.** 0 = No SCI generation 1 = Generate SCI if bit 3 is set in SYSBUS_FERR or SYSBUS_NERR
2	0b R/W	**SCI on System Bus Address Strobe Glitch Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 2 is set in SYSBUS_FERR or SYSBUS_NERR
1	0b R/W	**SCI on System Bus Data Strobe Glitch Detected Enable.** 0 = No SCI generation 1 = Generate SCI if bit 1 is set in SYSBUS_FERR or SYSBUS_NERR
0	0b R/W	**SCI on System Bus Request/Address Parity Error Enable.** 0 = No SCI generation 1 = Generate SCI if bit 0 is set in SYSBUS_FERR or SYSBUS_NERR

3.7.22 SMICMD_SYSBUS—SMI Command Register (D0:F1)

Address Offset:	6Ah
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SMI will be generated when the associated flag is set in either the SYSBUS_FERR or SYSBUS_NERR Register. When an error flag is set in the SYSBUS_FERR or SYSBUS_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b R/W	**SMI on System Bus BINIT# Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 7 is set in SYSBUS_FERR or SYSBUS_NERR
6	0b R/W	**SMI on System Bus xERR# Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 6 is set in SYSBUS_FERR or SYSBUS_NERR
5	0b R/W	**SMI on Non-DRAM Lock Error Enable.** 0 = No SMI generation 1 = Generate SMI if bit 5 is set in SYSBUS_FERR or SYSBUS_NERR
4	0b R/W	**SMI on System Bus Address Above TOM Enable.** 0 = No SMI generation 1 = Generate SMI if bit 4 is set in SYSBUS_FERR or SYSBUS_NERR
3	0b R/W	**SMI on System Bus Data Parity Error Enable.** 0 = No SMI generation 1 = Generate SMI if bit 3 is set in SYSBUS_FERR or SYSBUS_NERR
2	0b R/W	**SMI on System Bus Address Strobe Glitch Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 2 is set in SYSBUS_FERR or SYSBUS_NERR
1	0b R/W	**SMI on System Bus Data Strobe Glitch Detected Enable.** 0 = No SMI generation 1 = Generate SMI if bit 1 is set in SYSBUS_FERR or SYSBUS_NERR
0	0b R/W	**SMI on System Bus Request/Address Parity Error Enable.** 0 = No SMI generation 1 = Generate SMI if bit 0 is set in SYSBUS_FERR or SYSBUS_NERR

3.7.23 SERRCMD_SYSBUS—SERR Command Register (D0:F1)

Address Offset:	6Ch
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SERR will be generated when the associated flag is set in either the SYSBUS_FERR or SYSBUS_NERR Register. When an error flag is set in the SYSBUS_FERR or SYSBUS_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b R/W	**SERR on System Bus BINIT# Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 7 is set in SYSBUS_FERR or SYSBUS_NERR
6	0b R/W	**SERR on System Bus xERR# Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 6 is set in SYSBUS_FERR or SYSBUS_NERR
5	0b R/W	SERR **on Non-DRAM Lock Error Enable.** 0 = No SERR generation 1 = Generate SERR if bit 5 is set in SYSBUS_FERR or SYSBUS_NERR
4	0b R/W	**SERR on System Bus Address Above TOM Enable.** 0 = No SERR generation 1 = Generate SERR if bit 4 is set in SYSBUS_FERR or SYSBUS_NERR
3	0b R/W	**SERR on System Bus Data Parity Error Enable.** 0 = No SERR generation 1 = Generate SERR if bit 3 is set in SYSBUS_FERR or SYSBUS_NERR
2	0b R/W	**SERR on System Bus Address Strobe Glitch Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 2 is set in SYSBUS_FERR or SYSBUS_NERR
1	0b R/W	**SERR on System Bus Data Strobe Glitch Detected Enable.** 0 = No SERR generation 1 = Generate SERR if bit 1 is set in SYSBUS_FERR or SYSBUS_NERR
0	0b R/W	**SERR on System Bus Request/Address Parity Error Enable.** 0 = No SERR generation 1 = Generate SERR if bit 0 is set in SYSBUS_FERR or SYSBUS_NERR

3.7.24 DRAM_FERR—DRAM First Error Register (D0:F1)

Address Offset:	80h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

This register stores the FIRST ECC error on the DRAM interface. Only 1 error bit will be set in this register. Any future errors (NEXT errors) will be set in the DRAM_NERR Register. No further error bits in this register will be set until the existing error bit is cleared.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7:2	00h	Reserved
1	0b R/WC	**Uncorrectable Memory Error Detected.** 0 = No uncorrectable memory error detected. 1 = MCH detected an ECC error on the memory interface that is not correctable.
0	0b R/WC	**Correctable Memory Error Detected.** 0 = No correctable memory error detected. 1 = MCH detected and corrected an ECC error on the memory interface.

3.7.25 DRAM_NERR—DRAM Next Error Register (D0:F1)

Address Offset:	82h
Default:	00h
Sticky:	Yes
Access:	R/WC
Size:	8 Bits

The FIRST memory ECC error will be stored in the DRAM_FERR Register. This register stores all future memory ECC errors. Multiple bits in this register may be set.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7:2	00h	Reserved
1	0b R/WC	**Uncorrectable Memory Error Detected.** 0 = No uncorrectable memory error detected. 1 = The MCH has detected an ECC error on the memory interface that is not correctable.
0	0b R/WC	**Correctable Memory Error Detected.** 0 = No correctable memory error detected. 1 = The MCH has detected and corrected an ECC error on the memory interface.

3.7.26 SCICMD_DRAM—SCI Command Register (D0:F1)

Address Offset:	88h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SCI will be generated when the associated flag is set in either the DRAM_FERR or DRAM_NERR Register. When an error flag is set in the DRAM_FERR or DRAM_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7:2	000000b	Reserved
1	0b R/W	**SCI on Multiple-Bit DRAM ECC Error (DMERR).** 0 = Disable. 1 = Enable. The MCH generates an SCI when it detects a multiple-bit error reported by the DRAM controller.
0	0b R/W	**SCI on Single-Bit DRAM ECC Error (DSERR).** 0 = Disable. 1 = Enable. The MCH generates an SCI when the DRAM controller detects a single-bit error.

3.7.27 SMICMD_DRAM—SMI Command Register (D0:F1)

Address Offset:	8Ah
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SMI will be generated when the associated flag is set in the DRAM_FERR or DRAM_NERR Register. When an error flag is set in the DRAM_FERR or DRAM_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7:2	000000b	Reserved
1	0b R/W	**SMI on Multiple-Bit DRAM ECC Error (DMERR).** 0 = Disable. 1 = Enable. The MCH generates an SMI when it detects a multiple-bit error reported by the DRAM controller.
0	0b R/W	**SMI on Single-Bit DRAM ECC Error (DSERR).** 0 = Disable. 1 = Enable. The MCH generates an SMI when the DRAM controller detects a single-bit error.

3.7.28 SERRCMD_DRAM—SERR Command Register (D0:F1)

Address Offset:	8Ch
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SERR will be generated when the associated flag is set in either the DRAM_FERR or DRAM_NERR Register. When an error flag is set in the DRAM_FERR or DRAM_NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7:2	000000b	Reserved
1	0b R/W	**SERR on Multiple-Bit DRAM ECC Error (DMERR).** 0 = Disable. 1 = Enable. The MCH generates an SERR when it detects a multiple-bit error reported by the DRAM controller.
0	0b R/W	**SERR on Single-Bit DRAM ECC Error (DSERR).** 0 = Disable. 1 = Enable. The MCH generates an SERR when the DRAM controller detects a single-bit error.

3.7.29 DRAM_CELOG_ADD—DRAM First Correctable Memory Error Address Register (D0:F1)

Address Offset:	A0–A3h
Default:	0000_0000h
Sticky:	Yes
Access:	RO
Size:	32 Bits

This register contains the address of the first correctable memory error. This register is locked when bits in either the DRAM_FERR or DRAM_NERR Registers are set. If the bits in both registers are set to 0, the DRAM_CELOG_ADD can be updated; however, if a bit in either register is set to 1, then DRAM_CELOG_ADD will retain its value for logging purposes. This register is only valid if a bit in either the DRAM_FERR or DRAM_NERR Register is set.

Bits	Default, Access	Description
31:28	0h	Reserved
27:6	000000h RO	**CE Address.** This field contains address bits 33:12 of the first correctable memory error. The address bits are a physical address.
5:0	00h	Reserved

3.7.30 DRAM_UELOG_ADD—DRAM First Uncorrectable Memory Error Address Register (D0:F1)

Address Offset:	B0–B3h
Default:	0000_0000h
Sticky:	Yes
Access:	RO
Size:	32 Bits

This register contains the address of the first uncorrectable memory error. When a bit in either the DRAM_FERR or DRAM_NERR Register is set, this register is locked. This register is only valid if a bit in either the DRAM_FERR or DRAM_NERR Register is set.

Bits	Default, Access	Description
31:28	0h	Reserved
27:6	000000h RO	**UE Address.** This field contains address bits 33:12 of the first uncorrectable memory error. The address bits are a physical address.
5:0	00h	Reserved

3.7.31 DRAM_CELOG_SYNDROME—DRAM First Correctable Memory Error Register (D0:F1)

Address Offset:	D0–D1h
Default:	0000h
Sticky:	Yes
Access:	RO
Size:	16 Bits

This register contains the syndrome of the first correctable memory error. This register is locked when a bit in either the DRAM_FERR or DRAM_NERR Register is set. If the bits in both registers are set to 0, the DRAM_CELOG_SYNDROME can be updated; however, if a bit in either register is set to 1, then DRAM_CELOG_SYNDROME will retain its value for logging purposes. This register is only valid if a bit in either the DRAM_FERR or DRAM_NERR Register is set.

Bits	Default, Access	Description
15:0	0000h RO	ECC Syndrome for Correctable Errors.

3.8 HI_B Virtual PCI-to-PCI Bridge Registers (Device 2, Function 0)

This section provides the register descriptions for the HI_B virtual PCI-to-PCI bridge (Device 2, Function 0). Table 3-5 provides the register address map for this device, function.

Warning: Address locations that are not listed the table are considered reserved register locations. Writes to "Reserved" registers may cause system failure. Reads to "Reserved" registers may return a non-zero value.

Table 3-5. HI_B Virtual PCI-to-PCI Bridge Register Map (HI_A—D2:F0)

Offset	Mnemonic	Register Name	Default	Type
00–01h	VID2	Vendor ID	8086h	RO
02–03h	DID2	Device ID	2543h	RO
04–05h	PCICMD2	PCI Command	0000h	RO, R/W
06–07h	PCISTS2	PCI Status	00A0h	RO, R/WC
08h	RID2	Revision ID	02h	RO
0Ah	SUBC2	Sub Class Code	04h	RO
0Bh	BCC2	Base Class Code	06h	RO
0Dh	MLT2	Master Latency Timer	00h	R/W
0Eh	HDR2	Header Type	01h or 81h	RO
18h	PBUSN2	Primary Bus Number	00h	RO
19h	BUSN2	Secondary Bus Number	00h	R/W
1Ah	SUBUSN2	Subordinate Bus Number	00h	R/W
1Bh	SMLT2	Secondary Bus Master Latency Timer	00h	Reserved
1Ch	IOBASE2	I/O Base Address	F0h	R/W
1Dh	IOLIMIT2	I/O Limit Address	00h	R/W
1E–1Fh	SEC_STS2	Secondary Status	0160	RO, R/WC
20–21h	MBASE2	Memory Base Address	FFF0h	R/W
22–23h	MLIMIT2	Memory Limit Address	0000h	R/W
24–25h	PMBASE2	Prefetchable Memory Base Address	FFF0h	RO, R/W
26–27h	PMLIMIT2	Prefetchable Memory Limit Address	0000h	RO, R/W
3Eh	BCTRL2	Bridge Control	00h	RO, R/W

3.8.1 VID2—Vendor Identification Register (D2:F0)

Address Offset:	00–01h
Default:	8086h
Sticky:	No
Access:	RO
Size:	16 Bits

The VID Register contains the vendor identification number. This 16-bit register combined with the Device Identification Register uniquely identify any PCI device.

Bits	Default, Access	Description
15:0	8086h RO	**Vendor Identification Device 2 (VID2).** This register field contains the PCI standard identification for Intel (VID=8086h).

3.8.2 DID2—Device Identification Register (D2:F0)

Address Offset:	02–03h
Default:	2543h
Sticky:	No
Access:	RO
Size:	16 Bits

This 16-bit register combined with the Vendor Identification register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2543h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH device 2.

3.8.3 PCICMD2—PCI Command Register (D2:F0)

Address Offset:	04–05h
Default:	0000h
Sticky:	No
Access:	RO R/W
Size:	16 Bits

Since MCH Device 0 does not physically reside on a physical PCI bus, portions of this register are not implemented.

Bits	Default, Access	Description
15:10	00h	Reserved
9	0b RO	**Fast Back-to-Back Enable (FB2B).** Not Applicable; hardwired to 0.
8	0b R/W	**SERR Message Enable (SERRE).** This bit is a global enable bit for Device 2 SERR messaging. The MCH does not have an SERR# signal. The MCH communicates the SERR# condition by sending an SERR message to the ICH3-S. 0 = SERR message is not generated by the MCH for Device 2. 1 = The MCH is enabled to generate SERR messages over HI_A for specific Device 2 error conditions.
7	0b RO	**Address/Data Stepping (ADSTEP).** Not applicable; this bit is hardwired to 0.
6	0b RO	**Parity Error Enable (PERRE).** Hardwired to 0. Parity checking is not supported on the primary side of this device.
5	0b	Reserved
4	0b RO	**Memory Write and Invalidate Enable (MWIE).** Not applicable; hardwired to 0.
3	0b RO	**Special Cycle Enable (SCE).** Not applicable; hardwired to 0.
2	0b R/W	**Bus Master Enable (BME).** This bit is not functional. It is a R/W bit for compatibility with compliance testing software.
1	0b R/W	**Memory Access Enable (MAE).** 0 = Disable. All of device 2's memory space is disabled. 1 = Enable. This bit must be set to 1 to enable the Memory and Prefetchable memory address ranges defined in the MBASE2, MLIMIT2, PMBASE2, and PMLIMIT2 Registers.
0	0b R/W	**IO Access Enable (IOAE).** 0 = Disable. All of device 2's I/O space is disabled. 1 = Enable. This bit must be set to 1 to enable the I/O address range defined in the IOBASE2 and IOLIMIT2 Registers.

3.8.4 PCISTS2—PCI Status Register (D2:F0)

Address Offset:	06h
Default:	00A0h
Sticky:	No
Access:	RO, R/WC
Size:	16 Bits

PCISTS2 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 within the MCH.

Bits	Default, Access	Description
15	0b RO	**Detected Parity Error (DPE).** Hardwired to 0. Parity is not supported on the primary side of this device.
14	0b R/WC	**Signaled System Error (SSE).** 0 = No SERR generated by MCH Device 2. 1 = MCH Device 2 generates an SERR message over HI_A for any enabled Device 2 error condition. **Note:** Software clears this bit by writing a 1 to it.
13	0b RO	**Received Master Abort Status (RMAS).** Hardwired to 0. The concept of master abort does not exist on primary side of this device.
12	0b RO	**Received Target Abort Status (RTAS).** Hardwired to 0. The concept of target abort does not exist on primary side of this device.
11	0b RO	**Signaled Target Abort Status (STAS).** Hardwired to 0. The concept of target abort does not exist on primary side of this device.
10:9	00b RO	**DEVSEL# Timing (DEVT).** The MCH does not support subtractive decoding devices on bus 0. This bit field is therefore hardwired to 00 to indicate that device 2 uses the fastest possible decode.
8	0b RO	**Master Data Parity Error Detected (DPD).** Hardwired to 0. Parity is not supported on the primary side of this device.
7	1b RO	**Fast Back-to-Back (FB2B).** Hardwired to 1. Fast back to back writes are always supported on this interface.
6	0b	Reserved
5	1b RO	**66/60MHz capability (CAP66).** Hardwired to 1. Since HI_B is capable of delivering data at a rate equal to that of any PCI66 device this bit is hardwired to a 1 so that configuration software understands that downstream devices may also be effectively enabled for 66 MHz operation.
4:0	00h	Reserved

3.8.5 RID2—Revision Identification Register (D2:F0)

Address Offset:	08h
Default:	See table below
Sticky:	No
Access:	RO
Size:	8 Bits

This register contains the revision number of the MCH device 2.

Bits	Default, Access	Description
7:0	02h RO	**Revision Identification Number (RID).** This is an 8-bit value that indicates the revision identification number for the MCH device 2. 02h = A2 stepping

3.8.6 SUBC2—Sub-Class Code Register (D2:F0)

Address Offset:	0Ah
Default:	04h
Sticky:	No
Access:	RO
Size:	8 Bits

This register contains the Sub-Class Code for the MCH device 2.

Bits	Default, Access	Description
7:0	04h RO	**Sub-Class Code (SUBC).** This is an 8-bit value that indicates the category of Bridge into which device 2 of the MCH falls. 04h = PCI-to-PCI Bridge.

3.8.7 BCC2—Base Class Code Register (D2:F0)

Address Offset:	0Bh
Default:	06h
Sticky:	No
Access:	RO
Size	8 Bits

This register contains the Base Class Code of the MCH device 2.

Bits	Default, Access	Description
7:0	06h RO	**Base Class Code (BASEC).** This is an 8-bit value that indicates the Base Class Code for the MCH device 2. 06h = Bridge device

3.8.8 MLT2—Master Latency Timer Register (D2:F0)

Address Offset:	0Dh
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This functionality is not applicable. It is described here since these bits should be implemented as read/write to ensue proper execution of standard PCI-to-PCI bridge configuration software.

Bits	Default, Access	Description
7:3	00h R/W	**Scratchpad MLT (NA7.3).** These bits return the value with which they are written; however, they have no internal function and are implemented as a scratchpad.
2:0	000b	Reserved

3.8.9 HDR2—Header Type Register (D2:F0)

Address Offset:	0Eh
Default:	01h or 81h
Sticky:	No
Access:	RO
Size:	8 Bits

This register identifies the header layout of the configuration space.

Bits	Default, Access	Description
7:0	01h or 81h RO	**Header Type Register (HDR).** When Function 1 is enabled, this read only field returns 81h to indicate that MCH device 2 is a multi-function device with bridge header layout. When Function 1 is disabled, 01h is returned to indicate that MCH device 2 is a single-function device with bridge layout. Writes to this location have no effect.

3.8.10 PBUSN2—Primary Bus Number Register (D2:F0)

Address Offset:	18h
Default:	00h
Sticky:	No
Access:	RO
Size:	8 Bits

This register identifies that “virtual” PCI-PCI bridge is connected to bus 0.

Bits	Default, Access	Description
7:0	00h RO	**Primary Bus Number (BUSN).** Configuration software typically programs this field with the number of the bus on the primary side of the bridge. Since device 2 is an internal device and its primary bus is always 0, these bits are read only and are hardwired to 0.

3.8.11 BUSN2—Secondary Bus Number Register (D2:F0)

Address Offset:	19h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

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

Bits	Default, Access	Description
7:0	00h R/W	**Secondary Bus Number (BUSN).** This field is programmed by configuration software with the lowest bus number of the busses connected to HI_B. Since both bus 0, device 2 and the PCI to PCI bridge on the other end of the HI are considered by configuration software to be PCI bridges, this bus number will always correspond to the bus number assigned to HI_B.

3.8.12 SUBUSN2—Subordinate Bus Number Register (D2:F0)

Address Offset:	1Ah
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

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

Bits	Default, Access	Description
7:0	00h R/W	**Subordinate Bus Number (BUSN).** This register is programmed by configuration software with the number of the highest subordinate bus that lies behind the device 2 bridge.

3.8.13 SMLT2—Secondary Bus Master Latency Timer Register (D2:F0)

Address Offset:	1Bh
Default:	00h
Sticky:	no
Access:	Reserved
Size:	8 Bits

This register is not implemented.

