



# Intel<sup>®</sup> 848P Chipset

Datasheet

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*Intel<sup>®</sup> 82848P Memory Controller Hub (MCH)*

*February 2004*



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## Revision History

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Revision	Description	Date
-001	• Initial Release	August 2003
-002	• Revised document for the Intel® Pentium® 4 Processor on 90 nm process	January 2004

# Intel® 82848P MCH Features

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- Host Interface Support
  - Intel® Pentium® 4 processors with 512-KB L2 cache on 0.13 micron process / Intel® Pentium® 4 Processor on 90 nm process
  - VTT 1.1 V – 1.55 V ranges
  - 64-bit FSB frequencies of 400 MHz (100 MHz bus clock), 533 MHz (133 MHz bus clock), and 800 MHz (200 MHz bus clock). Maximum theoretical BW of 6.4 GB/s.
  - FSB Dynamic Bus Inversion on the data bus
  - 32-bit addressing for access to 2GB of memory space
  - 12-deep In Order Queue
  - AGTL+ On-die Termination (ODT)
  - Hyper-Threading Technology
- System Memory Controller Support
  - Single-channel (64 bits wide) DDR memory interface
  - Symmetric and asymmetric memory upgrade
  - 128-Mb, 256-Mb, 512-Mb technologies implemented as x8, x16 devices
  - four bank devices
  - Non-ECC, un-buffered DIMMs only
  - Maximum of two DIMMs, with each DIMM having one or two rows
  - Up to 2-GB system memory
  - Up to 32 open pages
  - 4-KB to 32-KB page sizes
  - Opportunistic refresh
  - Suspend-to-RAM support using CKE
  - SPD (Serial Presence Detect) Scheme for DIMM Detection
  - DDR (Double Data Rate type 1)
    - Maximum of two DDR DIMMs, single-sided and/or double-sided
    - DDR266, DDR333, DDR400 DIMM modules
    - DDR channel operation at 266 MHz, 333 MHz, and 400 MHz with a Peak BW of 2.1 GB/s, 2.7 GB/s, and 3.2 GB/s, respectively
    - Burst length of 4 and 8 (32 or 64 bytes per access, respectively)
    - SSTL\_2 signaling
- Communication Streaming Architecture (CSA) Interface Support
  - Gigabit Ethernet (GbE) communication devices supported on the CSA interface (e.g., Intel® 82547EI GbE controller)
  - 8-bit Hub Interface 1.5 electrical/transfer protocol
  - 266 MB/s point-to-point connection
  - 1.5 V operation
- Hub Interface (HI) Support
  - Hub Interface 1.5
  - 266 MB/s point-to-point connection to the ICH5
  - 66 MHz base clock
  - 1.5 V operation
- AGP Interface Support
  - Single AGP device
  - AGP 3.0 with 4X / 8X AGP data transfers and 4X / 8X fast writes, respectively
  - 32-bit 4X/8X data transfers and 4X/8X fast writes
  - Peak BW of 2 GB/s.
  - 0.8 V and 1.5 V AGP signalling levels; no 3.3 V support
  - AGP 2.0 1X/4X AGP data transfers and 4X fast writes
  - 32-deep AGP request queue
- MCH Package
  - 37.5 mm x 37.5 mm Flip Chip Ball Grid Array (FC-BGA) package
  - 932 solder balls



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# Introduction

# 1

This Memory Controller Hub (MCH) datasheet is for the Intel<sup>®</sup> 82848P MCH. The 82848P MCH is part of the Intel<sup>®</sup> 848P chipset. Each chipset contains two main components: Memory Controller Hub (MCH) for the host bridge and I/O Controller Hub for the I/O subsystem. The MCH provides the processor interface, system memory interface, CSA interface, AGP interface, and hub interface in an 848P chipset desktop platform. The 848P chipset uses either the Intel<sup>®</sup> 82801EB ICH5 or Intel<sup>®</sup> 82801ER ICH5R for the I/O Controller Hub.

## 1.1 Terminology

This section provides the definitions of some of the terms used in this document.

**Table 1. General Terminology (Sheet 1 of 2)**

Terminology	Description
AGP	Accelerated Graphics Port. In this document AGP refers to the AGP/PCI interface that is in the MCH. The MCH AGP interface supports only 0.8 V/1.5 V AGP 2.0/AGP 3.0 compliant devices using PCI (66 MHz), AGP 1X (66 MHz), 4X (266 MHz), and 8X (533 MHz) transfers. MCH does NOT support any 3.3 V devices. For AGP 2.0 PIPE# and SBA addressing cycles and their associated data phases are generally referred to as AGP transactions. FRAME# cycles are generally referred to as AGP/PCI transactions.
Bank	DRAM chips are divided into multiple banks internally. Commodity parts are all 4 bank, which is the only type the MCH supports. Each bank acts somewhat like a separate DRAM, opening and closing pages independently, allowing different pages to be open in each. Most commands to a DRAM target a specific bank, but some commands (i.e., Precharge All) are targeted at all banks. Multiple banks allows higher performance by interleaving the banks and reducing page miss cycles.
Channel	In the MCH a DRAM channel is the set of signals that connect to one set of DRAM DIMMs.
Chipset Core	The MCH internal base logic.
Column Address	The Column address selects one DRAM location, or the starting location of a burst, from within the open page on a read or write command.
Double-Sided DIMM	Terminology often used to describe a DIMM that contains two DRAM rows. Generally a Double-Sided DIMM contains two rows, with the exception noted above. This terminology is not used within this document.
DDR	Double Data Rate SDRAM. DDR describes the type of DRAMs that transfers two data items per clock on each pin. This is the only type of DRAM supported by the MCH.
Full Reset	A Full MCH Reset is defined in this document when RSTIN# is asserted.
GART	Graphics Aperture Re-map Table. GART is a table in memory containing the page re-map information used during AGP aperture address translations.
MCH	The Memory Controller Hub component that contains the processor interface, DRAM controller, CSA interface, and AGP interface. It communicates with the I/O controller hub (ICH5) over proprietary interconnects called HI.
GTLB	Graphics Translation Look-aside Buffer. A cache used to store frequently used GART entries.
HI	Hub Interface. HI is the proprietary Hub interconnect that connects the MCH to the ICH5. In this document HI cycles originating from or destined for the primary PCI interface on the ICH5 are generally referred to as HI/PCI or simply HI cycles.