Bits	Default, Access	Description
7:0	00h	Reserved

3.8.14 IOBASE2—I/O Base Address Register (D2:F0)

Address Offset:	1Ch
Default:	F0h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register controls the processor-to-HI_B I/O access routing based on the following formula:

IO_BASE ≤ address ≤ IO_LIMIT

Only the upper 4 bits are programmable. For the purpose of address decode, address bits A[11:0] are treated as 0. Thus, the bottom of the defined I/O address range will be aligned to a 4-KB boundary.

Bits	Default, Access	Description
7:4	0Fh R/W	**I/O Address Base (IOBASE).** This field corresponds to A[15:12] of the I/O addresses passed by the device 2 bridge to HI_B.
3:0	0h	Reserved

3.8.15 IOLIMIT2—I/O Limit Address Register (D2:F0)

Address Offset:	1Dh
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register controls the processor to HI_B I/O access routing based on the following formula:

IO_BASE≤ address ≤IO_LIMIT

Only the upper 4 bits are programmable. For the purpose of address decode, address bits A[11:0] are assumed to be FFFh. Thus, the top of the defined I/O address range will be at the top of a 4 KB aligned address block.

Bits	Default, Access	Description
7:4	0h R/W	**I/O Address Limit (IOLIMIT).** This field corresponds to A[15:12] of the I/O address limit of device 2. Devices between this upper limit and IOBASE2 will be passed to HI_B.
3:0	0h	Reserved

3.8.16 SEC_STS2—Secondary Status Register (D2:F0)

Address Offset:	1E–1Fh
Default:	0160h
Sticky:	No
Access:	RO, R/WC
Size:	16 Bits

SSTS2 is a 16-bit status register that reports the occurrence of error conditions associated with secondary side (i.e., HI_B side) of the "virtual" PCI-PCI bridge embedded within the MCH.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
15	0b R/WC	**Detected Parity Error (2DPE).** 0 = No parity error detected. 1 = MCH detected a parity error in the address or data phase of HI_B bus transactions.
14	0b R/WC	**Received System Error (2RSE).** 0 = No system error received. 1 = This bit is set to 1 when the MCH receives an SERR message on HI_B.
13	0b R/WC	**Received Master Abort Status (2RMAS).** 0 = No Master Abort received. 1 = The MCH received a Master Abort completion packet on HI_B.
12	0b R/WC	**Received Target Abort Status (2RTAS).** 0 = No Target Abort received. 1 = The MCH received a Target Abort completion packet on HI_B.
11	0b RO	**Signaled Target Abort Status (STAS).** Hardwired to 0. The MCH does not generate target aborts on HI_B.
10:9	01b RO	**DEVSEL# Timing (DEVT).** Hardwired to 01. This concept is not supported on HI_B.
8	0b RO	**Master Data Parity Error Detected (DPD).** Hardwired to 0. The MCH does not implement PERR messaging on HI_B.
7	1b RO	**Fast Back-to-Back (FB2B).** Hardwired to 1. This function is not supported on HI_B.
6	0b	Reserved
5	1b RO	**66/60 MHz capability (CAP66).** Hardwired to 1. HI_B is enabled for 66 MHz operation.
4:0	00h	Reserved

3.8.17 MBASE2—Memory Base Address Register (D2:F0)

Address Offset:	20–21h
Default:	FFF0h
Sticky:	No
Access:	R/W
Size:	16 Bits

This register controls the processor to HI_B non-prefetchable memory access routing based on the following formula:

MEMORY_BASE ≤ address ≤ 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 0s 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 0. The bottom of the defined memory address range will be aligned to a 1-MB boundary.

Bits	Default, Access	Description
15:4	FFFh R/W	**Memory Address Base (MBASE).** This field corresponds to A[31:20] of the lower limit of the memory range that will be passed by the device 2 bridge to HI_B.
3:0	0h	Reserved

3.8.18 MLIMIT2—Memory Limit Address Register (D2:F0)

Address Offset:	22–23h
Default:	0000h
Sticky:	No
Access:	R/W
Size:	16 Bits

This register controls the processor to HI_B non-prefetchable memory access routing based on the following formula:

MEMORY_BASE ≤ address ≤ 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 four bits of this register are read-only and return 0s 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. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block.

Note: The memory range covered by the MBASE and MLIMIT Registers are used to map non-prefetchable HI_B address ranges (typically where control/status memory-mapped I/O data structures of the graphics controller will reside) and PMBASE and PMLIMIT are used to map prefetchable address ranges (typically graphics local memory). This segregation allows application of USWC space attribute to be performed in a true plug-and-play manner to the prefetchable address range for improved HI memory access performance.

Configuration software is responsible for programming all address range registers (prefetchable, 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 MCH hardware to enforce prevention of overlap and operations of the system in the case of overlap are not guaranteed.

Bits	Default, Access	Description
15:4	000h R/W	**Memory Address Limit (MILIMIT).** This field 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 device 2 bridge to HI_B
3:0	0h	Reserved

3.8.19 PMBASE2—Prefetchable Memory Base Address Register (D2:F0)

Address Offset:	24–25h
Default:	FFF0h
Sticky:	No
Access:	RO, R/W
Size:	16 Bits

This register controls the processor to HI_B prefetchable memory accesses. See PM64BASE2 for usage. The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 36-bit address. For the purpose of address decode, bits A[19:0] are assumed to be 0. Thus, the bottom of the defined memory address range will be aligned to a 1-MB boundary.

Bits	Default, Access	Description
15:4	FFFh R/W	**Prefetchable Memory Address Base (PMBASE).** This field corresponds to A[31:20] of the lower limit of the address range passed by bridge device 2 across HI_B.
3:0	0h RO	**64-bit Addressing Support.** Hardwired to 0. The MCH does not support Outbound 64-bit addressing.

3.8.20 PMLIMIT2—Prefetchable Memory Limit Address Register (D2:F0)

Address Offset:	26h
Default:	0000h
Sticky:	No
Access:	RO, R/W
Size:	16 Bits

This register controls the processor to HI_B prefetchable memory accesses. See PM64BASE2 for usage. The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 36-bit address. For the purpose of address decode, bits A[19:0] are assumed to be FFFFh. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block.

Bits	Default, Access	Description
15:4	000h R/W	**Prefetchable Memory Address Limit (PMLIMIT).** This field corresponds to A[31:20] of the upper limit of the address range passed by bridge device 2 across HI_B.
3:0	0h RO	**64-bit Addressing Support.** Hardwired to 0. The MCH does not support Outbound 64-bit addressing.

3.8.21 BCTRL2—Bridge Control Register (D2:F0)

Address Offset:	3Eh
Default:	00h
Sticky:	No
Access:	RO, R/W
Size:	8 Bits

This register provides extensions to the PCICMD2 register that are specific to PCI-PCI bridges. The BCTRL provides additional control for the secondary interface (i.e., HI_B) as well as some bits that affect the overall behavior of the "virtual" PCI-PCI bridge in the MCH (e.g., VGA compatible address range mapping).

Bits	Default, Access	Description
7	0b RO	**Fast Back-to-Back Enable (FB2BEN).** Hardwired to 0. The MCH does not generate fast back-to-back cycles as a master on HI_B.
6	0b RO	**Secondary Bus Reset (SRESET).** Hardwired to 0. The MCH does not support generation of reset via this bit on the HI_B.
5	0b RO	**Master Abort Mode (MAMODE).** Hardwired to 0. Thus, when acting as a master on HI_B, the MCH will drop writes on the floor and return all 1s during reads when a Master Abort occurs.
4	0b	Reserved
3	0b R/W	**VGA Enable (VGAEN).** This bit controls the routing of processor-initiated transactions targeting VGA compatible I/O and memory address ranges. The following must be enforced via software. 0 = This bit is set to 0 if the video device is not present behind the bridge. 1 = If video device is behind the bridge, this bit is set to 1. **NOTE:** Only one of device 2–4's VGAEN bits are allowed to be set.
2	0b R/W	**ISA Enable (ISAEN).** Modifies the response by the MCH to an I/O access issued by the processor that target ISA I/O addresses. This applies only to I/O addresses that are enabled by the IOBASE and IOLIMIT Registers. 0 = All addresses defined by the IOBASE and IOLIMIT for processor I/O transactions will be mapped to HI_B. 1 = MCH does not forward to HI_B 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 HI_B, these cycles are forwarded to HI_A where they can be subtractively or positively claimed by the ISA bridge.
1	0b R/W	**SERR Enable (2SERREN).** This bit enables or disables forwarding of SERR messages from HI_B to HI_A, where they can be converted into interrupts that are eventually delivered to the processor. 0 = Disable 1 = Enable
0	0b R/W	**Parity Error Response Enable (2PEREN).** Controls the MCH's response to data phase parity errors on HI_B. 0 = Address and data parity errors on HI_B are not reported via the MCH HI_A SERR messaging mechanism. 1 = Address and data parity errors on HI_B are reported via the HI_A SERR messaging mechanism, if further enabled by 2SERREN. **NOTE:** Other types of error conditions can still be signaled via SERR messaging independent of this bit's state.

3.9 HI_B Virtual PCI-to-PCI Bridge Registers (Device 2, Function 1)

This section provides the register descriptions for the HI_B virtual PCI-to-PCI bridge (Device 2, Function 1). Table 3-6 provides the register address map for this device, function.

Warning: Address locations that are not listed in the table are considered reserved register locations. Writes to "Reserved" registers may cause system failure. Reads to "Reserved" registers may return a non-zero value.

Table 3-6. HI_B Virtual PCI-to-PCI Bridge Register Map (HI_A—D2:F1)

Offset	Mnemonic	Register Name	Default	Type
00–01h	VID	Vendor ID	8086h	RO
02–03h	DID	Device ID	2544h	RO
04–05h	PCICMD	PCI Command	0000h	RO, R/W
06–07h	PCISTS	PCI Status	0000h	R/WC
08h	RID	Revision ID	02h	RO
0Ah	SUBC	Sub Class Code	00h	RO
0Bh	BCC	Base Class Code	FFh	RO
0Eh	HDR	Header Type	00h or 80h	RO
2C–2Dh	SVID	Subsystem Vendor Identification	0000h	R/WO
2E–2Fh	SID	Subsystem Identification	0000h	R/WO
80h	HIB_FERR	Hub Interface_B First Error	00h	R/WC
82h	HIB_NERR	Hub Interface_B Next Error	00h	R/WC
A0h	SERRCMD2	SERR Command	00h	R/W
A2h	SMICMD2	SMI Command	00h	R/W
A4h	SCICMD2	SCI Command	00h	R/W

3.9.1 VID—Vendor Identification Register (D2:F1)

Address Offset:	00h
Default:	8086h
Sticky:	No
SMB Shadowed:	Yes
Access:	RO
Size:	16 Bits

The VID Register contains the vendor identification number. This 16-bit register combined with the Device Identification Register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	8086h RO	**Vendor Identification (VID).** This register field contains the PCI standard identification for Intel (VID=8086h).

3.9.2 DID—Device Identification Register (D2:F1)

Address Offset:	02h
Default:	2544h
Sticky:	No
SMB Shadowed:	Yes
Access:	RO
Size:	16 Bits

Bits	Default, Access	Description
15:0	2544h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH Host-HI Bridge Function 1. The value is 2544h.

3.9.3 PCICMD—PCI Command Register (D2:F1)

Address Offset:	04h
Default:	0000h
Sticky:	No
SMB Shadowed:	Yes
Access:	R/W
Size:	16 Bits

Since MCH Device 0 does not physically reside on a physical PCI bus portions of this register are not implemented.

Bits	Default, Access	Description
15:9	00h	Reserved
8	0b R/W	**SERR Enable (SERRE).** This bit is global enable bit for Device 2 SERR messaging. 0 = Disable. SERR is not generated by the MCH for Device 2. 1 = Enable. The MCH is enabled to generate SERR over HI_A for specific Device 2 error conditions that are individually enabled in the ERRCMD register. The error status is reported in the ERRSTAT and PCISTS Registers.
7:0	00h	Reserved

3.9.4 PCISTS—PCI Status Register (D2:F1)

Address Offset:	06h
Default:	0000h
Sticky:	No
SMB Shadowed:	Yes
Access:	R/WC
Size:	16 Bits

PCISTS is a 16-bit status register that reports the occurrence of error events on Device 0's PCI interface. Bit 14 is read/write clear. All other bits are Read Only. Since MCH Device 0 does not physically reside on PCI_A many of the bits are not implemented.

Bits	Default, Access	Description
15	0b	Reserved
14	0b R/WC	**Signaled System Error (SSE).** 0 = No signaled system error generated. 1 = MCH Device 2 generated an SERR over HI_A for any enabled Device 2 error condition. Device 2 error conditions are enabled in the PCICMD and ERRCMD Registers. Device 2 error flags are read/reset from the PCISTS or ERRSTAT Registers. **Note:** Software sets this bit to 0 by writing a 1 to it.
13:0	000h	Reserved

3.9.5 RID—Revision Identification Register (D2:F1)

Address Offset:	08h
Default:	See table below
Sticky:	No
SMB Shadowed:	Yes
Access:	RO
Size:	8 Bits

This register contains the revision number of the MCH Device 0.

Bits	Default, Access	Description
7:0	02h RO	**Revision Identification Number (RID).** This is an 8-bit value that indicates the revision identification number for the MCH Device 0. This value should always be the same as the RID for device0, function 0. 02h = A2 stepping

3.9.6 SUBC—Sub-Class Code Register (D2:F1)

Address Offset:	0Ah
Default:	00h
Sticky:	No
SMB Shadowed:	Yes
Access:	RO
Size:	8 Bits

This register contains the Sub-Class Code for the MCH Device 0.

Bits	Default, Access	Description
7:0	00h RO	**Sub-Class Code (SUBC).** This is an 8-bit value that indicates the category of undefined. 00h = Undefined device.

3.9.7 BCC—Base Class Code Register (D2:F1)

Address Offset: 0Bh
Default: FFh
Sticky: No
SMB Shadowed: Yes
Access: RO
Size: 8 Bits

This register contains the Base Class Code of the MCH Device 2.

Bits	Default, Access	Description
7:0	FFh RO	**Base Class Code (BASEC).** This is an 8-bit value that indicates the Base Class Code for the MCH. FFh =Non-defined device. Since this function is used for error conditions, it does not fall into any other class.

3.9.8 HDR—Header Type Register (D2:F1)

Address Offset: 0Eh
Default: 00h or 80h
Sticky: No
SMB Shadowed: Yes
Access: RO
Size: 8 Bits

This register identifies the header layout of the configuration space. No physical register exists at this location.

Bits	Default, Access	Description
7:0	00h or 80h RO	**PCI Header (HDR).** This read only field always returns 00h or 80h to indicate that the MCH is a multi-function device with standard header layout.

3.9.9 SVID—Subsystem Vendor Identification Register (D2:F1)

Address Offset:	2C–2Dh
Default:	0000h
Sticky:	No
SMB Shadowed:	Yes
Access:	R/WO
Size:	16 Bits

This value is used to identify the vendor of the subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem Vendor ID (SUBVID).** This field should be programmed during boot-up to indicate the vendor of the system board. After it has been written once, it becomes read only.

3.9.10 SID—Subsystem Identification Register (D2:F1)

Address Offset:	2E–2Fh
Default:	0000h
Sticky:	No
SMB Shadowed:	Yes
Access:	R/WO
Size:	16 Bits

This value is used to identify a particular subsystem.

Bits	Default, Access	Description
15:0	0000h R/WO	**Subsystem ID (SUBID).** This field should be programmed during BIOS initialization. After it has been written once, it becomes read only.

3.9.11 HIB_FERR—Hub Interface_B First Error Register (D2:F1)

Address Offset:	80h
Default:	00h
Sticky:	Yes
SMB Shadowed:	Yes
Access:	R/WC
Size:	8 Bits

This register store the FIRST error related to HI_B. Only one error bit will be set in this register. Any future errors (NEXT Errors) will be set. No further error bits in this register will be set until the existing error bit is cleared.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/WC	**MCH Received SERR From HI_B.** 0 = No SERR from HI_B detected. 1 = MCH detected a SERR on Hub Interface_B.
5	0b R/WC	**MCH Master Abort on HI_B (HIBMA).** MCH did a master abort to a HI_B request. 0 = No Master Abort on HI_B detected. 1 = MCH detected an invalid address that will be master aborted. This bit is set even when the MCH does not respond with the Master Abort completion packet.
4	0b R/WC	**Received Target Abort on HI_B.** 0 = No Target Abort on HI_B detected. 1 = MCH detected that an MCH originated cycle was terminated with a Target Abort completion packet.
3	0b R/WC	**Correctable Error on Header/Address from HI_B.** 0 = No correctable error on header/address from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a single bit correctable error.
2	0b R/WC	**Correctable Error on Data from HI_B.** 0 = No correctable error on data from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a single bit correctable error.
1	0b R/WC	**Uncorrectable Error on Header/Address from HI_B.** 0 = No uncorrectable error on header/address from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a multi-bit uncorrectable error.
0	0b R/WC	**Uncorrectable Error on Data Transfer from HI_B.** 0 = No uncorrectable error on data from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a multi-bit uncorrectable error.

3.9.12 HIB_NERR—Hub Interface_B Next Error Register (D2:F1)

Address Offset:	82h
Default:	00h
Sticky:	Yes
SMB Shadowed:	Yes
Access:	R/WC
Size:	8 Bits

The FIRST error related to HI_B will be stored in the HIB_FERR Register. This register store all future errors related to the HI_B. Multiple bits in this register may be set.

Note: Software must write a 1 to clear bits that are set.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/WC	**MCH Received SERR from HI_B.** 0 = No SERR from HI_B received. 1 = MCH received SERR from HI_B.
5	0b R/WC	**MCH Master Abort on HI_B (HIBMA).** MCH did a Master Abort to a HI_B Request. 0 = No Master Abort on HI_B detected. 1 = The MCH detected an invalid address that will be master aborted. This bit is set even when the MCH does not respond with the Master Abort completion packet.
4	0b R/WC	**Received Target Abort on HI_B.** 0 = No Target Abort detected. 1 = The MCH has detected that an MCH originated cycle was terminated with a Target Abort completion packet.
3	0b R/WC	**Correctable Error on Header/Address from HI_B.** 0 = No correctable error on header/address from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a single bit correctable error.
2	0b R/WC	**Correctable Error on Data from HI_B.** 0 = No correctable error on data from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a single bit correctable error.
1	0b R/WC	**Uncorrectable Error on Header/Address from HI_B.** 0 = No uncorrectable error on header/address from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a multi-bit uncorrectable error.
0	0b R/WC	**Uncorrectable Error on Data Transfer from HI_B.** 0 = No uncorrectable error on data from HI_B detected. 1 = Even when error correction is turned off, this bit may be set if a packet is received that has a multi-bit uncorrectable error.

3.9.13 SERRCMD2—SERR Command Register (D2:F1)

Address Offset:	A0h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SERR will be generated when the associated flag is set in the FERR or NERR Register. When an error flag is set in the FERR or NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7:6	00b	Reserved
5	0b R/W	**SERR on MCH Master Abort to a HI_B Request Enable.** 0 = No SERR generation 1 = Generate SERR if bit 5 is set in HIB_FERR or HIB_NERR
4	0b R/W	**SERR on Received Target Abort on HI_B Enable.** 0 = No SERR generation 1 = Generate SERR if bit 4 is set in HIB_FERR or HIB_NERR
3	0b R/W	**SERR on Correctable Error on Header/Address from HI_B Enable.** 0 = No SERR generation 1 = Generate SERR if bit 3 is set in HIB_FERR or HIB_NERR
2	0b R/W	**SERR on Correctable Error on Data from HI_B Enable.** 0 = No SERR generation 1 = Generate SERR if bit 2 is set in HIB_FERR or HIB_NERR
1	0b R/W	**SERR on Uncorrectable Error on Header/Address from HI_B Enable.** 0 = No SERR generation 1 = Generate SERR if bit 1is set in HIB_FERR or HIB_NERR
0	0b R/W	**SERR on Uncorrectable Error on Data Transfer from HI_B Enable.** 0 = No SERR generation 1 = Generate SERR if bit 0 is set in HIB_FERR or HIB_NERR

3.9.14 SMICMD2—SMI Command Register (D2:F1)

Address Offset:	A2h
Default:	00h
Sticky:	No
Access:	R/W
Size:	8 Bits

This register determines whether SMI will be generated when the associated flag is set in the FERR or NERR Register. When an error flag is set in the FERR or NERR Register, it can generate an SERR, SMI, or SCI when enabled in the SERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SMI on MCH Received SERR from HI_B Enable.** 0 = No SMI generation 1 = Generate SMI if bit 6 is set in HIB_FERR or HIB_NERR
5	0b R/W	**SMI on MCH Master Abort to a HI_B Request Enable.** 0 = No SMI generation 1 = Generate SMI if bit 5 is set in HIB_FERR or HIB_NERR
4	0b R/W	**SMI on Received Target Abort on HI_B Enable.** 0 = No SMI generation 1 = Generate SERR if bit 4 is set in HIB_FERR or HIB_NERR
3	0b R/W	**SMI on Correctable Error on Header/Address from HI_B Enable.** 0 = No SMI generation 1 = Generate SMI if bit 3 is set in HIB_FERR or HIB_NERR
2	0b R/W	**SMI on Correctable Error on Data from HI_B Enable.** 0 = No SMI generation 1 = Generate SMI if bit 2 is set in HIB_FERR or HIB_NERR
1	0b R/W	**SMI on Uncorrectable Error on Header/Address from HI_B Enable.** 0 = No SMI generation 1 = Generate SMI if bit 1is set in HIB_FERR or HIB_NERR
0	0b R/W	**SMI on Uncorrectable Error on Data Transfer from HI_B Enable.** 0 = No SMI generation 1 = Generate SMI if bit 0 is set in HIB_FERR or HIB_NERR

3.9.15 SCICMD2—SCI Command Register (D2:F1)

Address Offset:	A4h
Default:	00h
Sticky:	Yes
Access:	R/W
Size:	8 Bits

This register determines whether SCI will be generated when the associated flag is set in the FERR or NERR Register. When an error flag is set in the FERR or NERR Register, it can generate an SERR, SMI, or SCI when enabled in the ERRCMD, SMICMD, or SCICMD Registers, respectively. Only one message type can be enabled.

Bits	Default, Access	Description
7	0b	Reserved
6	0b R/W	**SCI on MCH Received SERR from HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 6 is set in HIB_FERR or HIB_NERR
5	0b R/W	**SCI on MCH Master Abort to a HI_B Request Enable.** 0 = No SCI generation 1 = Generate SCI if bit 5 is set in HIB_FERR or HIB_NERR
4	0b R/W	**SCI on Received Target Abort on HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 4 is set in HIB_FERR or HIB_NERR
3	0b R/W	**SCI on Correctable Error on Header/Address from HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 3 is set in HIB_FERR or HIB_NERR
2	0b R/W	**SCI on Correctable Error on Data from HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 2 is set in HIB_FERR or HIB_NERR
1	0b R/W	**SCI on Uncorrectable Error on Header/Address from HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 1is set in HIB_FERR or HIB_NERR
0	0b R/W	**SCI on Uncorrectable Error on Data Transfer from HI_B Enable.** 0 = No SCI generation 1 = Generate SCI if bit 0 is set in HIB_FERR or HIB_NERR

3.10 HI_C Virtual PCI-to-PCI Bridge Registers (Device 3, Function 0,1)

Device 3 is the HI_C virtual PCI-to-PCI bridge. The register descriptions for Device 3 are the same as Device 2 (except for the DID Registers). This section contains the DID Register descriptions for Device 3, Function 0,1. For other register descriptions, refer to Section 3.8 and Section 3.9.

3.10.1 DID—Device Identification Register (D3:F0)

Address Offset:	02–03h
Default:	2545h
Access:	RO
Size:	16 Bits

This 16-bit register combined with the Vendor Identification register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2545h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH device 3.

3.10.2 DID—Device Identification Register (D3:F1)

Address Offset:	02–03h
Default:	2546h
Access:	RO
Size:	16 Bits

This 16-bit register combined with the Vendor Identification register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2546h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH device 3.

3.11 HI_D Virtual PCI-to-PCI Bridge Registers (Device 4, Function 0,1)

Device 4 is the HI_D virtual PCI-to-PCI bridge. The register descriptions for Device 4 are the same as Device 2 (except for the DID Registers). This section contains the DID Register descriptions for Device 4, Function 0,1. For other register descriptions, refer to Section 3.8 and Section 3.9.

3.11.1 DID—Device Identification Register (D4:F0)

Address Offset:	02–03h
Default:	2547h
Access:	RO
Size:	16 Bits

This 16-bit register combined with the Vendor Identification Register uniquely identifies any PCI device.

Bits	Default, Access	Description
15:0	2547h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH device 4.

3.11.2 DID—Device Identification Register (D4:F1)

Address Offset:	02–03h
Default:	2548h
Access:	RO
Size:	16 Bits

This 16-bit register combined with the Vendor Identification Register uniquely identifies any PCI device. Writes to this register have no effect.

Bits	Default, Access	Description
15:0	2548h RO	**Device Identification Number (DID).** This is a 16-bit value assigned to the MCH device 4.

This page is intentionally left blank.

System Address Map 4

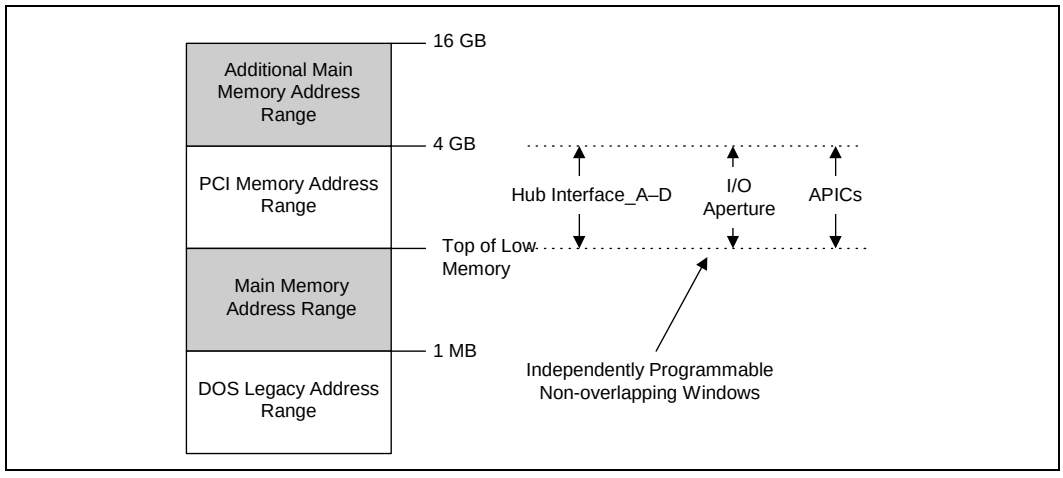
A system based on the E7500 chipset supports 16 GB of host-addressable memory space and 64 KB + 3 bytes of host-addressable I/O space. The I/O and memory spaces are divided by system configuration software into regions. The memory ranges are useful either as system memory or as specialized memory, while the I/O regions are used solely to control the operation of devices in the system.

4.1 System Memory Spaces

There are four basic regions of memory in the system:

- High Memory Range. Memory above 4 GB. This memory range is for additional main memory (1_0000_0000h to 3_FFFF_FFFFh).
- Memory between 1 MB and the Top of Low Memory (TOLM) Register. This is a main memory address range (0_0100_0000h to TOLM).
- Memory between the TOLM Register and 4 GB. This range is used for mapping APIC and Hub Interface_A–D. Programmable non-overlapping I/O windows can be mapped to this area.
- DOS Compatible memory area. Memory below 1 MB (0_0000_0000h to 0_0009_FFFFh).

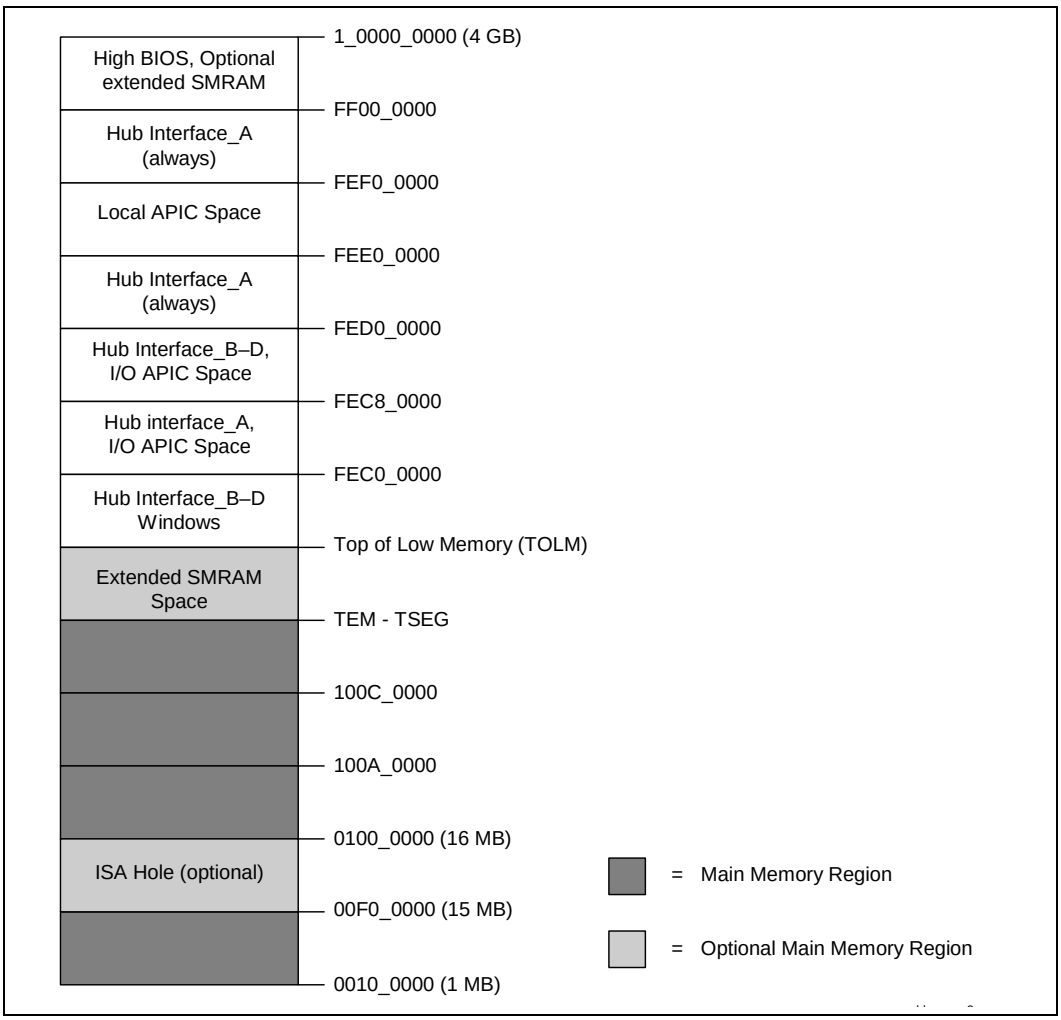
Figure 4-1. System Address Map



These address ranges are always mapped to system memory, regardless of the system configuration. Memory may be allocated from the main memory segment 0_0100_0000h to TOLM for use by System Management Mode (SMM) hardware and software. The top of main memory is defined by the Top of Low Memory (TOLM) Register. Note that the address of the highest 64 MB quantity of valid memory in the system is placed into the DRB7 Register. For systems with a total DRAM space and PCI memory-mapped space of less than 4 GB, this value will be the same as the one programmed into the TOLM Register. For other memory configurations, the two are unlikely to be the same, since the PCI configuration portion of the BIOS software will program the TOLM

Register to the maximum value that is less than 4 GB and also allows enough room for all populated PCI devices. Figure 4-2 shows the segments within the extended memory segment (1 MB to 4 GB).

Figure 4-2. Detailed Extended Memory Range Address Map



4.1.1 VGA and MDA Memory Spaces

Video cards use these legacy address ranges to map a frame buffer or a character-based video buffer. The address ranges in this memory space are:

- VGAA 0_000A_0000h to 0_000A_FFFFh
- MDA 0_000B_0000h to 0_000B_7FFFh
- VGAB 0_000B_8000h to 0_000B_FFFFh

By default, accesses to these ranges are forwarded to Hub Interface_A. However, if the VGA_EN bit is set in the BCTRL 2–4 configuration registers, then transactions within the VGA and MDA spaces are sent to Hub Interface_B, C, D, respectively.

Note: The VGA_EN bit may be set in one and only one of the BCTRL Registers. Software must not set more than one of the VGA_EN bits.

If the configuration bit MCHCFG.MDAP is set, accesses that fall within the MDA range will be sent to Hub Interface_A without regard for the VGAEN bits. Legacy support requires the ability to have a second graphics controller (monochrome) in the system. In a E7500 chipset system, accesses in the standard VGA range are forwarded to Hub Interface_B, C, D (depending on configuration bits). Since the monochrome adapter may be on the HI_A/PCI (or ISA) bus, the MCH must decode cycles in the MDA range and forward them to Hub Interface_A. This capability is controlled by a configuration bit (MDAP bit). In addition to the memory range B0000h to B7FFFh, the MCH decodes I/O cycles at 3B4h, 3B5h, 3B8h, 3B9h, 3BAh and 3BFh and forwards them to Hub Interface_A.

An optimization allows the system to reclaim the memory displaced by these regions. When SMM memory space is enabled by SMRAM.G_SMRAME and either the SMRAM.D_OPEN bit is set or the system bus receives an SMM-encoded request for code (not data), the transaction is steered to system memory rather than HI_A. Under these conditions, both of the VGAEN bits and the MDAP bit are ignored.

4.1.2 PAM Memory Spaces

The address ranges in this space are:

- PAMC0 0_000C_0000 to 0_000C_3FFF
- PAMC4 0_000C_4000 to 0_000C_7FFF
- PAMC8 0_000C_8000 to 0_000C_BFFF
- PAMCC 0_000C_C000 to 0_000C_FFFF
- PAMD0 0_000D_0000 to 0_000D_3FFF
- PAMD4 0_000D_4000 to 0_000D_7FFF
- PAMD8 0_000D_8000 to 0_000D_BFFF
- PAMDC 0_000D_C000 to 0_000D_FFFF
- PAME0 0_000E_0000 to 0_000E_3FFF
- PAME4 0_000E_4000 to 0_000E_7FFF
- PAME8 0_000E_8000 to 0_000E_BFFF
- PAMEC 0_000E_C000 to 0_000E_FFFF
- PAMF0 0_000F_0000 to 0_000F_FFFF

The 256 KB PAM region is divided into three parts:

- ISA expansion region: 128 KB area between 0_000C_0000h and 0_000D_FFFFh
- Extended BIOS region: 64 KB area between 0_000E_0000h and 0_000E_FFFFh,
- System BIOS region: 64 KB area between 0_000F_0000h and 0_000F_FFFFh.

The ISA expansion region is divided into eight, 16-KB segments. Each segment can be assigned one of four read/write states: read-only, write-only, read/write, or disabled. Typically, these blocks are mapped through the MCH and are subtractively decoded to ISA space.

The extended system BIOS region is divided into four, 16-KB segments. Each segment can be assigned independent read and write attributes so it can be mapped either to main memory or to Hub Interface_A. Typically, this area is used for RAM or ROM.

The system BIOS region is a single, 64-KB segment. This segment can be assigned read and write attributes. It is by default (after reset) read/write disabled and cycles are forwarded to Hub Interface_A. By manipulating the read/write attributes, the MCH can shadow BIOS into the main memory.

Note that the PAM region can be accessed by Hub Interface_A–D. All reads or writes from any Hub Interface that hits the PAM area is sent to main memory. If the system is setup so that there are Hub Interface accesses to the PAM regions, then the PAM region being accessed must be programmed to be both readable and writable by the processor. If the accessed PAM region is programmed for either reads or writes to be forwarded to Hub Interface_A, and there are Hub Interface accesses to that PAM, the system may fault.

4.1.3 ISA Hole Memory Space

BIOS software may optionally open a “window” between 15 MB and 16 MB (0_00F0_0000 to 0_00FF_FFFF) that relays transactions to Hub Interface_A instead of completing them with a system memory access. This window is opened with the FDHC.HEN configuration field.

4.1.4 I/O APIC Memory Space

The I/O APIC spaces are used to communicate with I/O APIC interrupt controllers that may be populated on Hub Interface_A through Hub Interface_D. Since it is difficult to relocate an interrupt controller using plug-and-play software, fixed address decode regions have been allocated for them. The address ranges are:

- I/OAPIC0 (HI_A) 0_FEC0_0000h to 0_FEC7_FFFFh
- I/OAPIC1 (HI_B) 0_FEC8_0000h to 0_FEC8_0FFFh
- I/OAPIC2 (HI_C) 0_FEC8_1000h to 0_FEC8_1FFFh
- I/OAPIC3 (HI_D) 0_FEC8_2000h to 0_FEC8_2FFFh

Processor accesses to the I/OAPIC0 region are always sent to Hub Interface_A. Processor accesses to the I/OAPIC1 region are always sent to Hub Interface_B and so on.

4.1.5 System Bus Interrupt Memory Space

The system bus interrupt space (0_FEE0_0000h to 0_FEEF_FFFFh) is the address used to deliver interrupts to the system bus. Any device on Hub Interface_A–D may issue a double-word memory write to 0FEEx_xxxxh. The MCH will forward this memory write along with the data to the system bus as an Interrupt Message Transaction. The MCH terminates the system bus transaction by providing the response and asserting TRDY#. This memory write cycle does not go to DRAM.

The processors may also use this region to send inter-processor interrupts (IPI) from one processor to another.

4.1.6 Device 2 Memory and Prefetchable Memory

Plug-and-play software configures the HI_B memory window to provide enough memory space for the devices behind this PCI-to-PCI Bridge. Accesses that have addresses that fall within this window are decoded and forwarded to Hub Interface_B for completion. The address ranges are:

- M2 MBASE2 to MLIMIT2
- PM2 PMBASE2 to PMLIMIT2

Note that these registers must be programmed with values that place the Hub Interface_B memory space window between the value in the TOLM Register and 4 GB. In addition, neither region should overlap with any other fixed or relocatable area of memory.

4.1.7 Device 3 Memory and Prefetchable Memory

Plug-and-play software configures the Hub Interface_C memory window to provide enough memory space for the devices behind this PCI-to-PCI Bridge. Accesses that have addresses that fall within this window are decoded and forwarded to Hub Interface_C for completion.

- M3 MBASE3 to MLIMIT3
- PM3 PMBASE3 to PMLIMIT3

Note that these registers must be programmed with values that place the Hub Interface_C memory space window between the value in the TOLM Register and 4 GB. In addition, neither region should overlap with any other fixed or relocatable area of memory.

4.1.8 Device 4 Memory and Prefetchable Memory

Plug-and-play software configures the Hub Interface_D memory window to provide enough memory space for the devices behind this PCI-to-PCI Bridge. Accesses that have addresses that fall within this window are decoded and forwarded to Hub Interface_D for completion.

- M4 MBASE4 to MLIMIT4
- PM4 PMBASE4 to PMLIMIT4

Note that these registers must be programmed with values that place the Hub Interface_D memory space window between the value in the TOLM Register and 4 GB. In addition, neither region should overlap with any other fixed or relocatable area of memory.

4.1.9 HI_A Subtractive Decode

All accesses that fall between the value programmed into the TOLM Register and 4 GB (i.e., TOLM and 4 GB) are subtractively decoded and forwarded to Hub Interface_A if they do not decode to a space that corresponds to another device.