Table 1. General Terminology (Sheet 2 of 2)

Terminology	Description
Host	This term is used synonymously with processor.
Intel® ICH5	Fifth generation IO Controller Hub component that contains additional functionality compared to the Intel® ICH4.
Primary PCI	The physical PCI bus that is driven directly by the ICH5 component. Communication between PCI and the MCH occurs over HI. Note that even though the Primary PCI bus is referred to as PCI it is <b>not</b> PCI Bus 0 from a configuration standpoint.
FSB	Processor Front Side Bus.
Row	A group of DRAM chips that fill out the data bus width of the system and are accessed in parallel by each DRAM command.
Row Address	The Row address is presented to the DRAMs during an Activate command and indicates which page to open within the specified bank (the bank number is also presented).
Scalable Bus	Processor-to-MCH interface. The compatible mode of the Scalable Bus is the P6 Bus. The Enhanced Mode of the Scalable Bus is the P6 Bus plus enhancements primarily consisting of source synchronous transfers for address and data, and FSB interrupt delivery. The Intel® Pentium® 4 processor implements a subset of the enhanced mode.
Single-Sided DIMM	Terminology often used to describe a DIMM that contains one DRAM row. Usually one row fits on a single side of the DIMM allowing the backside to be empty.
SDR	Single Data Rate SDRAM.
SDRAM	Synchronous Dynamic Random Access Memory.
Secondary PCI	The physical PCI interface that is a subset of the AGP bus driven directly by the MCH. It supports a subset of 32-bit, 66 MHz PCI 2.0 compliant components, but only at 1.5 V (not 3.3 V or 5 V).
SSTL_2	Stub Series Terminated Logic for 2.6 Volts (DDR)

## 1.2 Related Documents

Document <sup>1</sup>	Document Number/ Location
<i>Intel® 848P Chipset Platform Design Guide</i>	<a href="http://developer.intel.com/design/chipsets/designex/">http://developer.intel.com/design/chipsets/designex/</a>
<i>Intel® 848P Chipset Thermal Design Guide</i>	Note 2
<i>Intel® 848P Chipset Customer Reference Board Schematics</i>	Note 2
<i>Intel® 865G/865GV/865PE/865P CRB Schematics Addendum for the Intel® Pentium® 4 Processor on 90 nm Process with Loadline A Platforms - 2 Phase VR</i>	<a href="http://developer.intel.com/design/chipsets/schematics/300683.htm">http://developer.intel.com/design/chipsets/schematics/300683.htm</a>
<i>Intel® 865G/865GV/865PE/865P CRB Schematics Addendum for the Intel® Pentium® 4 Processor on 90 nm Process with Loadline A Platforms - 3Phase VR</i>	<a href="http://developer.intel.com/design/chipsets/schematics/300684.htm">http://developer.intel.com/design/chipsets/schematics/300684.htm</a>
<i>Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5R (ICH5R) Datasheet</i>	<a href="http://developer.intel.com/design/chipsets/datashts/252516.htm">http://developer.intel.com/design/chipsets/datashts/252516.htm</a>
<i>Intel® Pentium® 4 Processors with 512-KB L2 Cache on 0.13 Micron Process Datasheet</i>	<a href="http://developer.intel.com/design/pentium4/datashts/298643.htm">http://developer.intel.com/design/pentium4/datashts/298643.htm</a>
<i>JEDEC Double Data Rate (DDR) SDRAM Specification</i>	<a href="http://www.jedec.org">www.jedec.org</a>

Document <sup>1</sup>	Document Number/ Location
Intel <sup>®</sup> PC SDRAM Specification	<a href="http://developer.intel.com/technology/memory/pcsdram/spec/index.htm">http://developer.intel.com/technology/memory/pcsdram/spec/index.htm</a>
Accelerated Graphics Port Interface Specification, Revision 2.0	<a href="http://www.intel.com/technology/agp/agp_index.htm">http://www.intel.com/technology/agp/agp_index.htm</a>

**NOTES:**

1. For additional related documents, refer to the *Intel<sup>®</sup> 848P Chipset Platform Design Guide*.
2. Contact your Intel Field Sales Representative.

## 1.3 Intel<sup>®</sup> 848P Chipset System Overview

Figure 1 shows an example block diagram of an 848P chipset-based platform. The 848P chipset is designed for use in a desktop system based on the Pentium 4 processor with 512-KB L2 cache on 0.13 micron process in a 478-pin package and the Pentium 4 processor on 90 nm process. The processor interface supports the Pentium 4 processor subset of the Extended Mode of the Scalable Bus Protocol. In an 848P chipset-based platform, many I/O functions are integrated onto the ICH5.

The 848P chipset platform supports an external graphics device on AGP. The MCH's AGP interface supports 1x/4x/8x AGP data transfers and 4x/8x AGP fast writes, as defined in the *Accelerated Graphics Port Interface Specification, Revision 3.0*.