4.1.10 Main Memory Addresses

The high memory and extended memory address regions are together called main memory. Main memory is composed of address segments that refer to SDRAM system memory. Main memory addresses are mapped to SDRAM channels, devices, banks, rows, and columns in different ways depending upon the type of memory being used and the density or organization of the memory. Refer to Section 1.4.2 for supported DIMM configurations.

4.2 I/O Address Space

The MCH does not support the existence of any other I/O devices on the system bus. The MCH generates Hub Interface_A–D bus cycles for all processor I/O accesses. The MCH contains two internal registers in the processor I/O space, Configuration Address Register (CONF_ADDR) and the Configuration Data Register (CONF_DATA). These locations are used to implement the configuration space access mechanism and are described in Device Configuration Registers section.

The processor allows 64 KB + 3 bytes to be addressed within the I/O space. The MCH propagates the processor I/O address without any translation to the targeted destination bus. Note that the upper three locations can be accessed only during I/O address wrap-around when signal A16# is asserted on the system bus. A16# is asserted on the system bus whenever a DWord I/O access is made from address 0FFFDh, 0FFFEh, or 0FFFFh. In addition, A16# is asserted when software attempts a two bytes I/O access from address 0FFFFh.

The I/O accesses (other than ones used for configuration space access) are forwarded normally to Hub Interface_A–D. All I/O cycles receive a Defer Response. The MCH never posts an I/O write.

The MCH never responds to I/O or configuration cycles initiated on any of the hub interfaces. Hub interface transactions requiring completion are terminated with “master abort” completion packets on the hub interfaces. Hub interface I/O write transactions not requiring completion are dropped.

4.3 SMM Space

4.3.1 System Management Mode (SMM) Memory Range

The E7500 chipset supports the use of main memory as System Management RAM (SMM RAM), which enables the use of System Management Mode. The MCH supports three SMM options:

- Compatible SMRAM (C_SMRAM)
- High Segment (HSEG)
- Top of Memory Segment (TSEG).

System Management RAM space provides a memory area that is available for the SMI handlers and code and data storage. This memory resource is normally hidden from the system operating system so the processor has immediate access to this memory space upon entry to SMM. The MCH provides three SMRAM options:

- Below 1-MB option that supports compatible SMI handlers.
- Above 1-MB option that allows new SMI handlers to execute with write-back cacheable SMRAM.
- Optional larger write-back cacheable TSEG area from 128 KB to 1 MB in size above 1 MB that is reserved below the 4 GB in system DRAM memory space. The above 1-MB solutions require changes to compatible SMRAM handler code to properly execute above 1 MB.

4.3.2 TSEG SMM Memory Space

The TSEG SMM space (TOLM – TSEG to TOLM) allows system management software to partition a region of main memory just below the top of low memory (TOLM) that is accessible only by system management software. This region may be 128 KB, 256 KB, 512 KB, or 1 MB in size, depending upon the ESMRAMC.TSEG_SZ field. This space must be below 4 GB, so it is below TOLM and not the top of physical memory, SMM memory is globally enabled by SMRAM.G_SMRAME. Requests may access SMM system memory when either SMM space is open (SMRAM.D_OPEN) or the MCH receives an SMM code request on its system bus. To access the TSEG SMM space, TSEG must be enabled by ESMRAMC.T_EN. When all of these conditions are met, a system bus access to the TSEG space (between TOLM–TSEG and TOLM) is sent to system memory. When the high SMRAM is not enabled or if the TSEG is not enabled, memory requests from all interfaces are forwarded to system memory. When the TSEG SMM space is enabled, and an agent attempts a non-SMM access to TSEG space, then the transaction is specially terminated.

Hub interface originated accesses are not allowed to SMM space.

4.3.3 High SMM Memory Space

The HIGHSMM space (0_FEDA_0000h to 0_FEDB_FFFFh) allows cacheable access to the compatible SMM space by remapping valid SMM accesses between 0_FEDA_0000h and 0_FEDB_FFFFh to accesses between 0_000A_0000h and 0_000B_FFFFh. The accesses are remapped when SMRAM space is enabled; an appropriate access is detected on the system bus, and when ESMRAMC.H_SMRAME allows access to high SMRAM space. SMM memory accesses from any hub interface are specially terminated: reads are provided with the value from address 0 while writes are ignored entirely.

4.3.4 SMM Space Restrictions

When any of the following conditions are violated, the results of SMM accesses are unpredictable and may cause undesirable system behavior:

1. The Compatible SMM space must not be setup as cacheable.
2. Both D_OPEN and D_CLOSE must not be set to 1 at the same time.
3. When TSEG SMM space is enabled, the TSEG space must not be reported to the operating system as available DRAM. This is a BIOS responsibility.

4.3.5 SMM Space Definition

SMM space is defined by its addressed SMM space and its DRAM SMM space. The addressed SMM space is defined as the range of bus addresses used by the processor to access SMM space. DRAM SMM space is defined as the range of physical DRAM memory locations containing the SMM code. SMM space can be accessed at one of three transaction address ranges: Compatible, High, and TSEG. The Compatible and TSEG SMM space is not remapped and, therefore, the addressed and DRAM SMM space is the same address range. Since the High SMM space is remapped, the addressed and DRAM SMM space is a different address range. Note that the High DRAM space is the same as the Compatible Transaction Address space. Table 4-1 describes three unique address ranges:

- Compatible Transaction Address
- High Transaction Address
- TSEG Transaction Address

Table 4-1. SMM Address Range

SMM Space Enabled	Transaction Address Space	DRAM Space
Compatible	A0000h to BFFFFh	A0000h to BFFFFh
High	0FEDA0000h to 0FEDBFFFFh	A0000h to BFFFFh
TSEG	(TOLM–TSEG_SZ) to TOLM	(TOLM–TSEG_SZ) to TOLM

NOTES:
1. High SMM: This is different than in previous chipsets. In previous chipsets the High segment was the 384 KB region from A_0000h to F_FFFFh. However, C_0000h to F_FFFFh was not practically useful so it is deleted in the MCH.
2. TSEG SMM: This is different than in previous chipsets. In previous chipsets the TSEG address space was offset by 256 MB to allow for simpler decoding and the TSEG was remapped to just under the TOLM. In the MCH the TSEG region is not offset by 256 MB and it is not remapped.

4.4 Memory Reclaim Background

The following memory-mapped I/O devices are typically located below 4 GB:

- High BIOS
- HSEG
- XAPIC
- Local APIC
- System Bus Interrupts
- HI_B, HI_C, HI_D BARs

In previous generation MCHs, the physical main memory overlapped by the logical address space allocated to these memory-mapped I/O devices was unusable. In server systems the memory allocated to memory-mapped I/O devices could easily exceed 1 GB. The result is that a large amount of physical memory would not be usable.

The MCH provides the capability to re-claim the physical memory overlapped by the memory mapped I/O logical address space. The MCH re-maps physical memory from the Top of Low Memory (TOLM) boundary up to the 4 GB boundary (or DRB7 if less than 4 GB) to an equivalent sized logical address range located just above the top of physical memory

4.4.1 Memory Re-Mapping

An incoming address (referred to as a logical address) is checked to see if it falls in the memory re-map window. The bottom of the re-map window is defined by the value in the REMAPBASE Register. The top of the re-map window is defined by the value in the REMAPLIMIT Register. An address that falls within this window is remapped to the physical memory starting at the address defined by the TOLM Register.

Reliability, Availability, Serviceability, Usability, and Manageability (RASUM) 5

The E7500 chipset-based platforms provide the RASUM (Reliability, Availability, Serviceability, Usability, and Manageability) features required for entry-level and mid-range servers. These features include: Chipkill technology ECC for memory, ECC for all high-performance I/O, out-of-band manageability through SMBus target interfaces on all major components, memory scrubbing and auto-initialization, processor thermal monitoring, and hot-plug PCI.

5.1 DRAM ECC

The ECC used for DRAM provides chipkill technology protection for x4 SDRAMs. DRAMS that are x8 use the same algorithm but will not have chipkill technology protection, since at most only four bits can be corrected with this ECC.

5.2 DRAM Scrubbing

A special DRAM scrub algorithm will walk through all of main memory doing reads followed by writes back to the same location. Correctable errors found by the read are corrected and then the good data is written back to DRAM. A write is done in all cases, whether there were errors or not. This looks like a read-modify-write of 0 bytes to the system. The scrub unit starts at address 0 upon reset. Periodically, the unit will scrub one line and then increment the address counter by 64 bytes or one line. A 16-GB memory array would be completely scrubbed in approximately one day.

5.3 DRAM Auto-Initialization

The DRAM Auto-initialization algorithms initialize memory at reset to ensure that all lines have valid ECC.

5.4 SMBus Access

The processor will be able to access all configuration registers through host configuration cycles. Access via SMBus will be R/W to a shadowed set of the RASUM registers in the MCH, and read-only to all non-RASUM registers in the MCH. The SMBus can not use the MCH's SM-port to access any registers outside the MCH. The P64H2 and ICH3-S each have their own SMBus target port. A test mode will be provided to allow the processor to access the shadowed register set. Shadowing the RASUM registers ensures that BIOS code and system management ASIC firmware code can execute independently, without interference or synchronization efforts. PCI legacy registers associated with error reporting will not deviate from prior implementations. SMBus will have read-only access to the PCI legacy registers.

This page is intentionally left blank.

Electrical Characteristics 6

This chapter provides the absolute maximum ratings, thermal characteristics, and DC characteristics for the MCH.

6.1 Absolute Maximum Ratings

Warning: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operating beyond the "operating conditions" is not recommended and extended exposure beyond "operating conditions" may affect reliability.

Table 6-1. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit	Notes
$T_{storage}$	Storage Temperature	-55	150	°C	
VCC_MCH	1.2 V Supply Voltage with respect to VSS	-0.38	2.1	V	
VTT_AGTL	Supply Voltage input with respect to VSS	-0.38	2.1	V	
VDD_DDR	DDR Buffer Supply Voltage	2	3	V	

6.2 Thermal Characteristics

The MCH is designed for operation at die temperatures between 0 °C and 110 °C. The thermal resistance of the package is given in Table 6-2.

Table 6-2. MCH Package Thermal Resistance

Parameter	Air Flow	
	No Air Flow (0 Meter/Second)	1.0 Meter/Second [2]
Psi_{jt} (°C/Watt) [1]	0.5	1.0
$Theta_{ja}$ (°C/Watt) [1]	13.0	11.2

NOTES:
1. Typical value measured in accordance with EIA/JESD 51-2 testing standard.
2. 1 meter/second is equivalent to 196.9 linear feet/minute

6.3 Power Characteristics

Table 6-3. Thermal Power Dissipation (VCC1_2 = 1.2 V ±5%)

Symbol	Parameter	Min	Typ	Max	Unit	Notes
P_{MCH}	Thermal Power Dissipation for MCH		11.6	15.6	W	1

NOTES:
1. TDP Typ is the Thermal Design Power (11.6 W) and it is the estimated maximum possible expected power generated in a component by a realistic application. It is based on extrapolations in both hardware and software technology over the life of the component. It does not represent the expected power generated by a power virus. Studies by Intel indicate that no useful application will cause thermally significant power dissipation exceeding the TDP Typ specification, although it is possible to concoct higher power synthetic workloads as reflected in the TDP Max specification.

Table 6-4. DC Characteristics Functional Operating Range (VCC1_2 = 1.2 V ±5%)

Symbol	Parameter	Min	Typ	Max	Unit	Notes
I_{CC}	1.2 V Plumas Core and HI			3.1	A	
I_{VTT}	1.55 V AGTL			2.0	A	
I_{dd_DDR}	2.5 V VDD DDR (2 channel)			7	A	

6.4 I/O Interface Signal Groupings

The signal description includes the type of buffer used for the particular signal:

- AGTL+ Open Drain AGTL+ interface signal. Refer to the AGTL+ I/O Specification for complete details. The MCH integrates AGTL+ termination resistors.
- CMOS 1.2 V CMOS buffers.
- DDR DDR SDRAM signaling Interface

Table 6-5. Signal Groups System Bus Interface

Signal Group	Signal Type	Signals	Notes
(a)	AGTL+ I/O	AP[1:0]#, ADS#, BNR#, DBSY#, DP[3:0]#, DRDY#, HA[35:3]#, HADSTB[1:0] #, HD[63:0] #, HDSTBP[3:0]#, HDSTBN[3:0]#, HIT#, HITM#, HREQ[4:0]#, BREQ0#, DBI[3;0]#	
(b)	AGTL+ Output	BPRI#, CPURST#, DEFER#, HTRDY#, RS [2:0]#, RSP#	
(c)	AGTL+ Input	HLOCK#, XERR#	
(d)	Host Reference Voltage	HDVREF[3:0], HAVREF[1:0], HCCVREF	
(e)	Host Voltage Swing	HXSWING, HYSWING	
(f)	Host Compensation	HXRCOMP, HYRCOMP	
(g)	CLK Inputs	HCLKINN, HCLKINP	
(h)	AGTL + Termination Voltage	VTT	

Table 6-6. Signal Groups DDR Interface

Signal Group	Signal Type	Signals	Notes
(i)	DDR I/O	DQ_x [63:0], CB_x [7:0], DQS_x [17:0]	1
(j)	DDR Output	CMDCLK_x [3:0], CMDCLK_x#[3:0], MA_x [12:0], BA_x [1:0], RAS_x#, CAS_x#, WE_x#, CS_x [7:0]#, CKE_x, RCVENOUT_x#	1
(k)	DDR Input	RCVENIN_x#	1
(l)	DDR Compensation CMOS I/O	DDRCOMP_x	1
(m)	DDR Compensation for impedance control	DDRCVOH_x, DDRCVOL_x	1
(n)	DDR Reference Voltage	DDRVREF_x [5:0]	1

NOTES:
1. x = A, B DDR channel

Table 6-7. Signal Groups Hub Interface 2.0 (HI_B–D)

Signal Group	Signal Type	Signals	Notes
(o)	Hub Interface CMOS I/O	HI_x [21:0], PSTRBF_x, PSTRBS_x	1
(p)	Hub Interface CMOS Input Clock	CLK66	2
(q)	Hub Interface Reference Voltage Input	HIVREF_x	1
(r)	Hub Interface Voltage Swing	HISWNG_x	1
(s)	Hub Interface Compensation CMOS I/O	HIRCOMP_x	1

NOTES:
1. x = B, C, D (referencing Hub Interface_B–D).
2. CLK66 is shared on HI 1.5 and HI 2.0

Table 6-8. Signal Groups Hub Interface 1.5 (HI_A)

Signal Group	Signal Type	Signals	Notes
(t)	Hub Interface CMOS I/O	HI_A [11:0], HI_STBF, HI_STBS	
(u)	Hub Interface CMOS Input Clock	CLK66	1
(v)	Hub Interface Reference Voltage Input	HIVREF_A	
(w)	Hub Interface Voltage Swing	HISWNG_A	
(x)	Hub Interface Compensation CMOS I/O	HIRCOMP_A	

NOTES:
1. CLK66 is shared on HI 1.5 and HI 2.0

Table 6-9. Signal Groups SMBus

Signal Group	Signal Type	Signals	Notes
(y)	SMBus I/O Buffer	SMB_CLK, SMB_DATA	

Table 6-10. Signal Groups Reset and Miscellaneous

Signal Group	Signal Type	Signals	Notes
(z)	Miscellaneous CMOS Input	RSTIN#, PWRGOOD, XORMODE#	

6.5 DC Characteristics

Table 6-11. Operating Condition Supply Voltage (VCC1_2 = 1.2 V ±5%)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
VTT	(h)	Host AGTL+ Termination Voltage	1.15	1.3	1.45	V	
VDD_DDR		DDR Buffer Voltage	2.3	2.5	2.7	V	
VCC_MCH		1.2 V Supply voltage	1.14	1.2	1.26	V	

Table 6-12. System Bus Interface (VCC1_2 = 1.2 V ±5%)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
V_{IL_H}	(a), (c)	Host AGTL+ Input Low Voltage			(2/3 x VTT) – 0.1GTLREF	V	
V_{IH_H}	(a), (c)	Host AGTL+ Input High Voltage	(2/3 x VTT) + 0.1GTLREF			V	
V_{OL_H}	(a), (b)	Host AGTL+ Output Low Voltage		1/3 x VTT	(1/3 x VTT) + 0.1GTLREF	V	
V_{OH_H}	(a), (b)	Host AGTL+ Output High Voltage	VTT–0.1	VTT		V	
RTT		Host termination Resistance	46	50	54	W	
I_{OL_H}	(a), (b)	Host AGTL+ Output Low Leakage			(2/3 x VTTmax) / RTT min	A	
I_{L_H}	(a), (c)	Host AGTL+ Input Leakage Current	10			µA	
C_{PAD}	(a), (c)	Host AGTL+ Input Capacitance	1		3.5	pF	
CCVREF	(d)	Host Common clock Reference Voltage		2/3 x VTT		V	
HxVREF	(d)	Host Address and Data Reference Voltage		2/3 x VTT		V	
HXSWNG, HYSWNG	(e)	Host Compensation Reference Voltage		1/3 x VTT		V	

Table 6-13. DDR Interface (VCC1_2 = 1.2 V ±5%)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
$V_{IL (DC)}$	(i), (k)	DDR Input Low Voltage		DDRVREF – 0.150		V	
$V_{IH (DC)}$	(i), (k)	DDR Input High Voltage	DDRVREF + 0.150			V	
$V_{IL (AC)}$	(i), (k)	DDR Input Low Voltage			DDRVREF –0.310		
$V_{IH (AC)}$	(i), (k)	DDR Input High Voltage	DDRVREF +0.310				
V_{OL}	(i), (j)	DDR Output Low Voltage	0		0.7	V	
V_{OH}	(i), (j)	DDR Output High Voltage	1.7		VDD_DDR	V	
C_{Out}	(i), (k)	DDR Input Pin Capacitance	2.5		5	pF	
$I_{OL (DC)}$	(i), (j)	DDR Output Low Current			-50	mA	
I_{OH}	(i), (j)	DDR Output High Current			50	mA	
$I_{OL (AC)}$	(i), (j)	DDR Output Low Current			50	mA	
$I_{OH (AC)}$	(i), (j)	DDR Output High Current			50	mA	
I_{Leak}	(i), (k)	Input Leakage Current			50	µA	
C_{IN}	(i), (k)	Input Pin Capacitance	2.5		5	pF	
DDRVREF	(n)	DDR Reference Voltage		VDD_DDR/2		V	

Table 6-14. Hub Interface 2.0 Configured for 50 Ω (VCC1_2 = 1.2 V ±5%)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
V_{IL_HI}	(o)	Hub Interface Input Low Voltage		0	HIVREF–0.1	V	
V_{IH_HI}	(o)	Hub Interface Input High Voltage	HIVREF +0.1	0.7	—	V	
V_{OL_HI}	(o)	Hub Interface Output Low Voltage	-0.03	0	0.05	V	1
V_{OHT_HI}	(o)	Hub Interface Terminator High Voltage	HISWNG –0.50		HISWNG +0.50	V	2
V_{OHD_HI}	(o)	Hub Interface Output High Voltage	HISWNG –0.50		HISWNG +0.50	V	2
I_{IL_HI}	(o)	Hub Interface Input Leakage Current			25	µA	
C_{IN_HI}	(o)	Hub Interface Input Pin Capacitance			3.5	pF	
ΔC_{IN}		Strobe to Data Pin Capacitance Delta	-0.50		0.50	pF	
L_{PIN}		Pin Inductance (Signal)			5	nH	
Z_{PD}		Pull-Down Impedance	45	50	55	Ω	
Z_{PU}		Pull-Up Impedance	22.5	25	27.5	Ω	
V_{CCP}		I/O Supply Voltage		1.2		V	
C_{Clk}	(p)	CLK66 Pin Capacitance			0.025	V	
HIVREF_x	(q)	Hub Interface Reference Voltage	0.343	0.35	0.357	V	
HISWNG_x	(r)	Hub Interface Swing Reference Voltage		0.8		V	
HIRCOMP_x	(s)	Hub Interface Compensation Resistance	24.75	25	25.25	Ω	

NOTES:
1. V_{OL} is measured at IOUT = 1.0 mA
2. There are two V_{OH} specifications. V_{OHT} applies when the pin is in receive (terminating) mode and tests the strength of the terminator / pull-down device. V_{OHT} is measured with the specified pull-up resistor tied to V_{DDHI}. V_{OHD} applies when the pin is driving a high level and tests the strength of the pull-up device. V_{OHD} is measured into a standard resistive load to ground representing the target impedance of the receiver terminator (Z_{TARG}). The output driver is also responsible for not driving the receiver higher than the maximum VIH. This represents the absolute maximum allowed voltage allowed on the receiver pin (i.e., V_{OH} due to incomplete impedance updates on the drivers and terminator). This specification allows inter-operation between devices over many process generations. A given platform where the devices have higher voltage tolerances may specify a higher V_{IH} (max).