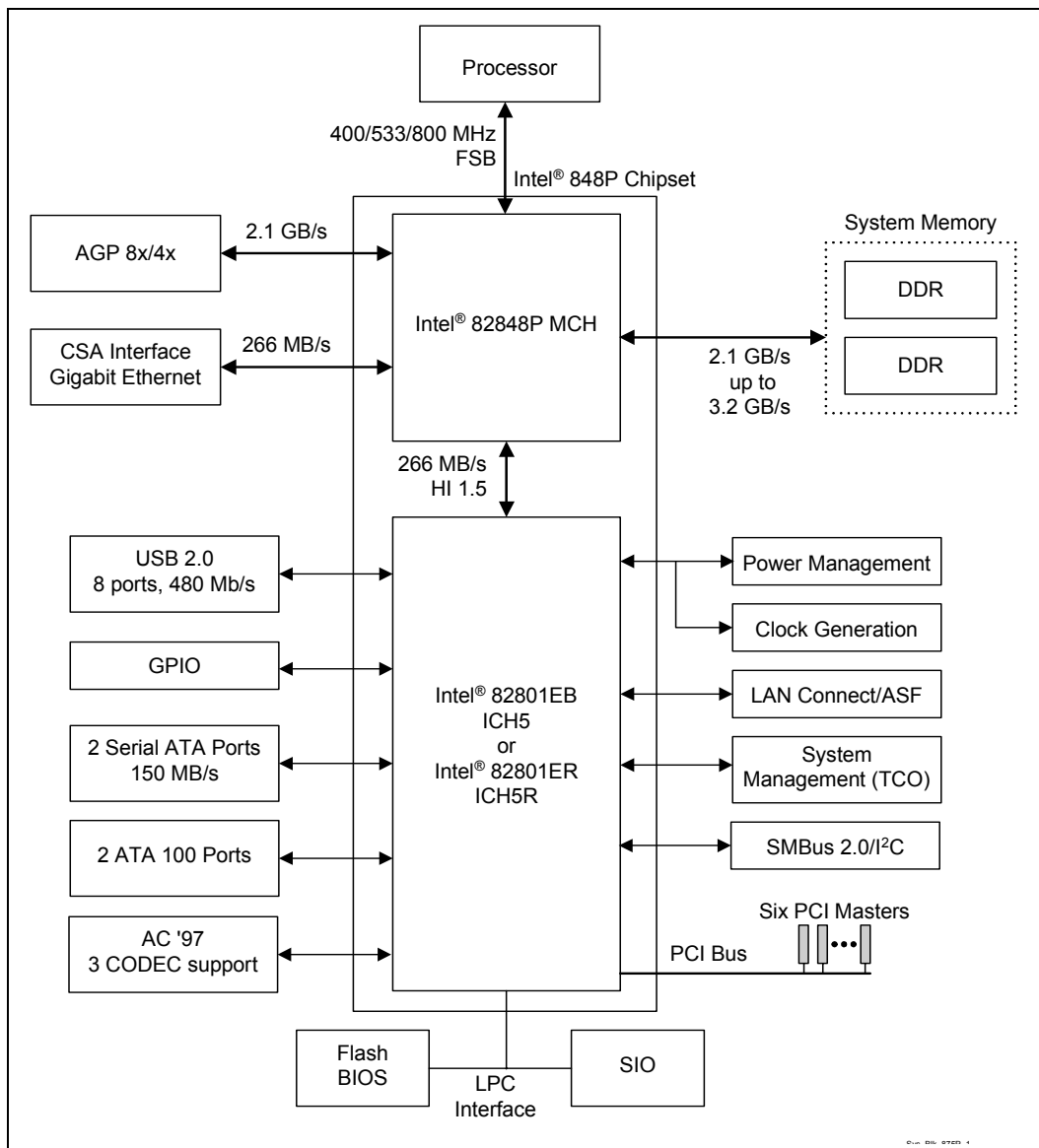
The MCH provides a Communications Streaming Architecture (CSA) Interface that connects the MCH to a Gigabit Ethernet (GbE) controller.

The 848P chipset platforms support 2 GB of system memory. For the 848P chipset, the memory can be 266/333/400 MHz Double Data Rate (DDR) memory components. Available bandwidth is 3.2 GB/s using DDR400.

The 82801EB ICH5 integrates an Ultra ATA 100 controller, two Serial ATA host controllers, one EHCI host controller, and four UHCI host controllers supporting eight external USB 2.0 ports, LPC interface controller, flash BIOS interface controller, PCI interface controller, AC '97 digital controller, integrated LAN controller, an ASF controller and a hub interface for communication with the MCH. The ICH5 component provides the data buffering and interface arbitration required to ensure that system interfaces operate efficiently and provide the bandwidth necessary to enable the system to obtain peak performance. The 82801ER ICH5R elevates Serial ATA storage performance to the next level with Intel<sup>®</sup> RAID Technology.

The ACPI compliant ICH5 platform can support the Full-on, Stop Grant, Suspend to RAM, Suspend to Disk, and Soft-Off power management states. Through the use of the integrated LAN functions, the ICH5 also supports Alert Standard Format for remote management.

Figure 1. Intel® 848P Chipset System Block Diagram





## 1.4 Intel® 82848P MCH Overview

The 82848P Memory Controller Hub (MCH) provides the host bridge interfaces in an 848P chipset based platform. The MCH contains advanced desktop power management logic.

The MCH's role in a system is to manage the flow of information between its five interfaces: the processor front side bus (FSB), the memory attached to the DRAM controller, the AGP 3.0 port, the Hub Interface, and CSA interface. This includes arbitrating between the five interfaces when each initiates an operation. While doing so, the MCH must support data coherency via snooping and must perform address translation for access to AGP Aperture memory. To increase system performance, the MCH incorporates several queues and a write cache.

### 1.4.1 Host Interface

The MCH can use a single Pentium 4 processor with 512-KB L2 cache on 0.13 micron process in a 478-pin package or the Pentium 4 processor on 90 nm process. The processor interface supports the Intel® Pentium® 4 processor subset of the extended mode of the Scalable Bus Protocol. The MCH supports FSB frequencies of 400/533/800 MHz (100 MHz, 133 MHz, and 200 MHz HCLK, respectively) using a scalable FSB VCC\_CPU. The MCH supports 32-bit host addressing, decoding up to 4 GB of the processor's memory address space.

Host-initiated I/O cycles are decoded to AGP/PCI\_B, Hub Interface, or the MCH configuration space. Host-initiated memory cycles are decoded to AGP/PCI\_B, Hub Interface or system DDR. All memory accesses from the host interface that hit the graphics aperture are translated using an AGP address translation table. AGP/PCI\_B device accesses to non-cacheable system memory are not snooped on the host bus. Memory accesses initiated from AGP/PCI\_B using PCI semantics and from hub interface to system DRAM will be snooped on the host bus.

## 1.4.2 System Memory Interface

The MCH integrates a system memory DDR controller with two, 64-bit wide interfaces. Only Double Data Rate (DDR) DRAM memory is supported; consequently, the buffers support only SSTL\_2 signal interfaces. The memory controller interface is fully configurable through a set of control registers.

### System Memory Interface

- Supports one 64-bit wide DDR data channel
- Available bandwidth up to 3.2 GB/s (DDR400).
- Support for non ECC.
- Supports 128-Mb, 256-Mb, 512-Mb DDR technologies
- Supports only x8, x16, DDR devices with four banks
- Registered DIMMs not supported
- Supports opportunistic refresh
- SPD (Serial Presence Detect) scheme for DIMM detection support
- Suspend-to-RAM support using CKE
- Supports configurations defined in the JEDEC DDR1 DIMM specification only
- Up to 2.0 GB of DDR
- Supports up to two DDR DIMMs, single-sided and/or double-sided
- Supports DDR266, DDR333, and DDR400 unregistered non-ECC DIMMs
- Supports up to 16 simultaneous open pages
- Does not support mixed-mode / uneven double-sided DDR DIMMs

## 1.4.3 Hub Interface

The Hub Interface connects the MCH to the ICH5. Virtually all communication between the MCH and the ICH5 occurs over the hub interface. The MCH supports only HI 1.5, which uses HI 1.0 protocol with HI 2.0 electrical characteristics. The hub interface runs at 266 MT/s (with 66 MHz base clock) and uses 1.5 V signaling. Accesses between hub interface and AGP/PCI\_B are limited to hub interface originated memory writes to AGP.

## 1.4.4 Communications Streaming Architecture (CSA) Interface

The CSA interface connects the MCH with a Gigabit Ethernet (GbE) controller. The MCH supports only HI 1.5 over the interface that uses HI 1.0 protocol with HI 2.0 electrical characteristics. The CSA interface runs at 266 MT/s (with 66 MHz base clock) and uses 1.5 V signaling.

### 1.4.5 AGP 8X Interface

A single AGP or PCI 66 component or connector (not both) is supported by the MCH's AGP interface. Support for AGP 3.0 includes 0.8 V and 1.5 V AGP electrical characteristics. Support for a single PCI-66 device is limited to the subset supported by the AGP 2.0 specification. An external graphics device is a requirement. The AGP PCI\_B buffers operate only the 1.5 V mode and supports the AGP 1.5 V connector.

The AGP/PCI\_B interface supports up to 8X AGP signaling and up to 8X fast writes. AGP semantic cycles to system DDR are not snooped on the host bus. PCI semantic cycles to system DDR are snooped on the host bus. The MCH supports PIPE# or SBA[7:0] AGP address mechanisms, but not both simultaneously. Either the PIPE# or the SBA[7:0] mechanism must be selected during system initialization. The MCH contains a 32 deep AGP request queue. High-priority accesses are supported.

## 1.5 Clock Ratios

Table 2 lists the supported system memory clock ratios. AGP, CSA, and HI run at 66 MHz common clock and asynchronous to the chipset core. There is no required skew or ratio between FSB/chipset core and 66 MHz system clocks.

**Table 2. System Memory Clock Ratios**

Host Clock	DRAM Clock	Ratios	DRAM Data Rate	DRAM Type	Peak Bandwidth
100 MHz	133 MHz	3/4	266 MT/s	DDR-DRAM	2.1 GB/s
133 MHz	133 MHz	1/1	266 MT/s	DDR-DRAM	2.1 GB/s
200 MHz	133 MHz	3/2	266 MT/s	DDR-DRAM	2.1 GB/s
133 MHz	166 MHz	4/5	333 MT/s	DDR-DRAM	2.7 GB/s
200 MHz)	160 MHz	5/4	320 MT/s	DDR-DRAM	2.6 GB/s
200 MHz	200 MHz	1/1	400 MT/s	DDR-DRAM	3.2 GB/s

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# Signal Description

# 2

This chapter 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:

<b>I</b>	Input pin
<b>O</b>	Output pin
<b>I/O</b>	Bi-directional Input/Output pin
<b>s/t/s</b>	Sustained Tri-state. This pin is driven to its inactive state prior to tri-stating.