Table 6-15. Hub Interface 1.5 with Parallel Buffer Mode Configured for 50 Ω (VCC1_2 = 1.2 V ±5%)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
V_{IL_HI}	(t)	Hub Interface Input Low Voltage		0	HIVREF–0.1	V	
V_{IH_HI}	(t)	Hub Interface Input High Voltage	HIVREF+0.1	0.7	—	V	
V_{OL_HI}	(t)	Hub Interface Output Low Voltage	-0.03	0	0.05	V	1
V_{OHT_HI}	(t)	Hub Interface Terminator Voltage	HISWNG–0.50		HISWNG+0.50	V	2
V_{OHD_HI}	(t)	Hub Interface Output High Voltage	HISWNG–0.50		HISWNG+0.50	V	2
I_{IL_HI}	(t)	Hub Interface Input Leakage Current			25	µA	
C_{IN_HI}	(t)	Hub Interface Input Pin Capacitance			3.5	pF	
ΔC_{IN}		Strobe to Data Pin Capacitance delta	-0.50		0.50	pF	
L_{PIN}		Pin Inductance (Signal)			5	nH	
Z_{PD}		Pull-down Impedance	45	50	55	Ω	
Z_{PU}		Pull-up Impedance	22.5	25	27.5	Ω	
V_{CCP}		I/O Supply Voltage		1.2		V	
C_{Clk}	(u)	CLK66 Pin Capacitance			0.025	V	
HIVREF_A	(v)	Hub Interface Reference Voltage	0.343	0.35	0.357	V	
HISWNG_A	(w)	Hub Interface Swing Reference Voltage		0.8		V	3
HIRCOMP_A	(x)	Hub Interface Compensation Resistance	24.75	25	25.25	Ω	

NOTES:
1. V_{OL} is measured at I_{OUT} = 1.0 mA
2. There are two V_{OH} specifications. V_{OHT} applies when the pin is in receive (terminating) mode and tests the strength of the terminator / pull-down device. V_{OHT} is measured with the specified pull-up resistor tied to V_{DDHI}. V_{OHD} applies when the pin is driving a high level and tests the strength of the pull-up device. V_{OHD} is measured into a standard resistive load to ground representing the target impedance of the receiver terminator (Z_{TARG}). The output driver is also responsible for not driving the receiver higher than the maximum VIH. This represents the absolute maximum allowed voltage allowed on the receiver pin (i.e., V_{OH} due to incomplete impedance updates on the drivers and terminator). This specification allows inter-operation between devices over many process generations. A given platform where the devices have higher voltage tolerances may specify a higher V_{IH} (max).
3. For Hub Interface 1.5, a HISWNG of 0.8 V is recommended, but a value of 0.7 V is allowed as long as system validation is performed.

Ballout and Package Specifications 7

This chapter provides the ballout and package dimensions for the E7500 MCH. In addition, internal component package trace lengths to enable trace length compensation are listed.

7.1 Ballout

Figure 7-1 shows a top view of the ballout footprint. Figure 7-2 and Figure 7-3 expand the detail of the ballout footprint to list the signal names for each ball. Table 7-1 lists the MCH ballout with the listing organized alphabetically by signal name.

Figure 7-1. Intel® E7500 MCH Ballout (Top View)

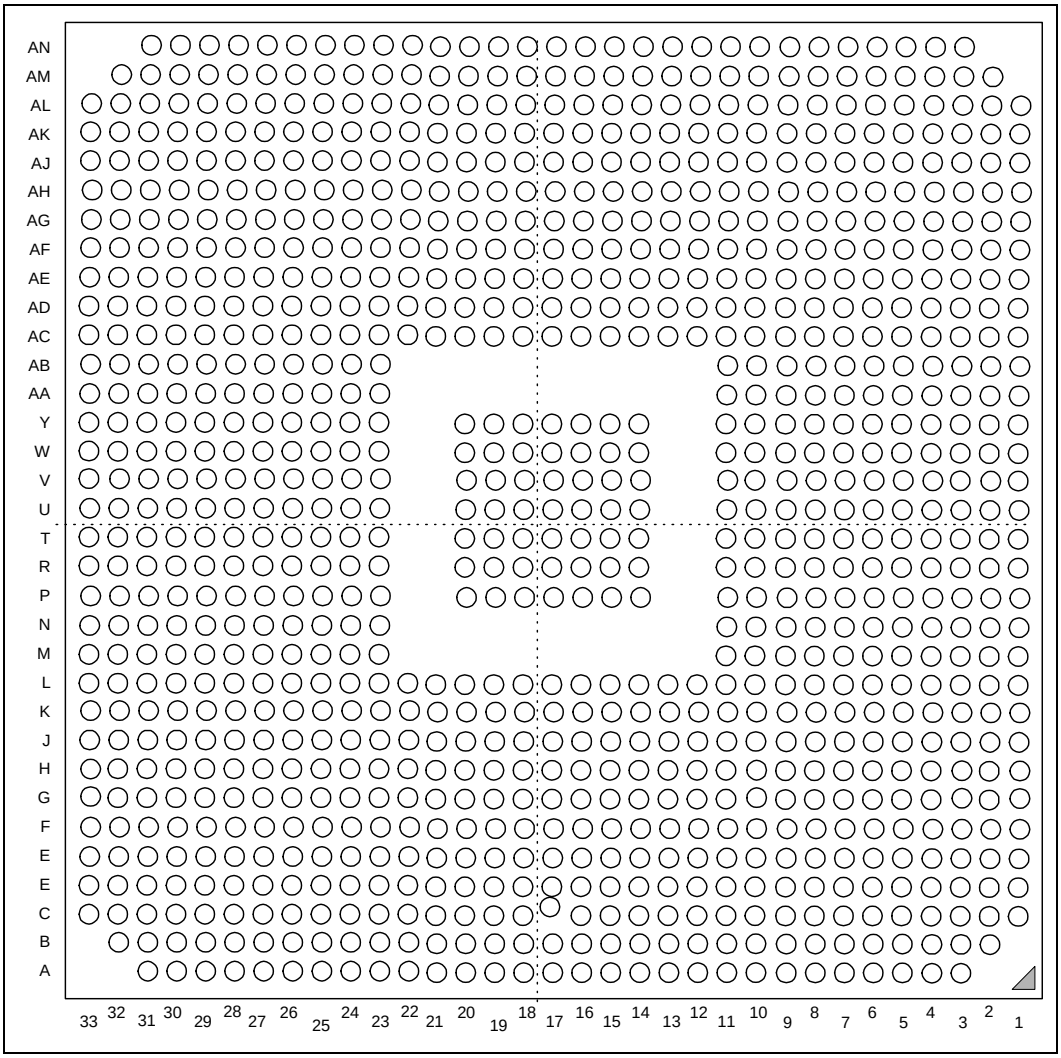


Figure 7-2. Intel® E7500 MCH Ballout (Left Half of Top View)

	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
AN			VSS	VCC2_5	DQ4_A	DQ1_A	VSS	VCC2_5	DQ8_A	RAS_A#	VSS	VCC2_5	DQ30_A	DQ20_A	VSS	VCC2_5	DQ18_A
AM		VCC2_5	MA12_A	MA9_A	VSS	DQ5_A	DQS0_A	VSS	DQ12_A	DQ9_A	VSS	RCVENIN_A#	DQ26_A	VSS	DQ21_A	Reserved	VSS
AL	VSS	DQ60_B	BA0_A	VSS	MA7_A	MA6_A	VSS	DQ6_A	DQ7_A	VCC2_5	DQS1_A	DQ14_A	VSS	DQ27_A	DQ17_A	VSS	DQ22_A
AK	VCC2_5	CS1_B#	VSS	MA11_A	MA8_A	VSS	DDRVREF4_A	MA1_A	VSS	DQ13_A	DQS10_A	VSS	DDRV REF3_A	DQS12_A	DQ16_A	DQS11_A	DDRC VOH_A
AJ	VSS	VSS	DQ61_B	DQ56_B	VCC2_5	DDRVREF5_A	MA3_A	VCC2_5	CMDCLK1_A	MA10_A	VCC2_5	DQ15_A	DQ29_A	VCC2_5	DQ31_A	DQ23_A	VCC2_5
AH	DQ55_B	DQ50_B	DQ51_B	VSS	CS0_B#	MA5_A	VSS	MA2_A	CMDCLK1_A#	VSS	BA1_A	DQ3_A	VSS	DQ28_A	DQ25_A	VSS	DDRCOMP_A
AG	DQ38_B	DDRV REF1_B	VSS	DQ54_B	DQ57_B	VCC2_5	MA4_A	CMDCLK2_A	VSS	CMDCLK0_A	CMDCLK0_A#	VCC2_5	DQ10_A	RCVEN OUT_A#	VCC2_5	DQS2_A	CB5_A
AF	VCC2_5	VSS	DQ34_B	CS2_B#	VSS	DQS16_B	CS3_B#	VSS	CMDCLK2_A#	MA0_A	VCC2_5	DQ0_A	DQS9_A	VSS	DQ24_A	DQ19_A	VSS
AE	DQ33_B	DQS4_B	CS4_B#	VCC2_5	VSS	DQS6_B	DQS7_B	CS5_B#	CMDCLK3_A	CMDCLK3_A#	WE_A#	CAS_A#	DQ2_A	DQ11_A	CKE_A	DQS3_A	CB4_A
AD	VCC2_5	DQ37_B	DQ43_B	VSS	VCC2_5	CS6_B#	DQS15_B	VSS	VCC2_5	VCC2_5	VSS	VCC2_5	VSS	VCC2_5	VSS	VCC2_5	VSS
AC	VSS	VSS	DQS5_B	DQS13_B	VSS	DQ52_B	DQ62_B	VSS	DDR VREF0_B	VSS	VCC2_5	VSS	VCC2_5	VSS	VCC2_5	VSS	VCC2_5
AB	DQ41_B	DQ45_B	VCC2_5	DQS14_B	DQ46_B	VSS	DQ49_B	DQ63_ B	DQ58_B	VCC2_5	VSS						
AA	CB3_B	CB7_B	CB6_B	VSS	DQ40_B	DQ36_B	VCC2_5	DQ53_B	DQ59_B	VSS	VCC2_5						
Y	VCC2_5	VSS	CB2_B	DQS17_B	VCC2_5	DQ44_B	CS7_B#	VSS	DQ48_B	VCC2_5	VSS			VCCA1_2	VSS	VCCA1_2	VSS
W	VSS	DDR CVOH_B	VSS	DDR COMP_B	DQS8_B	VSS	DQ32_B	DQ39_B	DQ35_B	VSS	VCC2_5			VSS	VCC1_2	VSS	VCC1_2
V	DQ22_B	RAS_B#	DQ23_B	VSS	DDRC VOL_B	CB0_B	VSS	DQ42_B	DQ47_B	VCC2_5	VSS			VCCA1_2	VSS	VCC1_2	VSS
U	DQS2_B	VSS	DQS11_B	DQ18_B	VCC2_5	CB4_B	CB5_B	DDR VREF2_B	CB1_B	VSS	VCC2_5			VSS	VCC1_2	VSS	VCC1_2
T	VCC2_5	DQ27_B	VCC2_5	DQ17_B	DQ16_B	VSS	DQ21_B	DQ19_B	DQ31_B	VCC2_5	VSS			VCCA1_2	VSS	VCC1_2	VSS
R	VSS	DQ20_B	DQS12_B	VSS	DQS3_B	DQ30_B	VSS	DQ26_B	RCVEN OUT_B#	VSS	VCC2_5			VSS	VCC1_2	VSS	VCC1_2
P	DQ25_B	VSS	DQ29_B	DQ24_B	VCC2_5	DQ15_B	DQ10_B	DQ14_B	DQ11_B	VCC2_5	VSS			VCCA1_2	VSS	VCC1_2	VSS
N	DDR VREF3_B	DQ28_B	VSS	RCVENIN_B#	DQS10_B	VSS	DQ4_B	DQ7_B	DQ3_B	VSS	VCC2_5						
M	VCC2_5	CKE_B	DQS1_B	VSS	DQ6_B	CMDCLK1_B#	VSS	MA0_B	DDR VREF4_B	VCC2_5	VSS						
L	VSS	VSS	DQ13_B	DQS0_B	VCC2_5	CMDCLK1_B	CMDCLK3_B#	VCC2_5	MA10_B	VSS	VCC2_5	VCC1_2	VSS	VCC1_2	VSS	VCC1_2	VSS
K	Reserved	DQ9_B	VCC2_5	DQ1_B	MA1_B	VSS	CMDCLK3_B	BA0_B	CMDCLK2_B#	VCC2_5	VCC1_2	VSS	VCC1_2	VSS	VCC1_2	VSS	VCC1_2
J	DQ8_B	DQ2_B	DQ12_B	VSS	CMDCLK0_B	CMDCLK0_B#	VSS	CMDCLK2_B	SMB_CLK	VSS	VSS	HI VREF_D	VSS	VSS	VSS	VSS	VSS
H	VCC2_5	VSS	DQS9_B	MA2_B	VCC2_5	CAS_B#	BA1_B	VSS	HI17_D	HI6_D	HI16_D	VSS	HI21_D	VCC1_2	VCC1_2	HI20_C	HISWNG_C
G	VSS	DQ5_B	VSS	MA3_B	MA5_B	VSS	VCC2_5	HI2_D	HI1_D	HI4_D	VSS	HI8_D	HIRCOMP_D	VSS	VSS	HI2_C	VSS
F	DQ0_B	MA4_B	MA6_B	VSS	MA9_B	VSS	VSS	HI3_D	HI18_D	HISWNG_D	HI14_D	HI15_D	VSS	HI18_C	HI5_C	VSS	HI15_C
E	MA7_B	VSS	MA8_B	DDR VREF5_B	VCC2_5	RSTIN#	HI20_D	VCC1_2	VSS	HI9_D	HI13_D	VCC1_2	HI7_C	HI4_C	VCC1_2	HI14_C	PUSTRBS_C
D	VCC2_5	WE_B#	VSS	VSS	Reserved	HI0_D	PSTRBF_D	PSTRBS_D	VSS	HI11_D	VSS	HI0_C	HI6_C	VSS	HI8_C	PUSTRBF_C	VSS
C	VSS	MA12_B	MA11_B	VSS	XOR MODE#	VSS	VSS	HI7_D	PUSTRBS_D	HI17_C	PSTRBF_C	HI3_C	VSS	HIRCOMP_C	HI11_C	HI13_C	HI2_B
B		VCC2_5	SMB_DATA	Reserved	VSS	VCC1_2	VSS	VSS	PUSTRBF_D	HI1_C	PSTRBS_C	VSS	HI16_C	HI10_C	VSS	HI12_C	HI17_B
A			VSS	VCC1_2	VSS	PWR GOOD	HI5_D	VCC1_2	HI10_D	HI12_D	VSS	VCC1_2	HIVREF_C	HI9_C	VSS	VCC1_2	HI4_B
	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17

Figure 7-3. Intel® E7500 MCH Ballout (Right Half of Top View)

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
DDRCVOL_A	VSS	VCC2_5	DQ37_A	DQ42_A	VSS	VCC2_5	VSS	CS4_A#	VCC2_5	VSS	DQ51_A	VCC2_5	VSS			AN
DDR VREF2_A	CB6_A	VSS	DQ33_A	DQS5_A	VSS	DQ47_A	DQ54_A	VSS	DQS15_A	DQ55_A	VSS	DQ63_A	DQ58_A	DQ59_A		AM
CB2_A	VCC2_5	DQ32_A	DQS4_A	VSS	DQ43_A	CS2_A#	DDR VREF1_A	DQS6_A	VSS	DQS7_A	DQ62_A	VSS	CS6_A#	CS7_A#	VCC2_5	AL
VSS	CB3_A	DQ36_A	VSS	DQS14_A	CS1_A#	VCC2_5	VSS	VCC2_5	CS5_A#	VSS	AP1#	RSP#	VSS	xERR#	VSS	AK
DQS8_A	DQ34_A	VCC2_5	DQS13_A	DQ46_A	VCC2_5	VSS	DQ57_A	VSS	DDR VREF0_A	AP0#	VCC_CPU	HA27#	HAVREF1	VSS	HA34#	AJ
CB1_A	VSS	DQ38_A	DQ41_A	VSS	DQ49_A	DQ60_A	DQS16_A	CS3_A#	VSS	HA33#	HA31#	VSS	HA21#	HA20#	VCC_CPU	AH
VSS	CB7_A	DQ39_A	VCC2_5	DQ52_A	DQ50_A	DQ56_A	VSS	BINIT#	HA32#	VSS	HA35#	HA26#	VCC_CPU	HA22#	VSS	AG
DQS17_A	DQ35_A	VSS	DQ45_A	DQ53_A	VSS	VSS	BREQ0#	VSS	HA30#	HA23#	VCC_CPU	HAVREF0	HA29#	VSS	HA25#	AF
CB0_A	DQ44_A	DQ40_A	CS0_A#	DQ48_A	DQ61_A	VCC2_5	VSS	HA28#	VCC_CPU	HA14#	HA10#	VSS	HA15#	HA11#	HADSTB0#	AE
VCC2_5	VSS	VCC2_5	VSS	VCC2_5	VSS	VSS	VSS	HA24#	HADSTB1#	VSS	HA16#	HA9#	VSS	HA6#	VCC_CPU	AD
VSS	VCC2_5	VSS	VCC2_5	VSS	VSS	VCC_CPU	HA19#	VSS	HA18#	HA12#	VCC_CPU	HA8#	HA5#	VSS	VSS	AC
					VCC_CPU	VSS	HA13#	HA17#	VSS	HA7#	VSS	VSS	HREQ3#	HREQ0#	HA4#	AB
					VSS	VCC_CPU	VSS	HA3#	HREQ2#	VSS	DP2#	DP3#	VSS	DP1#	HREQ1#	AA
VCCA1_2	VSS	VCCA1_2			VCC_CPU	VSS	HREQ4#	VSS	ADS#	HCCVREF	VCC_CPU	DP0#	DRDY#	VSS	VCC_CPU	Y
VSS	VCC1_2	VSS			VSS	VCC_CPU	CPURST#	DEFER#	VCC_CPU	DBSY#	HITM#	VSS	HTRDY#	VSS	VSS	W
VCC1_2	VSS	VCC1_2			VCC_CPU	VSS	VSS	HXSWING	HLOCK#	VSS	RS1#	HXRCOMP	VSS	RS0#	BNR#	V
VSS	VCCA CPU1_2	VSS			VSS	VCC_CPU	VSS	VSS	HD59#	BPRI#	VCC_CPU	RS2#	HCLKINN	VSS	HIT#	U
VCC1_2	VSS	VCC1_2			VCC_CPU	VSS	HD60#	HD63#	HDVREF3	HD57#	HD61#	VSS	HD58#	HCLKINP	VCC_CPU	T
VSS	VCC1_2	VSS			VSS	VCC_CPU	VSS	HD47#	HD46#	VSS	HD62#	HDSTBN3#	VCC_CPU	HD56#	VSS	R
VCCAHI1_2	VSS	VCC1_2			VCC_CPU	VSS	HD42#	VSS	HD44#	HDVREF2	VCC_CPU	HD50#	HDSTBP3#	VSS	DBI3#	P
					VSS	VCC_CPU	VSS	HDVREF1	HD45#	HD40#	VSS	HD49#	HD54#	HD53#	HD55#	N
					VCC_CPU	VSS	VSS	HD24#	HD31#	VSS	VSS	HD43#	VSS	HD51#	VCC_CPU	M
VCC1_2	VSS	VCC1_2	VSS	VCC1_2	VSS	VCC_CPU	VSS	VSS	HD17#	HD18#	VCC_CPU	DBI2#	HD48#	HD52#	VSS	L
VSS	VCC1_2	VSS	VCC1_2	VSS	VCC1_2	VSS	VCC_CPU	VSS	VCC_CPU	HDSTBN1#	HYSWING	VSS	HD35#	HD38#	HD39#	K
CLK66	VSS	HI15_B	HI8_A	VSS	HI6_A	HI9_A	VSS	HD14#	HD15#	VSS	HD41#	HDSTBP2#	VSS	HDSTBN2#	HD37#	J
VSS	PSTRBS_B	HI16_B	VSS	HISWNG_A	HIRCOMP_A	VSS	HI7_A	VSS	HD12#	HDSTBP1#	VCC_CPU	HD32#	HD33#	VSS	VCC_CPU	H
HI1_B	PSTRBF_B	VSS	HI21_B	HI11_A	VSS	HI2_A	HIVREF_A	VSS	VSS	HD20#	HYRCOMP	VSS	HD36#	HD34#	VSS	G
HI21_C	VSS	HI20_B	HI9_B	VSS	HI10_A	HI3_A	VSS	DBI0#	HD16#	VSS	HD22#	HD26#	VCC_CPU	HD28#	HD30#	F
VCC1_2	HIRCOMP_B	HI18_B	VCC1_2	HI13_B	HI0_A	VCC1_2	HI5_A	HD4#	VCC_CPU	HD19#	VSS	HD23#	HD29#	VSS	HD25#	E
HI0_B	HI7_B	VSS	HIVREF_B	HI12_B	VSS	HI_STBS	HI4_A	VSS	HD11#	HD21#	VCC_CPU	VSS	HD27#	DBI1#	VCC_CPU	D
HI3_B	VSS	HI8_B	HI11_B	VSS	HI14_B	HI_STBF	VSS	HD7#	HD10#	VSS	HDVREF0	HD9#	VCC_CPU	HD13#	VSS	C
VSS	HISWNG_B	HI6_B	VSS	PUSTRBS_B	HI1_A	VSS	HD0#	HDSTBP0#	VSS	HDSTBN0#	HD3#	VSS	HD5#	VSS		B
HI5_B	VSS	VCC1_2	HI10_B	PUSTRBF_B	VSS	VCC1_2	HD1#	HD8#	VSS	VCC_CPU	HD6#	HD2#	VSS			A
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