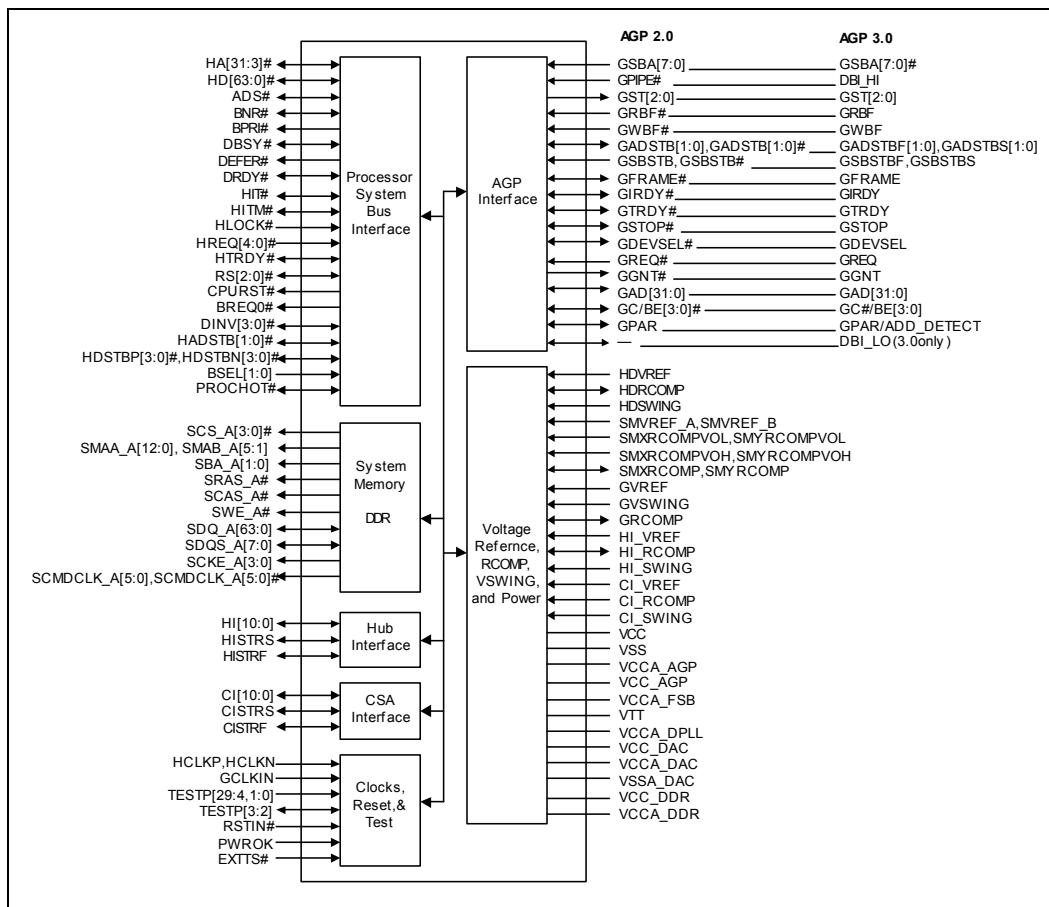
The signal description also includes the type of buffer used for the particular signal:

<b>AGTL+</b>	Open Drain AGTL+ interface signal. Refer to the AGTL+ I/O Specification for complete details. The MCH integrates AGTL+ termination resistors, and supports VTT from 1.15 V to 1.55 V (not including guard banding).
<b>AGP</b>	AGP interface signals. These signals are compatible with AGP 2.0 1.5 V signaling and AGP 3.0 0.8 V swing signaling Environment DC and AC Specifications. The buffers are not 3.3 V tolerant.
<b>HI15</b>	Hub Interface 1.5 compatible signals
<b>LVTTTL</b>	Low Voltage TTL 3.3 V compatible signals
<b>SSTL_2</b>	Stub Series Terminated Logic 2.6 V compatible signals.
<b>2.6 VGPIO</b>	2.6 V buffers used for misc GPIO signals
<b>3.3 VGPIO</b>	3.3 V buffers used for DAC/DCC signals
<b>CMOS</b>	CMOS buffers.

Host Interface signals that perform multiple transfers per clock cycle may be marked as either “4X” (for signals that are “quad-pumped”) or 2X (for signals that are “double-pumped”).

Note that the processor address and data bus signals are logically inverted signals. In other words, the actual values are inverted from what appears on the processor bus. This has been taken into account in the 848P chipset and the address and data bus signals are inverted inside the MCH host bridge. All processor control signals follow normal convention. A 0 indicates an active low level (low voltage) if the signal name is followed by # symbol; a 1 indicates an active high level (high voltage) if the signal has no # suffix.

Figure 2. Intel® 82848P MCH Interface Block Diagram



## 2.1 Host Interface Signals

Signal Name	Type	Description										
ADS#	I/O AGTL+	<b>Address Strobe:</b> The processor bus owner asserts ADS# to indicate the first of two cycles of a request phase. The MCH can assert this signal for snoop cycles and interrupt messages.										
BNR#	I/O AGTL+	<b>Block Next Request:</b> This signal is used to block the current request bus owner from issuing a new requests. This signal is used to dynamically control the processor bus pipeline depth.										
BPRI#	O AGTL+	<b>Priority Agent Bus Request:</b> The MCH is the only Priority Agent on the processor bus. It asserts this signal to obtain the ownership of the address bus. This signal has priority over symmetric bus requests and will cause the current symmetric owner to stop issuing new transactions unless the HLOCK# signal was asserted.										
BREQ0#	O AGTL+	<b>Bus Request 0#:</b> The MCH pulls the processor bus BREQ0# signal low during CPURST#. The signal is sampled by the processor on the active-to-inactive transition of CPURST#. The minimum setup time for this signal is 4 HCLKs. The minimum hold time is 2 clocks and the maximum hold time is 20 HCLKs. BREQ0# should be terminated high (Pulled up) after the hold time requirement has been satisfied.  <b>NOTE:</b> This signal is called BR0# in the Intel processor specification.										
BSEL[1:0]	I CMOS	<b>Core / FSB Frequency (FSBFREQ) Select Strap:</b> This strap is latched at the rising edge of PWROK. These pins has no default internal pull-up resistor. 00 = Core frequency is 100 MHz, FSB frequency is 400 MHz 01 = Core frequency is 133 MHz, FSB frequency is 533 MHz 10 = Core frequency is 200 MHz, FSB frequency is 800 MHz 11 = Reserved										
CPURST#	O AGTL+	<b>CPU Reset:</b> The CPURST# pin is an output from the MCH. The MCH asserts CPURST# while RSTIN# (PCIRST# from Intel <sup>®</sup> ICH5) is asserted and for approximately 1 ms after RSTIN# is deasserted. The CPURST# allows the processors to begin execution in a known state.  Note that the ICH5 must provide processor frequency select strap setup and hold times around CPURST#. This requires strict synchronization between the MCH CPURST# deassertion and ICH5 driving the straps.										
DBSY#	I/O AGTL+	<b>Data Bus Busy:</b> This signal is used by the data bus owner to hold the data bus for transfers requiring more than one cycle.										
DEFER#	O AGTL+	<b>Defer:</b> DEFER# indicates that the MCH will terminate the transaction currently being snooped with either a deferred response or with a retry response.										
DINV[3:0]#	I/O AGTL+ 4X	<b>Dynamic Bus Inversion:</b> These signals are driven along with the HD[63:0]# signals. They indicate if the associated signals are inverted. DINV[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.  <table border="0"> <tr> <td><b>DINV[x]#</b></td> <td><b>Data Bits</b></td> </tr> <tr> <td>DINV3#</td> <td>HD[63:48]#</td> </tr> <tr> <td>DINV2#</td> <td>HD[47:32]#</td> </tr> <tr> <td>DINV1#</td> <td>HD[31:16]#</td> </tr> <tr> <td>DINV0#</td> <td>HD[15:0]#</td> </tr> </table> <b>NOTE:</b> This signal is called DBI[3:0] in the Intel processor specification.	<b>DINV[x]#</b>	<b>Data Bits</b>	DINV3#	HD[63:48]#	DINV2#	HD[47:32]#	DINV1#	HD[31:16]#	DINV0#	HD[15:0]#
<b>DINV[x]#</b>	<b>Data Bits</b>											
DINV3#	HD[63:48]#											
DINV2#	HD[47:32]#											
DINV1#	HD[31:16]#											
DINV0#	HD[15:0]#											
DRDY#	I/O AGTL+	<b>Data Ready:</b> This signal is asserted for each cycle that data is transferred.										

Signal Name	Type	Description										
HA[31:3]#	I/O AGTL+ 2X	<p><b>Host Address Bus:</b> HA[31:3]# connect to the processor address bus. During processor cycles the HA[31:3]# are inputs. The MCH drives HA[31:3]# during snoop cycles on behalf of HI and AGP/Secondary PCI initiators. HA[31:3]# are transferred at 2X rate. Note that the address is inverted on the processor bus.</p> <p><b>NOTE:</b> The MCH drives the HA7# signal, which is then sampled by the processor and the MCH on the active-to-inactive transition of CPURST#. The minimum setup time for this signal is 4 HCLKs. The minimum hold time is 2 clocks and the maximum hold time is 20 HCLKs.</p>										
HADSTB[1:0]#	I/O AGTL+ 2X	<p><b>Host Address Strobe:</b> HADSTB[1:0]# are source synchronous strobes used to transfer HA[31:3]# and HREQ[4:0]# at the 2X transfer rate.</p> <table border="0"> <thead> <tr> <th>Strobe</th> <th>Address Bits</th> </tr> </thead> <tbody> <tr> <td>HADSTB0#</td> <td>A[16:3]#, REQ[4:0]#</td> </tr> <tr> <td>HADSTB1#</td> <td>A[31:17]#</td> </tr> </tbody> </table>	Strobe	Address Bits	HADSTB0#	A[16:3]#, REQ[4:0]#	HADSTB1#	A[31:17]#				
Strobe	Address Bits											
HADSTB0#	A[16:3]#, REQ[4:0]#											
HADSTB1#	A[31:17]#											
HD[63:0]#	I/O AGTL+ 4X	<p><b>Host Data:</b> These signals are connected to the processor data bus. Data on HD[63:0]# is transferred at a 4X rate. Note that the data signals may be inverted on the processor bus, depending on the DINV[3:0] signals.</p>										
HDSTBP[3:0]# HDSTBN[3:0]#	I/O AGTL+ 4X	<p><b>Differential Host Data Strobes:</b> These signals are differential source synchronous strobes used to transfer HD[63:0]# and DINV[3:0]# at the 4X transfer rate.</p> <table border="0"> <thead> <tr> <th>Strobe</th> <th>Data Bits</th> </tr> </thead> <tbody> <tr> <td>HDSTBP3#, HDSTBN3#</td> <td>HD[63:48]#, DINV3#</td> </tr> <tr> <td>HDSTBP2#, HDSTBN2#</td> <td>HD[47:32]#, DINV2#</td> </tr> <tr> <td>HDSTBP1#, HDSTBN1#</td> <td>HD[31:16]#, DINV1#</td> </tr> <tr> <td>HDSTBP0#, HDSTBN0#</td> <td>HD[15:0]#, DINV0#</td> </tr> </tbody> </table>	Strobe	Data Bits	HDSTBP3#, HDSTBN3#	HD[63:48]#, DINV3#	HDSTBP2#, HDSTBN2#	HD[47:32]#, DINV2#	HDSTBP1#, HDSTBN1#	HD[31:16]#, DINV1#	HDSTBP0#, HDSTBN0#	HD[15:0]#, DINV0#
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HDSTBP1#, HDSTBN1#	HD[31:16]#, DINV1#											
HDSTBP0#, HDSTBN0#	HD[15:0]#, DINV0#											
HIT#	I/O AGTL+	<p><b>Hit:</b> This signal indicates that a caching agent holds an unmodified version of the requested line. HIT# is also driven in conjunction with HITM# by the target to extend the snoop window.</p>										
HITM#	I/O AGTL+	<p><b>Hit Modified:</b> This signal 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 also driven in conjunction with HIT# to extend the snoop window.</p>										
HLOCK#	I AGTL+	<p><b>Host Lock:</b> All processor bus cycles sampled with the assertion of HLOCK# and ADS#, until the negation of HLOCK# must be atomic (i.e., <i>no HI or AGP/PCI snoopable access</i> to system memory are allowed when HLOCK# is asserted by the processor).</p>										
HREQ[4:0]#	I/O AGTL+ 2X	<p><b>Host Request Command:</b> These signals define the attributes of the request. HREQ[4:0]# are transferred at 2X rate. They are asserted by the requesting agent during both halves of 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.</p> <p>The transactions supported by the MCH Host Bridge are defined in the <a href="#">Chapter 5</a>.</p>										