Table 7-1. MCH Signal List

Signal Name	Ball #
ADS#	Y7
AP0#	AJ6
AP1#	AK5
BA0_A	AL31
BA0_B	K26
BA1_A	AH23
BA1_B	H27
BINIT#	AG8
BNR#	V1
BPRI#	U6
BREQ0#	AF9
CAS_A#	AE22
CAS_B#	H28
CB0_A	AE16
CB0_B	V28
CB1_A	AH16
CB1_B	U25
CB2_A	AL16
CB2_B	Y31
CB3_A	AK15
CB3_B	AA33
CB4_A	AE17
CB4_B	U28
CB5_A	AG17
CB5_B	U27
CB6_A	AM15
CB6_B	AA31
CB7_A	AG15
CB7_B	AA32
CKE_A	AE19
CKE_B	M32
CLK66	J16
CMDCLK0_A	AG24
CMDCLK0_A#	AG23
CMDCLK0_B	J29
CMDCLK0_B#	J28
CMDCLK1_A	AJ25
CMDCLK1_A#	AH25
CMDCLK1_B	L28
CMDCLK1_B#	M28
CMDCLK2_A	AG26
CMDCLK2_A#	AF25
CMDCLK2_B	J26
CMDCLK2_B#	K25
CMDCLK3_A	AE25
CMDCLK3_A#	AE24
CMDCLK3_B	K27
CMDCLK3_B#	L27
CPURST#	W9
CS0_A#	AE13
CS0_B#	AH29

Table 7-1. MCH Signal List

Signal Name	Ball #
CS1_A#	AK11
CS1_B#	AK32
CS2_A#	AL10
CS2_B#	AF30
CS3_A#	AH8
CS3_B#	AF27
CS4_A#	AN8
CS4_B#	AE31
CS5_A#	AK7
CS5_B#	AE26
CS6_A#	AL3
CS6_B#	AD28
CS7_A#	AL2
CS7_B#	Y27
DBI0#	F8
DBI1#	D2
DBI2#	L4
DBI3#	P1
DBSY#	W6
DDRCOMP_A	AH17
DDRCOMP_B	W30
DDRCVOH_A	AK17
DDRCVOH_B	W32
DDRCVOL_A	AN16
DDRCVOL_B	V29
DDRVREF0_A	AJ7
DDRVREF0_B	AC25
DDRVREF1_A	AL9
DDRVREF1_B	AG32
DDRVREF2_A	AM16
DDRVREF2_B	U26
DDRVREF3_A	AK21
DDRVREF3_B	N33
DDRVREF4_A	AK27
DDRVREF4_B	M25
DDRVREF5_A	AJ28
DDRVREF5_B	E30
DEFER#	W8
DP0#	Y4
DP1#	AA2
DP2#	AA5
DP3#	AA4
DQ0_A	AF22
DQ0_B	F33
DQ1_A	AN28
DQ1_B	K30
DQ2_A	AE21
DQ2_B	J32
DQ3_A	AH22
DQ3_B	N25
DQ4_A	AN29

Table 7-1. MCH Signal List

Signal Name	Ball #
DQ4_B	N27
DQ5_A	AM28
DQ5_B	G32
DQ6_A	AL26
DQ6_B	M29
DQ7_A	AL25
DQ7_B	N26
DQ8_A	AN25
DQ8_B	J33
DQ9_A	AM24
DQ9_B	K32
DQ10_A	AG21
DQ10_B	P27
DQ11_A	AE20
DQ11_B	P25
DQ12_A	AM25
DQ12_B	J31
DQ13_A	AK24
DQ13_B	L31
DQ14_A	AL22
DQ14_B	P26
DQ15_A	AJ22
DQ15_B	P28
DQ16_A	AK19
DQ16_B	T29
DQ17_A	AL19
DQ17_B	T30
DQ18_A	AN17
DQ18_B	U30
DQ19_A	AF18
DQ19_B	T26
DQ20_A	AN20
DQ20_B	R32
DQ21_A	AM19
DQ21_B	T27
DQ22_A	AL17
DQ22_B	V33
DQ23_A	AJ18
DQ23_B	V31
DQ24_A	AF19
DQ24_B	P30
DQ25_A	AH19
DQ25_B	P33
DQ26_A	AM21
DQ26_B	R26
DQ27_A	AL20
DQ27_B	T32
DQ28_A	AH20
DQ28_B	N32
DQ29_A	AJ21
DQ29_B	P31

Table 7-1. MCH Signal List

Signal Name	Ball #
DQ30_A	AN21
DQ30_B	R28
DQ31_A	AJ19
DQ31_B	T25
DQ32_A	AL14
DQ32_B	W27
DQ33_A	AM13
DQ33_B	AE33
DQ34_A	AJ15
DQ34_B	AF31
DQ35_A	AF15
DQ35_B	W25
DQ36_A	AK14
DQ36_B	AA28
DQ37_A	AN13
DQ37_B	AD32
DQ38_A	AH14
DQ38_B	AG33
DQ39_A	AG14
DQ39_B	W26
DQ40_A	AE14
DQ40_B	AA29
DQ41_A	AH13
DQ41_B	AB33
DQ42_A	AN12
DQ42_B	V26
DQ43_A	AL11
DQ43_B	AD31
DQ44_A	AE15
DQ44_B	Y28
DQ45_A	AF13
DQ45_B	AB32
DQ46_A	AJ12
DQ46_B	AB29
DQ47_A	AM10
DQ47_B	V25
DQ48_A	AE12
DQ48_B	Y25
DQ49_A	AH11
DQ49_B	AB27
DQ50_A	AG11
DQ50_B	AH32
DQ51_A	AN5
DQ51_B	AH31
DQ52_A	AG12
DQ52_B	AC28
DQ53_A	AF12
DQ53_B	AA26
DQ54_A	AM9
DQ54_B	AG30
DQ55_A	AM6

Table 7-1. MCH Signal List

Signal Name	Ball #
DQ55_B	AH33
DQ56_A	AG10
DQ56_B	AJ30
DQ57_A	AJ9
DQ57_B	AG29
DQ58_A	AM3
DQ58_B	AB25
DQ59_A	AM2
DQ59_B	AA25
DQ60_A	AH10
DQ60_B	AL32
DQ61_A	AE11
DQ61_B	AJ31
DQ62_A	AL5
DQ62_B	AC27
DQ63_A	AM4
DQ63_B	AB26
DQS0_A	AM27
DQS0_B	L30
DQS1_A	AL23
DQS1_B	M31
DQS2_A	AG18
DQS2_B	U33
DQS3_A	AE18
DQS3_B	R29
DQS4_A	AL13
DQS4_B	AE32
DQS5_A	AM12
DQS5_B	AC31
DQS6_A	AL8
DQS6_B	AE28
DQS7_A	AL6
DQS7_B	AE27
DQS8_A	AJ16
DQS8_B	W29
DQS9_A	AF21
DQS9_B	H31
DQS10_A	AK23
DQS10_B	N29
DQS11_A	AK18
DQS11_B	U31
DQS12_A	AK20
DQS12_B	R31
DQS13_A	AJ13
DQS13_B	AC30
DQS14_A	AK12
DQS14_B	AB30
DQS15_A	AM7
DQS15_B	AD27
DQS16_A	AH9
DQS16_B	AF28

Table 7-1. MCH Signal List

Signal Name	Ball #
DQS17_A	AF16
DQS17_B	Y30
DRDY#	Y3
HA3#	AA8
HA4#	AB1
HA5#	AC3
HA6#	AD2
HA7#	AB6
HA8#	AC4
HA9#	AD4
HA10#	AE5
HA11#	AE2
HA12#	AC6
HA13#	AB9
HA14#	AE6
HA15#	AE3
HA16#	AD5
HA17#	AB8
HA18#	AC7
HA19#	AC9
HA20#	AH2
HA21#	AH3
HA22#	AG2
HA23#	AF6
HA24#	AD8
HA25#	AF1
HA26#	AG4
HA27#	AJ4
HA28#	AE8
HA29#	AF3
HA30#	AF7
HA31#	AH5
HA32#	AG7
HA33#	AH6
HA34#	AJ1
HA35#	AG5
HADSTB0#	AE1
HADSTB1#	AD7
HAVREF0	AF4
HAVREF1	AJ3
HCCVREF	Y6
HCLKINN	U3
HCLKINP	T2
HD0#	B9
HD1#	A9
HD2#	A4
HD3#	B5
HD4#	E8
HD5#	B3
HD6#	A5
HD7#	C8

Table 7-1. MCH Signal List

Signal Name	Ball #
HD8#	A8
HD9#	C4
HD10#	C7
HD11#	D7
HD12#	H7
HD13#	C2
HD14#	J8
HD15#	J7
HD16#	F7
HD17#	L7
HD18#	L6
HD19#	E6
HD20#	G6
HD21#	D6
HD22#	F5
HD23#	E4
HD24#	M8
HD25#	E1
HD26#	F4
HD27#	D3
HD28#	F2
HD29#	E3
HD30#	F1
HD31#	M7
HD32#	H4
HD33#	H3
HD34#	G2
HD35#	K3
HD36#	G3
HD37#	J1
HD38#	K2
HD39#	K1
HD40#	N6
HD41#	J5
HD42#	P9
HD43#	M4
HD44#	P7
HD45#	N7
HD46#	R7
HD47#	R8
HD48#	L3
HD49#	N4
HD50#	P4
HD51#	M2
HD52#	L2
HD53#	N2
HD54#	N3
HD55#	N1
HD56#	R2
HD57#	T6
HD58#	T3

Table 7-1. MCH Signal List

Signal Name	Ball #
HD59#	U7
HD60#	T9
HD61#	T5
HD62#	R5
HD63#	T8
HDSTBN0#	B6
HDSTBN1#	K6
HDSTBN2#	J2
HDSTBN3#	R4
HDSTBP0#	B8
HDSTBP1#	H6
HDSTBP2#	J4
HDSTBP3#	P3
HDVREF0	C5
HDVREF1	N8
HDVREF2	P6
HDVREF3	T7
HI_STBF	C10
HI_STBS	D10
HI0_A	E11
HI0_B	D16
HI0_C	D22
HI0_D	D28
HI1_A	B11
HI1_B	G16
HI1_C	B24
HI1_D	G25
HI2_A	G10
HI2_B	C17
HI2_C	G18
HI2_D	G26
HI3_A	F10
HI3_B	C16
HI3_C	C22
HI3_D	F26
HI4_A	D9
HI4_B	A17
HI4_C	E20
HI4_D	G24
HI5_A	E9
HI5_B	A16
HI5_C	F19
HI5_D	A27
HI6_A	J11
HI6_B	B14
HI6_C	D21
HI6_D	H24
HI7_A	H9
HI7_B	D15
HI7_C	E21
HI7_D	C26

Table 7-1. MCH Signal List

Signal Name	Ball #
HI8_A	J13
HI8_B	C14
HI8_C	D19
HI8_D	G22
HI9_A	J10
HI9_B	F13
HI9_C	A20
HI9_D	E24
HI10_A	F11
HI10_B	A13
HI10_C	B20
HI10_D	A25
HI11_A	G12
HI11_B	C13
HI11_C	C19
HI11_D	D24
HI12_B	D12
HI12_C	B18
HI12_D	A24
HI13_B	E12
HI13_C	C18
HI13_D	E23
HI14_B	C11
HI14_C	E18
HI14_D	F23
HI15_B	J14
HI15_C	F17
HI15_D	F22
HI16_B	H14
HI16_C	B21
HI16_D	H23
HI17_B	B17
HI17_C	C24
HI17_D	H25
HI18_B	E14
HI18_C	F20
HI18_D	F25
HI20_B	F14
HI20_C	H18
HI20_D	E27
HI21_B	G13
HI21_C	F16
HI21_D	H21
HIRCOMP_A	H11
HIRCOMP_B	E15
HIRCOMP_C	C20
HIRCOMP_D	G21
HISWNG_A	H12
HISWNG_B	B15
HISWNG_C	H17
HISWNG_D	F24

Table 7-1. MCH Signal List

Signal Name	Ball #
HIT#	U1
HITM#	W5
HIVREF_A	G9
HIVREF_B	D13
HIVREF_C	A21
HIVREF_D	J22
HLOCK#	V7
HREQ0#	AB2
HREQ1#	AA1
HREQ2#	AA7
HREQ3#	AB3
HREQ4#	Y9
HTRDY#	W3
HXRCOMP	V4
HXSWING	V8
HYRCOMP	G5
HYSWING	K5
MA0_A	AF24
MA0_B	M26
MA1_A	AK26
MA1_B	K29
MA2_A	AH26
MA2_B	H30
MA3_A	AJ27
MA3_B	G30
MA4_A	AG27
MA4_B	F32
MA5_A	AH28
MA5_B	G29
MA6_A	AL28
MA6_B	F31
MA7_A	AL29
MA7_B	E33
MA8_A	AK29
MA8_B	E31
MA9_A	AM30
MA9_B	F29
MA10_A	AJ24
MA10_B	L25
MA11_A	AK30
MA11_B	C31
MA12_A	AM31
MA12_B	C32
PSTRBF_B	G15
PSTRBF_C	C23
PSTRBF_D	D27
PSTRBS_B	H15
PSTRBS_C	B23
PSTRBS_D	D26
PUSTRBF_B	A12
PUSTRBF_C	D18

Table 7-1. MCH Signal List

Signal Name	Ball #
PUSTRBF_D	B25
PUSTRBS_B	B12
PUSTRBS_C	E17
PUSTRBS_D	C25
PWRGOOD	A28
RAS_A#	AN24
RAS_B#	V32
RCVENIN_A#	AM22
RCVENIN_B#	N30
RCVENOUT_A#	AG20
RCVENOUT_B#	R25
Reserved	B30
Reserved	AM18
Reserved	K33
Reserved	D29
RS0#	V2
RS1#	V5
RS2#	U4
RSP#	AK4
RSTIN#	E28
SMB_CLK	J25
SMB_DATA	B31
VCC_CPU	AC5
VCC_CPU	AG3
VCC_CPU	AJ5
VCC_CPU	AF5
VCC_CPU	AH1
VCC_CPU	K7
VCC_CPU	F3
VCC_CPU	P5
VCC_CPU	R3
VCC_CPU	W7
VCC_CPU	H5
VCC_CPU	L5
VCC_CPU	U5
VCC_CPU	Y5
VCC_CPU	AE7
VCC_CPU	K9
VCC_CPU	AD1
VCC_CPU	D1
VCC_CPU	H1
VCC_CPU	M1
VCC_CPU	T1
VCC_CPU	Y1
VCC_CPU	A6
VCC_CPU	E7
VCC_CPU	AA10
VCC_CPU	AB11
VCC_CPU	AC10
VCC_CPU	C3
VCC_CPU	D5

Table 7-1. MCH Signal List

Signal Name	Ball #
VCC_CPU	L10
VCC_CPU	M11
VCC_CPU	N10
VCC_CPU	P11
VCC_CPU	R10
VCC_CPU	T11
VCC_CPU	U10
VCC_CPU	V11
VCC_CPU	W10
VCC_CPU	Y11
VCC1_2	L18
VCC1_2	L20
VCC1_2	L22
VCC1_2	B28
VCC1_2	H20
VCC1_2	A10
VCC1_2	A14
VCC1_2	A18
VCC1_2	A22
VCC1_2	E10
VCC1_2	E13
VCC1_2	E16
VCC1_2	E19
VCC1_2	E22
VCC1_2	K13
VCC1_2	K15
VCC1_2	K17
VCC1_2	K19
VCC1_2	K21
VCC1_2	K23
VCC1_2	P14
VCC1_2	P18
VCC1_2	R17
VCC1_2	R19
VCC1_2	T14
VCC1_2	T16
VCC1_2	T18
VCC1_2	U17
VCC1_2	U19
VCC1_2	V16
VCC1_2	V18
VCC1_2	W15
VCC1_2	W17
VCC1_2	W19
VCC1_2	A26
VCC1_2	A30
VCC1_2	R15
VCC1_2	V14
VCC1_2	E26
VCC1_2	H19
VCC1_2	K11

Table 7-1. MCH Signal List

Signal Name	Ball #
VCC1_2	L12
VCC1_2	L14
VCC1_2	L16
VCC2_5	R23
VCC2_5	AN4
VCC2_5	AN7
VCC2_5	AA23
VCC2_5	AC13
VCC2_5	AC15
VCC2_5	AC17
VCC2_5	AC19
VCC2_5	U23
VCC2_5	W23
VCC2_5	AB24
VCC2_5	AD12
VCC2_5	AD14
VCC2_5	AD16
VCC2_5	AD18
VCC2_5	AD20
VCC2_5	AD25
VCC2_5	AD29
VCC2_5	AD33
VCC2_5	AE10
VCC2_5	AE30
VCC2_5	AF33
VCC2_5	AJ11
VCC2_5	AJ14
VCC2_5	AJ17
VCC2_5	AJ20
VCC2_5	AJ23
VCC2_5	AK33
VCC2_5	AN10
VCC2_5	AN14
VCC2_5	AN18
VCC2_5	AN22
VCC2_5	AN26
VCC2_5	H33
VCC2_5	L29
VCC2_5	M33
VCC2_5	P24
VCC2_5	P29
VCC2_5	T24
VCC2_5	T33
VCC2_5	U29
VCC2_5	V24
VCC2_5	Y24
VCC2_5	Y29
VCC2_5	Y33
VCC2_5	AA27
VCC2_5	AG13
VCC2_5	AG19

Table 7-1. MCH Signal List

Signal Name	Ball #
VCC2_5	AG22
VCC2_5	AK10
VCC2_5	AK8
VCC2_5	AL1
VCC2_5	AL15
VCC2_5	AL24
VCC2_5	G27
VCC2_5	AC21
VCC2_5	AC23
VCC2_5	L23
VCC2_5	N23
VCC2_5	AD22
VCC2_5	AD24
VCC2_5	AJ26
VCC2_5	AJ29
VCC2_5	AN30
VCC2_5	D33
VCC2_5	E29
VCC2_5	H29
VCC2_5	K24
VCC2_5	M24
VCC2_5	AF23
VCC2_5	AG28
VCC2_5	AM32
VCC2_5	B32
VCC2_5	L26
VCC2_5	AB31
VCC2_5	K31
VCC2_5	T31
VCCA1_2	P20
VCCA1_2	T20
VCCA1_2	V20
VCCA1_2	Y14
VCCA1_2	Y16
VCCA1_2	Y18
VCCA1_2	Y20
VCCACPU1_2	U15
VCCAHI1_2	P16
VSS	AD11
VSS	AD13
VSS	AD15
VSS	AD17
VSS	AD19
VSS	AD21
VSS	AD23
VSS	AD26
VSS	AD30
VSS	AE29
VSS	AE9
VSS	AF10
VSS	AF11

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	AF14
VSS	AF17
VSS	AF20
VSS	AF26
VSS	AF29
VSS	AF32
VSS	AG16
VSS	AG25
VSS	AG31
VSS	AH12
VSS	AH15
VSS	AH18
VSS	AH21
VSS	AH24
VSS	AH27
VSS	AH30
VSS	AJ32
VSS	AJ33
VSS	AK13
VSS	AK16
VSS	AK22
VSS	AK25
VSS	AK28
VSS	AK31
VSS	AL12
VSS	AL18
VSS	AL21
VSS	AL27
VSS	AL30
VSS	AL33
VSS	AM11
VSS	AM14
VSS	AM17
VSS	AM20
VSS	AM23
VSS	AM26
VSS	AM29
VSS	AN11
VSS	AK9
VSS	AM8
VSS	AC8
VSS	G7
VSS	D30
VSS	AF8
VSS	AA9
VSS	J6
VSS	V3
VSS	F28
VSS	AG6
VSS	AH7
VSS	AH4

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	AN15
VSS	AN19
VSS	AN23
VSS	AN27
VSS	AN3
VSS	AN31
VSS	AN6
VSS	B10
VSS	B13
VSS	B16
VSS	B19
VSS	B22
VSS	B26
VSS	B29
VSS	B4
VSS	B7
VSS	C1
VSS	C12
VSS	C15
VSS	C21
VSS	C27
VSS	C30
VSS	C33
VSS	C6
VSS	C9
VSS	D11
VSS	D14
VSS	D17
VSS	D20
VSS	D23
VSS	D31
VSS	D8
VSS	E25
VSS	E32
VSS	F12
VSS	F15
VSS	F18
VSS	F21
VSS	F27
VSS	F30
VSS	F6
VSS	F9
VSS	G1
VSS	G11
VSS	G14
VSS	G17
VSS	G20
VSS	G23
VSS	G28
VSS	G31
VSS	G33

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	AL4
VSS	AJ2
VSS	AK3
VSS	AD6
VSS	AK6
VSS	AL7
VSS	AM5
VSS	AF2
VSS	AD3
VSS	AG1
VSS	AK1
VSS	U9
VSS	E2
VSS	H2
VSS	K4
VSS	J3
VSS	K8
VSS	L8
VSS	G4
VSS	M6
VSS	P2
VSS	M3
VSS	M9
VSS	P8
VSS	N9
VSS	U2
VSS	R6
VSS	T4
VSS	V6
VSS	W4
VSS	W2
VSS	Y2
VSS	AA3
VSS	AA6
VSS	Y8
VSS	J19
VSS	J20
VSS	G19
VSS	E5
VSS	J23
VSS	AB5
VSS	D4
VSS	AE4
VSS	AC2
VSS	AG9
VSS	L9
VSS	C28
VSS	B27
VSS	AB4
VSS	AB7
VSS	AD9

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	G8
VSS	H10
VSS	H13
VSS	H16
VSS	H22
VSS	H26
VSS	H32
VSS	H8
VSS	J12
VSS	J15
VSS	J18
VSS	J21
VSS	J24
VSS	J27
VSS	J30
VSS	J9
VSS	K12
VSS	K14
VSS	K16
VSS	K18
VSS	K20
VSS	K22
VSS	K28
VSS	L1
VSS	L24
VSS	L32
VSS	L33
VSS	M23
VSS	M27
VSS	M30
VSS	N5
VSS	N24
VSS	N28
VSS	N31
VSS	P15
VSS	P17
VSS	P19
VSS	P23
VSS	P32
VSS	R1
VSS	R14
VSS	R18
VSS	R20
VSS	R24
VSS	R27
VSS	R30
VSS	R33
VSS	R9
VSS	T15
VSS	T17
VSS	T19

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	AA11
VSS	AB10
VSS	AC11
VSS	AD10
VSS	AN9
VSS	M10
VSS	M5
VSS	N11
VSS	P10
VSS	R11
VSS	T10
VSS	U11
VSS	V10
VSS	W11
VSS	Y10
VSS	B2
VSS	J17

Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	K10
VSS	L11
VSS	L13
VSS	L15
VSS	L17
VSS	L19
VSS	L21
VSS	R16
VSS	AC29
VSS	AJ10
VSS	D25
VSS	A11
VSS	A15
VSS	A19
VSS	A23
VSS	A29
VSS	A3
VSS	A31
VSS	A7
VSS	AA24
VSS	AA30
VSS	AB23
VSS	AB28
VSS	AC1
VSS	AC12
VSS	AC14
VSS	AC16
VSS	AC18
VSS	AC20
VSS	AC22
VSS	AC24
VSS	AC26
VSS	AC32
VSS	AC33
VSS	T23

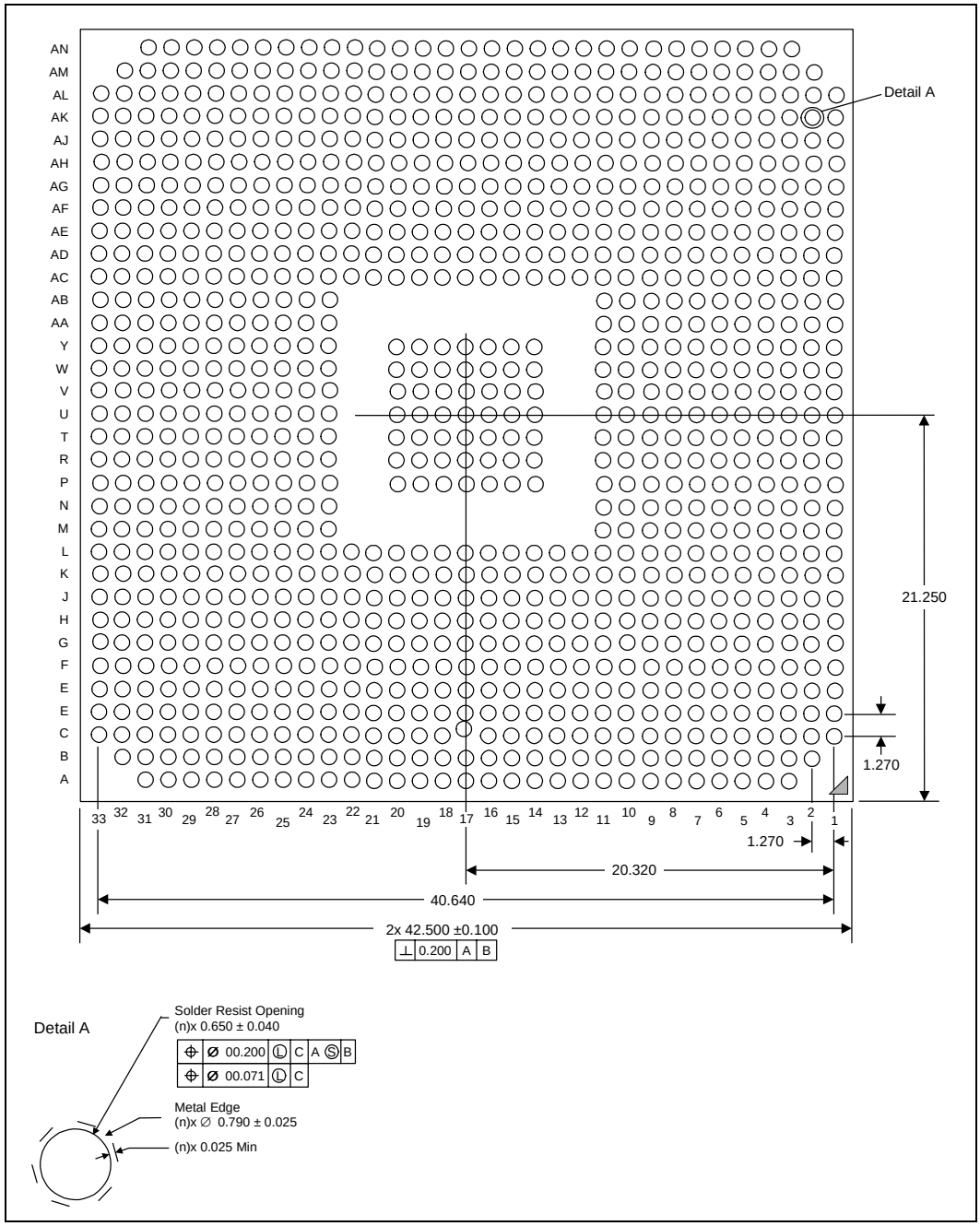
Table 7-1. MCH Signal List

Signal Name	Ball #
VSS	T28
VSS	U14
VSS	U16
VSS	U18
VSS	U20
VSS	U24
VSS	U32
VSS	U8
VSS	V15
VSS	V17
VSS	V19
VSS	V23
VSS	V27
VSS	V30
VSS	V9
VSS	W1
VSS	W14
VSS	W16
VSS	W18
VSS	W20
VSS	W24
VSS	W28
VSS	W31
VSS	W33
VSS	Y15
VSS	Y17
VSS	Y19
VSS	Y23
VSS	Y26
VSS	Y32
VSS	AJ8
WE_A#	AE23
WE_B#	D32
xERR#	AK2
XORMODE#	C29

7.2 Package Specifications

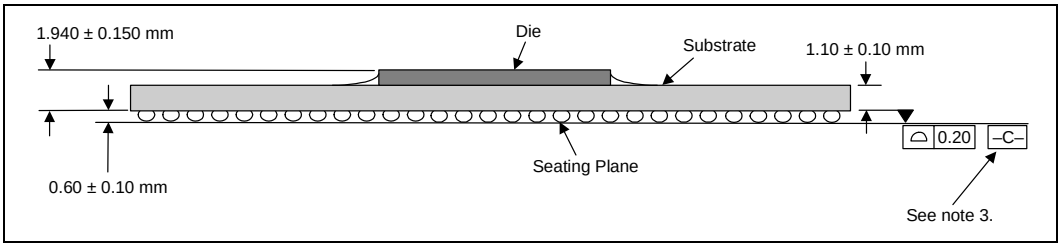
Figure 7-4 and Figure 7-5 provide the package specifications for the MCH.

Figure 7-4. MCH Package Dimensions (Top View)



NOTE:
1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1982.

Figure 7-5. MCH Package Dimensions (Side View)



NOTES:
1. All dimensions are in millimeters.
2. Substrate thickness and package overall height are thicker than standard 492-L-PBGA
3. Primary datum —C— and seating plane are defined by the spherical crowns of the solder balls.
4. All dimensions and tolerances conform to ANSI Y14.5M-1982.

7.3 Chipset Interface Trace Length Compensation

In this section, detailed information is given about the internal component package trace lengths to enable trace length compensation. Trace length compensation is required for platform design. These lengths must be considered when matching trace lengths as described in the *Intel® Xeon™ Processor with 512-KB L2 Cache and Intel® E7500 Chipset Platform Design Guide.* Note that these lengths represent the actual lengths from pad to ball.

The data given can be normalized from a particular reference ball to simplify routing. If the longest trace is used as the reference for normalization, use Equation 7-1.

Equation 7-1.

$$\Delta L_{PKG} = L_{REF} - L_{PKG}$$

L_{REF} is the nominal package length of the reference signal used for normalization.

ΔL_{PKG} is the nominal Δ package trace length of the MCH from the reference trace.

To calculate the ΔL_{PCB} for signals from the MCH to the device, use Equation 7-2.

Equation 7-2.

$$\Delta L_{PCB} = \frac{\Delta L_{PKG} \times V_{PKG}}{V_{PCB}}$$

ΔL_{PCB} is the nominal Δ PCB trace length to be added on the PCB.

ΔL_{PKG} is the nominal Δ package trace length of the MCH (refer to Equation 1).

V_{PKG} is the MCH package trace delay due to signal velocity. The nominal value is 150 ps/in.

V_{PCB} is the PCB trace delay due to signal velocity. The nominal value is 175 ps/in on the recommended stackup.

Note: Use care when converting delays and velocities (x ps/in is a delay, y in/ps is a velocity).

Table 7-2 shows example values when signal MEMORY1 trace length is used for normalization.

Table 7-2. Example Normalization Table

	L_{PKG} (mils)	ΔL_{PKG} (mils)	ΔL_{PCB} (mils)	Target L_{PCB} (mils)
MEMORY1	175.984	0.000	0.000	3500.000
MEMORY2	152.364	23.620	20.246	3520.246
MEMORY3	130.315	45.669	39.145	3539.145
MEMORY4	118.897	57.087	48.932	3548.932
• • •	• • •	• • •	• • •	• • •
MEMORYN	102.756	73.228	62.767	3562.767

7.3.1 MCH System Bus Signal Package Trace Length Data

Table 7-3 is the MCH package trace length information for the system bus.

Table 7-3. MCH L_{PKG} Data for the System Bus (Sheet 1 of 2)

Signal	Ball No.	L_{PKG} (mils)
HADSTB0#	AE1	797.99
HA3#	AA8	296.14
HA4#	AB1	692.09
HA5#	AC3	602.24
HA6#	AD2	761.50
HA7#	AB6	469.09
HA8#	AC4	569.02
HA9#	AD4	631.65
HA10#	AE5	612.17
HA11#	AE2	781.97
HA12#	AC6	469.44
HA13#	AB9	578.15
HA14#	AE6	576.69
HA15#	AE3	702.60
HA16#	AD5	512.91
HREQ0#	AB2	665.47
HREQ1#	AA1	684.80
HREQ2#	AA7	397.91
HREQ3#	AB3	591.46
HREQ4#	Y9	308.86
HADSTB1#	AD7	430.11
HA17#	AB8	334.72
HA18#	AC7	390.55
HA19#	AC9	379.57
HA20#	AH2	860.71
HA21#	AH3	732.09
HA22#	AG2	772.17
HA23#	AF6	567.76
HA24#	AD8	403.50
HA25#	AF1	798.46
HA26#	AG4	690.75
HA27#	AJ4	695.39
HA28#	AE8	413.27
HA29#	AF3	736.10
HA30#	AF7	521.58
HA31#	AH5	619.72
HA32#	AG7	497.28
HA33#	AH6	601.73
HA34#	AJ1	877.87
HA35#	AG5	611.77
HCLKINN	U3	639.53
HCLKINP	T2	639.61

Signal	Ball No.	L_{PKG} (mils)
HDSTBN0#	B6	842.99
HDSTBP0#	B8	739.72
HD0#	B9	682.48
HD1#	A9	775.98
HD2#	A4	955.20
HD3#	B5	933.07
HD4#	E8	648.77
HD5#	B3	1044.33
HD6#	A5	930.87
HD7#	C8	732.77
HD8#	A8	763.54
HD9#	C4	909.13
HD10#	C7	779.65
HD11#	D7	765.00
HD12#	H7	535.59
HD13#	C2	1059.96
HD14#	J8	398.46
HD15#	J7	457.64
DBI0#	F8	596.13
HDSTBN1#	K6	480.24
HDSTBP1#	H6	562.32
HD16#	F7	617.72
HD17#	L7	378.98
HD18#	L6	450.04
HD19#	E6	762.64
HD20#	G6	680.20
HD21#	D6	771.73
HD22#	F5	809.84
HD23#	E4	859.72
HD24#	M8	334.68
HD25#	E1	1030.20
HD26#	F4	851.54
HD27#	D3	892.64
HD28#	F2	945.08
HD29#	E3	905.20
HD30#	F1	1031.89
HD31#	M7	400.67
DBI1#	D2	981.89

Table 7-3. MCH L_{PKG} Data for the System Bus (Sheet 2 of 2)

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
HDSTBN2#	J2	783.19	HDSTBN3#	R4	529.41
HDSTBP2#	J4	726.26	HDSTBP3#	P3	605.71
HD32#	H4	715.47	HD48#	L3	669.41
HD33#	H3	803.03	HD49#	N4	596.42
HD34#	G2	865.59	HD50#	P4	584.80
HD35#	K3	723.94	HD51#	M2	723.07
HD36#	G3	818.54	HD52#	L2	729.17
HD37#	J1	803.50	HD53#	N2	707.44
HD38#	K2	740.32	HD54#	N3	605.91
HD39#	K1	821.65	HD55#	N1	760.00
HD40#	N6	419.37	HD56#	R2	613.43
HD41#	J5	720.87	HD57#	T6	534.25
HD42#	P9	315.91	HD58#	T3	580.20
HD43#	M4	622.60	HD59#	U7	367.72
HD44#	P7	373.34	HD60#	T9	271.46
HD45#	N7	351.31	HD61#	T5	479.33
HD46#	R7	332.80	HD62#	R5	451.46
HD47#	R8	306.89	HD63#	T8	312.87
DBI2#	L4	649.69	DBI3#	P1	686.77

7.3.1.1 MCH DDR Channel A Signal Package Trace Length Data

Table 7-4 is the MCH package trace length information for channel A of the DDR memory interface.