Signal Name	Type	Description																		
HTRDY#	O AGTL+	<b>Host Target Ready:</b> This signal indicates that the target of the processor transaction is able to enter the data transfer phase.																		
PROCHOT#	I/O AGTL+	<b>Processor Hot:</b> This signal informs the chipset when processor Tj>thermal Monitor trip point.																		
RS[2:0]#	I/O AGTL+	<p><b>Response Signals:</b> These signals indicate the type of response according to the following:</p> <table border="1"> <thead> <tr> <th>Encoding</th> <th>Response Type</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>Idle state</td> </tr> <tr> <td>001</td> <td>Retry response</td> </tr> <tr> <td>010</td> <td>Deferred response</td> </tr> <tr> <td>011</td> <td>Reserved (not driven by MCH)</td> </tr> <tr> <td>100</td> <td>Hard Failure (not driven by MCH)</td> </tr> <tr> <td>101</td> <td>No data response</td> </tr> <tr> <td>110</td> <td>Implicit Writeback</td> </tr> <tr> <td>111</td> <td>Normal data response</td> </tr> </tbody> </table>	Encoding	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
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The following is the list of processor bus interface signals that are **not** supported by the MCH.

Signal Name Not Supported	Function Not Supported	Thus, MCH Does Not Support
AP[1:0]#	Address bus parity	Parity protection on address bus
DP[3:0]#	Data parity	Data parity errors on host interface
HA[35:32]	Upper address bits	Only supports a 4-GB system address space
RSP#	Response (RS) parity	Response parity errors on host interface
IERR#	Processor Internal Error	Responding to processor internal error
BINIT#	Bus Initialization Signal	Reset of the Host Bus state machines.
MCERR#	Machine Check Error	Signaling or recognition of Machine Check Error

## 2.2 Memory Interface

### 2.2.1 DDR DRAM Interface

Signal Name	Type	Description																		
SCMDCLK_A[5:0]	O SSTL_2	<b>Differential DDR Clock:</b> SCMDCLK_Ax and SCMDCLK_Ax# pairs are differential clock outputs. The crossing of the positive edge of SCMDCLK_Ax and the negative edge of SCMDCLK_Ax# is used to sample the address and control signals on the DRAM. There are three pairs to each DIMM.																		
SCMDCLK_A[5:0]#	O SSTL_2	<b>Complementary Differential DDR Clock:</b> These are the complementary Differential DDR Clock signals.																		
SCS_A[3:0]#	O SSTL_2	<b>Chip Select:</b> These signals select particular DRAM components during the active state. There is one SCS_A# for each DRAM row, toggled on the positive edge of SCMDCLK_Ax.																		
SMAA_A[12:0]	O SSTL_2	<b>Memory Address:</b> These signals are used to provide the multiplexed row and column address to the DRAM.																		
SMAB_A[5:1] / TESTP[29:25]	O SSTL_2	<b>Memory Address Copies:</b> SMAB_A[5:1] are identical to SMAA_A[5:1] and are used to reduce loading for Selective CPC (clock-per-command).																		
SBA_A[1:0]	O SSTL_2	<b>Bank Select (Bank Address):</b> These signals define which banks are selected within each DRAM row. Bank select and memory address signals combine to address every possible location within an DRAM device.																		
SRAS_A#	O SSTL_2	<b>Row Address Strobe:</b> SRAS_A# is used with SCAS_A# and SWE_A# (along with SCS_A#) to define the DRAM commands.																		
SCAS_A#	O SSTL_2	<b>Column Address Strobe:</b> SCAS_A# is used with SRAS_A# and SWE_A# (along with SCS_A#) to define the DRAM commands.																		
SWE_A#	O SSTL_2	<b>Write Enable:</b> SWE_A# is used with SCAS_A# and SRAS_A# (along with SCS_A#) to define the DRAM commands.																		
SDQ_A[63:0]	I/O SSTL_2	<b>Data Lines:</b> SDQ_A[63:0] interface to the DRAM data bus.																		
SDQS_A[7:0]	I/O SSTL_2	<p><b>Data Strobes:</b> Data strobes are used for capturing data. During writes, SDQS_A[7:0] are centered in data. During reads, SDQS_A[7:0] are edge aligned with data. The following list matches the data strobe with the data bytes.</p> <table border="1"> <thead> <tr> <th>Data Strobes</th> <th>Data Bytes</th> </tr> </thead> <tbody> <tr> <td>SDQS_A7</td> <td>SDQ_A[63:56]</td> </tr> <tr> <td>SDQS_A6</td> <td>SDQ_A[55:48]</td> </tr> <tr> <td>SDQS_A5</td> <td>SDQ_A[47:40]</td> </tr> <tr> <td>SDQS_A4</td> <td>SDQ_A[39:32]</td> </tr> <tr> <td>SDQS_A3</td> <td>SDQ_A[31:24]</td> </tr> <tr> <td>SDQS_A2</td> <td>SDQ_A[23:16]</td> </tr> <tr> <td>SDQS_A1</td> <td>SDQ_A[15:8]</td> </tr> <tr> <td>SDQS_A0</td> <td>SDQ_A[7:0]</td> </tr> </tbody> </table>	Data Strobes	Data Bytes	SDQS_A7	SDQ_A[63:56]	SDQS_A6	SDQ_A[55:48]	SDQS_A5	SDQ_A[47:40]	SDQS_A4	SDQ_A[39:32]	SDQS_A3	SDQ_A[31:24]	SDQS_A2	SDQ_A[23:16]	SDQS_A1	SDQ_A[15:8]	SDQS_A0	SDQ_A[7:0]
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SDQS_A3	SDQ_A[31:24]																			
SDQS_A2	SDQ_A[23:16]																			
SDQS_A1	SDQ_A[15:8]																			
SDQS_A0	SDQ_A[7:0]																			
SCKE_A[3:0]	O SSTL_2	<b>Clock Enable:</b> SCKE_A[3:0] are used to initialize DDR DRAM during power-up and to place all DRAM rows into and out of self-refresh during Suspend-to-RAM. SCKE_A[3:0] are also used to dynamically power down inactive DRAM rows. There is one SCKE_Ax per DRAM row, toggled on the positive edge of SCMDCLK_Ax.																		