Table 7-4. MCH L_{PKG} Data for DDR Channel A (Sheet 1 of 3)

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
DQS0_A	AM27	760.59	DQS2_A	AG18	338.67
DQS9_A	AF21	291.45	DQS11_A	AK18	477.64
DQ0_A	AF22	345.91	DQ16_A	AK19	499.02
DQ1_A	AN28	853.78	DQ17_A	AL19	583.11
DQ2_A	AE21	284.59	DQ18_A	AN17	674.17
DQ3_A	AH22	447.83	DQ19_A	AF18	297.50
DQ4_A	AN29	867.36	DQ20_A	AN20	697.09
DQ5_A	AM28	817.76	DQ21_A	AM19	630.75
DQ6_A	AL26	707.24	DQ22_A	AL17	534.80
DQ7_A	AL25	642.13	DQ23_A	AJ18	455.77
DQS1_A	AL23	602.87	DQS3_A	AE18	226.03
DQS10_A	AK23	552.99	DQS12_A	AK20	500.71
DQ8_A	AN25	761.06	DQ24_A	AF19	300.32
DQ9_A	AM24	712.95	DQ25_A	AH19	423.19
DQ10_A	AG21	371.89	DQ26_A	AM21	625.04
DQ11_A	AE20	273.13	DQ27_A	AL20	578.15
DQ12_A	AM25	737.68	DQ28_A	AH20	440.20
DQ13_A	AK24	607.13	DQ29_A	AJ21	503.66
DQ14_A	AL22	578.43	DQ30_A	AN21	703.07
DQ15_A	AJ22	475.71	DQ31_A	AJ19	438.58

Table 7-4. MCH L_{PKG} Data for DDR Channel A (Sheet 2 of 3)

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
DQS4_A	AL13	595.67	DQS7_A	AL6	733.15
DQS13_A	AJ13	473.62	DQS16_A	AH9	483.27
DQ32_A	AL14	586.58	DQ56_A	AG10	446.54
DQ33_A	AM13	662.60	DQ57_A	AJ9	572.13
DQ34_A	AJ15	512.60	DQ58_A	AM3	957.28
DQ35_A	AF15	350.43	DQ59_A	AM2	990.51
DQ36_A	AK14	516.50	DQ60_A	AH10	527.88
DQ37_A	AN13	730.83	DQ61_A	AE11	337.46
DQ38_A	AH14	447.76	DQ62_A	AL5	779.02
DQ39_A	AG14	358.19	DQ63_A	AM4	882.36
DQS5_A	AM12	693.27	DQS8_A	AJ16	432.48
DQS14_A	AK12	531.46	DQS17_A	AF16	281.57
DQ40_A	AE14	402.72	CB0_A	AE16	256.61
DQ41_A	AH13	453.46	CB1_A	AH16	412.22
DQ42_A	AN12	704.45	CB2_A	AL16	559.57
DQ43_A	AL11	666.30	CB3_A	AK15	560.08
DQ44_A	AE15	270.32	CB4_A	AE17	375.28
DQ45_A	AF13	344.49	CB5_A	AG17	359.80
DQ46_A	AJ12	506.22	CB6_A	AM15	656.14
DQ47_A	AM10	703.35	CB7_A	AG15	371.50
DQS6_A	AL8	676.58			
DQS15_A	AM7	755.79			
DQ48_A	AE12	278.66			
DQ49_A	AH11	463.74			
DQ50_A	AG11	441.73			
DQ51_A	AN5	898.50			
DQ52_A	AG12	412.05			
DQ53_A	AF12	377.68			
DQ54_A	AM9	742.17			
DQ55_A	AM6	855.47			

Table 7-4. MCH L_{PKG} Data for DDR Channel A (Sheet 3 of 3)

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
CMDCLK0_A	AG24	447.35	CMDCLK2_A	AG26	459.06
CMDCLK0_A#	AG23	405.28	CMDCLK2_A#	AF25	367.24
BA0_A	AL31	789.29	BA0_A	AL31	789.29
BA1_A	AH23	427.72	BA1_A	AH23	427.72
CAS_A#	AE22	411.22	CAS_A#	AE22	411.22
CKE_A	AE19	249.80	CKE_A	AE19	249.80
CS0_A#	AE13	434.96	CS4_A#	AN8	805.28
CS1_A#	AK11	594.41	CS5_A#	AK7	716.34
MA0_A	AF24	340.16	MA0_A	AF24	340.16
MA1_A	AK26	640.55	MA1_A	AK26	640.55
MA2_A	AH26	512.01	MA2_A	AH26	512.01
MA3_A	AJ27	568.58	MA3_A	AJ27	568.58
MA4_A	AG27	466.97	MA4_A	AG27	466.97
MA5_A	AH28	595.79	MA5_A	AH28	595.79
MA6_A	AL28	791.89	MA6_A	AL28	791.89
MA7_A	AL29	735.71	MA7_A	AL29	735.71
MA8_A	AK29	698.35	MA8_A	AK29	698.35
MA9_A	AM30	827.80	MA9_A	AM30	827.80
MA10_A	AJ24	572.17	MA10_A	AJ24	572.17
MA11_A	AK30	712.64	MA11_A	AK30	712.64
MA12_A	AM31	865.00	MA12_A	AM31	865.00
RAS_A#	AN24	757.84	RAS_A#	AN24	757.84
WE_A#	AE23	298.19	WE_A#	AE23	298.19
CMDCLK1_A	AJ25	544.88	CMDCLK3_A	AE25	359.80
CMDCLK1_A#	AH25	473.52	CMDCLK3_A#	AE24	322.68
BA0_A	AL31	789.29	BA0_A	AL31	789.29
BA1_A	AH23	427.72	BA1_A	AH23	427.72
CAS_A#	AE22	411.22	CAS_A#	AE22	411.22
CKE_A	AE19	249.80	CKE_A	AE19	249.80
CS2_A#	AL10	641.10	CS6_A#	AL3	892.80
CS3_A#	AH8	622.17	CS7_A#	AL2	917.36
MA0_A	AF24	340.16	MA0_A	AF24	340.16
MA1_A	AK26	640.55	MA1_A	AK26	640.55
MA2_A	AH26	512.01	MA2_A	AH26	512.01
MA3_A	AJ27	568.58	MA3_A	AJ27	568.58
MA4_A	AG27	466.97	MA4_A	AG27	466.97
MA5_A	AH28	595.79	MA5_A	AH28	595.79
MA6_A	AL28	791.89	MA6_A	AL28	791.89
MA7_A	AL29	735.71	MA7_A	AL29	735.71
MA8_A	AK29	698.35	MA8_A	AK29	698.35
MA9_A	AM30	827.80	MA9_A	AM30	827.80
MA10_A	AJ24	572.17	MA10_A	AJ24	572.17
MA11_A	AK30	712.64	MA11_A	AK30	712.64
MA12_A	AM31	865.00	MA12_A	AM31	865.00
RAS_A#	AN24	757.84	RAS_A#	AN24	757.84
WE_A#	AE23	298.19	WE_A#	AE23	298.19

7.3.1.2 MCH DDR Channel B Signal Package Trace Length Data

Table 7-5 is the MCH package trace length information for channel B of the DDR memory interface.

Table 7-5. MCH L_{PKG} Data for DDR Channel B (Sheet 1 of 3)

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
DQS0_B	L30	545.94	DQS3_B	R29	445.98
DQS9_B	H31	698.39	DQS12_B	R31	541.50
DQ0_B	F33	870.43	DQ24_B	P30	523.82
DQ1_B	K30	639.33	DQ25_B	P33	694.80
DQ2_B	J32	695.67	DQ26_B	R26	287.40
DQ3_B	N25	275.85	DQ27_B	T32	586.46
DQ4_B	N27	344.82	DQ28_B	N32	655.83
DQ5_B	G32	796.61	DQ29_B	P31	587.64
DQ6_B	M29	488.98	DQ30_B	R28	415.72
DQ7_B	N26	329.65	DQ31_B	T25	307.72
DQS1_B	M31	586.65	DQS4_B	AE32	756.46
DQS10_B	N29	459.05	DQS13_B	AC30	609.57
DQ8_B	J33	765.35	DQ32_B	W27	375.75
DQ9_B	K32	724.84	DQ33_B	AE33	825.12
DQ10_B	P27	361.38	DQ34_B	AF31	780.55
DQ11_B	P25	246.21	DQ35_B	W25	627.56
DQ12_B	J31	710.35	DQ36_B	AA28	499.10
DQ13_B	L31	635.83	DQ37_B	AD32	766.85
DQ14_B	P26	322.21	DQ38_B	AG33	863.70
DQ15_B	P28	423.86	DQ39_B	W26	328.87
DQS2_B	U33	660.43	DQS5_B	AC31	692.56
DQS11_B	U31	545.16	DQS14_B	AB30	598.03
DQ16_B	T29	441.22	DQ40_B	AA29	567.36
DQ17_B	T30	511.14	DQ41_B	AB33	769.02
DQ18_B	U30	523.03	DQ42_B	V26	288.03
DQ19_B	T26	318.23	DQ43_B	AD31	746.26
DQ20_B	R32	631.77	DQ44_B	Y28	421.18
DQ21_B	T27	366.58	DQ45_B	AB32	743.46
DQ22_B	V33	697.36	DQ46_B	AB29	590.71
DQ23_B	V31	556.89	DQ47_B	V25	633.50

Table 7-5. MCH L_{PKG} Data for DDR Channel B (Sheet 2 of 3)

Signal	Ball No.	L_{PKG} (mils)
DQS6_B	AE28	569.17
DQS15_B	AD27	502.05
DQ48_B	Y25	247.68
DQ49_B	AB27	417.01
DQ50_B	AH32	865.47
DQ51_B	AH31	860.08
DQ52_B	AC28	547.40
DQ53_B	AA26	339.80
DQ54_B	AG30	780.12
DQ55_B	AH33	946.54
DQS7_B	AE27	488.39
DQS16_B	AF28	548.74
DQ56_B	AJ30	741.93
DQ57_B	AG29	692.99
DQ58_B	AB25	480.35
DQ59_B	AA25	260.73
DQ60_B	AL32	924.06
DQ61_B	AJ31	816.65
DQ62_B	AC27	478.39
DQ63_B	AB26	360.59

Signal	Ball No.	L_{PKG} (mils)
DQS8_B	W29	470.79
DQS17_B	Y30	551.26
CB0_B	V28	422.40
CB1_B	U25	262.04
CB2_B	Y31	639.37
CB3_B	AA33	724.06
CB4_B	U28	421.42
CB5_B	U27	356.31
CB6_B	AA31	605.00
CB7_B	AA32	701.69

Table 7-5. MCH L_{PKG} Data for DDR Channel B (Sheet 3 of 3)

Signal	Ball No.	L_{PKG} (mils)
CMDCLK0_B	J29	595.43
CMDCLK0_B#	J28	539.65
BA0_B	K26	370.75
BA1_B	H27	430.16
CAS_B#	H28	542.21
CKE_B	M32	660.59
CS0_B#	AH29	693.82
CS1_B#	AK32	899.92
MA0_B	M26	333.74
MA1_B	K29	540.43
MA2_B	H30	659.69
MA3_B	G30	705.39
MA4_B	F32	793.19
MA5_B	G29	612.68
MA6_B	F31	747.72
MA7_B	E33	892.05
MA8_B	E31	728.54
MA9_B	F29	603.94
MA10_B	L25	435.71
MA11_B	C31	794.25
MA12_B	C32	813.07
RAS_B#	V32	651.06
WE_B#	D32	818.43

Signal	Ball No.	L_{PKG} (mils)
CMDCLK2_B	J26	397.24
CMDCLK2_B#	K25	313.50
BA0_B	K26	370.75
BA1_B	H27	430.16
CAS_B#	H28	542.21
CKE_B	M32	660.59
CS4_B#	AE31	739.72
CS5_B#	AE26	463.94
MA0_B	M26	333.74
MA1_B	K29	540.43
MA2_B	H30	659.69
MA3_B	G30	705.39
MA4_B	F32	793.19
MA5_B	G29	612.68
MA6_B	F31	747.72
MA7_B	E33	892.05
MA8_B	E31	728.54
MA9_B	F29	603.94
MA10_B	L25	435.71
MA11_B	C31	794.25
MA12_B	C32	813.07
RAS_B#	V32	651.06
WE_B#	D32	818.43

CMDCLK1_B	L28	417.28
CMDCLK1_B#	M28	405.28
BA0_B	K26	370.75
BA1_B	H27	430.16
CAS_B#	H28	542.21
CKE_B	M32	660.59
CS2_B#	AF30	739.06
CS3_B#	AF27	515.04
MA0_B	M26	333.74
MA1_B	K29	540.43
MA2_B	H30	659.69
MA3_B	G30	705.39
MA4_B	F32	793.19
MA5_B	G29	612.68
MA6_B	F31	747.72
MA7_B	E33	892.05
MA8_B	E31	728.54
MA9_B	F29	603.94
MA10_B	L25	435.71
MA11_B	C31	794.25
MA12_B	C32	813.07
RAS_B#	V32	651.06
WE_B#	D32	818.43

CMDCLK3_B	K27	423.70
CMDCLK3_B#	L27	400.43
BA0_B	K26	370.75
BA1_B	H27	430.16
CAS_B#	H28	542.21
CKE_B	M32	660.59
CS6_B#	AD28	575.79
CS7_B#	Y27	353.35
MA0_B	M26	333.74
MA1_B	K29	540.43
MA2_B	H30	659.69
MA3_B	G30	705.39
MA4_B	F32	793.19
MA5_B	G29	612.68
MA6_B	F31	747.72
MA7_B	E33	892.05
MA8_B	E31	728.54
MA9_B	F29	603.94
MA10_B	L25	435.71
MA11_B	C31	794.25
MA12_B	C32	813.07
RAS_B#	V32	651.06
WE_B#	D32	818.43

7.3.1.3 MCH Hub Interface_A Signal Package Trace Length Data

Table 7-6 is the MCH package trace length information for Hub Interface_A.

Table 7-6. MCH L_{PKG} Data for Hub Interface_A

Signal	Ball No.	L_{PKG} (mils)
HI_STBF	C10	659.09
HI_STBS	D10	623.43
HI0_A	E11	519.92
HI1_A	B11	743.78
HI2_A	G10	468.03
HI3_A	F10	501.54
HI4_A	D9	633.62
HI5_A	E9	543.11
HI6_A	J11	317.83
HI7_A	H9	426.55

7.3.1.4 MCH Hub Interface_B Signal Package Trace Length Data

Table 7-7 is the MCH package trace length information for Hub Interface_B.

Table 7-7. MCH L_{PKG} Data for Hub Interface_B

Signal	Ball No.	L_{PKG} (mils)
PSTRBF_B	G15	333.78
PSTRBS_B	H15	300.32
HI0_B	D16	482.83
HI1_B	G16	478.27
HI2_B	C17	544.45
HI3_B	C16	571.54
HI4_B	A17	677.56
HI5_B	A16	679.33
HI6_B	B14	597.40
HI7_B	D15	531.18
HI20_B	F14	414.53

Signal	Ball No.	L_{PKG} (mils)
PUSTRBF_B	A12	678.70
PUSTRBS_B	B12	645.75
HI8_B	C14	591.54
HI9_B	F13	433.19
HI10_B	A13	702.76
HI11_B	C13	568.78
HI12_B	D12	518.46
HI13_B	E12	504.53
HI14_B	C11	611.77
HI15_B	J14	272.14
HI21_B	G13	386.58

7.3.1.5 MCH Hub Interface_C Signal Package Trace Length Data

Table 7-8 is the MCH package trace length information for Hub Interface_C.

Table 7-8. MCH L_{PKG} Data for Hub Interface_C

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
PSTRBF_C	C23	681.10	PUSTRBF_C	D18	514.80
PSTRBS_C	B23	732.52	PUSTRBS_C	E17	464.80
HI0_C	D22	635.32	HI8_C	D19	557.40
HI1_C	B24	757.96	HI9_C	A20	728.98
HI2_C	G18	360.95	HI10_C	B20	665.71
HI3_C	C22	696.42	HI11_C	C19	616.69
HI4_C	E20	495.43	HI12_C	B18	650.47
HI5_C	F19	394.84	HI13_C	C18	561.77
HI6_C	D21	609.57	HI14_C	E18	453.94
HI7_C	E21	516.69	HI15_C	F17	379.61
HI20_C	H18	294.76	HI21_C	F16	416.61

7.3.1.6 MCH Hub Interface_D Signal Package Trace Length Data

Table 7-9 is the MCH package trace length information for Hub Interface_D.

Table 7-9. MCH L_{PKG} Data for Hub Interface_D

Signal	Ball No.	L_{PKG} (mils)	Signal	Ball No.	L_{PKG} (mils)
PSTRBF_D	D27	720.08	PUSTRBF_D	B25	760.04
PSTRBS_D	D26	731.54	PUSTRBS_D	C25	716.14
HI0_D	D28	772.84	HI8_D	G22	496.18
HI1_D	G25	565.51	HI9_D	E24	588.62
HI2_D	G26	538.23	HI10_D	A25	816.22
HI3_D	F26	592.94	HI11_D	D24	618.90
HI4_D	G24	517.40	HI12_D	A24	808.66
HI5_D	A27	902.48	HI13_D	E23	526.58
HI6_D	H24	416.58	HI14_D	F23	494.53
HI7_D	C26	745.28	HI15_D	F22	497.05
HI20_D	E27	700.00	HI21_D	H21	502.40

Testability 8

In the MCH, the ability for Automated Test Equipment (ATE) board-level testing has been implemented as an XOR chain. An XOR chain is a chain of XOR gates, each with one input pin connected to it.

The MCH uses the XORMODE# pin to activate the XOR test mode. The method to put the MCH in XOR test is to assert the XORMODE# signal. When the following conditions are met, the chip will be in XOR test mode. If any of the following are not met, then XOR test will not be enabled.

1. Assert PWRGOOD
2. Assert RSTIN# for 128 clocks beyond the assertion of PWRGOOD (RSTIN# may be held asserted before PWRGOOD is asserted).
3. Deassert RSTIN#
4. Assert XORMODE# and hold asserted.
5. The clocks may be held at the 0 or 1 state; or be fully running. Since HCLKINP/HCLKINN is a differential pair, the 2 clock inputs should be held in opposite states.
6. As long as XORMODE# is asserted the MCH is in XOR test. As soon as XORMODE# is asserted and 2 HCLKINP/HCLKINN cycles have occurred, all the XOR chains are functional.
7. After deasserting XORMODE#, the MCH should be reset before any other testing is done.

There are eight chains of XORs divided up functionally.

Note: For all test modes except Asynchronous XOR mode, input pin XORMODE# should be driven high.

8.1 XOR Chains

The XOR chain outputs (XOR chains 8 through 1) are visible on HI_A[7:0]. In Long XOR chain mode the delay through the 4 pad ring chains (chains 1, 2, 3, 4) may be observed on HI4_A.

RSTIN# is not part of any XOR chain. This is in addition to HI_A[7:0]. The chain partitioning is listed in Table 8-1. When signals are grouped in Table 8-1 (e.g., DQ_A[63:0]), the chain order is the same as the ascending numerical name of the pin name (i.e., the chain order for DQ_A[63:0] is DQ_A0, DQ_A1, DQ_A2, ... DQ_A63).

Table 8-1. XOR Chains

Chain #1	Chain #2	Chain #3	Chain #4	Chain #5	Chain #6	Chain #7	Chain #8
DQ_A[63:0]	DQS_A[17:0]	DQ_B[63:0]	DQS_B[17:0]	HI_STBF	HI_B[17:0]	HD[63:0]#	ADS#
CB_A[7:0]	CMDCLK_A [3:0]	CB_B[7:0]	CMDCLK_B [3:0]	HI_STBS	PSTRBF_B	DP[3:0]#	AP[1:0]#
	CMDCLK_A [3:0]#		CMDCLK_B [3:0]#	HI10_A	PSTRBS_B		BINIT#
	MA_A[12:0]		MA_B[12:0]	HI8_A	PUSTRBF_B		BNR#
	BA_A[1:0]		BA_B[1:0]	HI9_A	PUSTRBS_B		BPRI#
	RAS_A#		RAS_B#	HI11_A	HI18_B		BREQ0#
	CAS_A#		CAS_B#	SMB_CLK	HI16_B		CPURST#
	WE_A#		WE_B#	SMB_DATA	HI17_B		DBSY#
	CS_A[7:0]#		CS_B[7:0]#		HI_C[17:0]		DEFER#
	CKE_A[1:0]		CKE_B[1:0]		PSTRBF_C		DBI[3:0]#
	RCVENINS _A#		RCVENIN _B#		PSTRBS_C		DRDY#
	RCVENOUT _A#		RCVENOUT _B#		PUSTRBF_C		HA[35:3]#
					PUSTRBS_C		HADSTB [1:0]#
					HI18_C		HREQ[4:0]#
					HI16_C		HDSTBP [3:0]#
					HI17_C		HDSTBN [3:0]#
					HI_D[17:0]		HIT#
					PSTRBF_D		HITM#
					PSTRBS_D		HLOCK#
					PUSTRBF_D		HTRDY#
					PUSTRBS_D		XERR#
					HI18_D		RS[2:0]#
					HI16_D		RSP#
					HI17_D		
Out = HI1_A	Out = HI2_A	Out = HI3_A	Out = HI4_A	Out = HI5_A	Out = HI6_A	Out = HI7_A	Out = HI8_A