## 2.3 Hub Interface

Signal Name	Type	Description
HI[10:0]	I/O sts HI15	<b>Packet Data:</b> HI[10:0] are the data signals used for HI read and write operations.
HISTRS	I/O sts HI15	<b>Packet Strobe:</b> HISTRS is one of two differential strobe signals used to transmit or receive packet data over HI.
HISTRF	I/O sts HI15	<b>Packet Strobe Complement:</b> HISTRF is one of two differential strobe signals used to transmit or receive packet data over HI.

## 2.4 CSA Interface

Signal Name	Type	Description
CI[10:0]	I/O sts HI15	<b>Packet Data:</b> CI[10:0] are data signals used for CI read and write operations.
CISTRS	I/O sts HI15	<b>Packet Strobe:</b> CISTRS is one of two differential strobe signals used to transmit or receive packet data over CI.
CISTRF	I/O sts HI15	<b>Packet Strobe Complement:</b> CISTRF is one of two differential strobe signals used to transmit or receive packet data over CI.

## 2.5 AGP Interface Signals

### 2.5.1 AGP Addressing Signals

Signal Name	Type	Description
GPIPE# (2.0) DBI_HI (3.0)	I/O AGP	<p><b>Pipelined Read:</b> This signal is asserted by the current master to indicate a full width address is to be queued by the target. The master enqueues one request each rising clock edge while GPIPE# is asserted. When GPIPE# is deasserted, no new requests are enqueued across the GAD bus.</p> <p>GPIPE# may be used in AGP 2.0 signaling modes, but is not permitted by the AGP 3.0 specification. When operating in AGP 3.0 signaling mode, the GPIPE# signal is used for DBI_HI.</p> <p>GPIPE# is a sustained tri-state signal from the master (<i>graphics controller</i>) and is an input to the MCH.</p> <p>In AGP 3.0 signaling mode this signal is Dynamic Bus Inversion HI.</p> <p><b>Dynamic Bus Inversion HI:</b> This signal goes along with GAD[31:16] to indicate whether GAD[31:16] must be inverted on the receiving end.</p> <ul style="list-style-type: none"> <li>DBI_HI = 0: GAD[31:16] are not inverted so receiver may use as is.</li> <li>DBI_HI = 1: GAD[31:16] are inverted so receiver must invert before use.</li> </ul> <p>The GADSTBF1 and GADSTBS1 strobes are used with DBI_HI. In AGP 3.0 4X data rate mode dynamic bus inversion is disabled by the MCH while transmitting (data never inverted and DBI_HI driven low); dynamic bus inversion is enabled when receiving data. For 8X data rate, dynamic bus inversion is enabled when transmitting and receiving data.</p>
GSBA[7:0] (2.0) GSBA[7:0]# (3.0)	I AGP	<p><b>Sideband Address:</b> This bus provides an additional bus to pass address and command to the MCH from the AGP master.</p> <p><b>NOTE:</b> In AGP 2.0 signaling mode, when sideband addressing is disabled, these signals are isolated. When sideband addressing is enabled, internal pull-ups are enabled to prevent indeterminate values on them in cases where the Graphics Card may not have its GSBA[7:0] output drivers enabled yet.</p>

#### NOTES:

- The previous table contains two mechanisms to queue requests by the AGP master. Note that the master can only use one mechanism. When *GPIPE#* is used to queue addresses the master is not allowed to queue addresses using the SB bus. For example, during configuration time, if the master indicates that it can use either mechanism, the configuration software will indicate which mechanism the master will use. Once this choice has been made, the master will continue to use the mechanism selected until the master is reset (and reprogrammed) to use the other mode. This change of modes is not a dynamic mechanism but rather a static decision when the device is first being configured after reset.
- The term (2.0) following a signal name indicates its function in AGP 2.0 signaling mode (1.5 V swing).
- The term (3.0) following a signal name indicates its function in AGP 3.0 signaling mode (0.8 V swing).

## 2.5.2 AGP Flow Control Signals

Signal Name	Type	Description
GRBF# (2.0) GRBF (3.0)	I AGP	<b>Read Buffer Full:</b> This signal indicates if the master is ready to accept previously requested low priority read data. When GRBF(#) is asserted, the MCH is not allowed to return low priority read data to the AGP master on the first block. GRBF(#) is only sampled at the beginning of a cycle.  If the AGP master is always ready to accept return read data, it is not required to implement this signal.
GWBF# (2.0) GWBF (3.0)	I AGP	<b>Write Buffer Full:</b> This signal indicates if the master is ready to accept fast write data from the MCH. When GWBF(#) is asserted, the MCH is not allowed to drive fast write data to the AGP master. GWBF(#) is only sampled at the beginning of a cycle.  If the AGP master is always ready to accept fast write data, it is not required to implement this signal.

**NOTE:**

1. The term (2.0) following a signal name indicates its function in AGP 2.0 signaling mode (1.5 V swing).
2. The term (3.0) following a signal name indicates its function in AGP 3.0 signaling mode (0.8 V swing).

## 2.5.3 AGP Status Signals

Signal Name	Type	Description																		
GST[2:0] (2.0) GST[2:0] (3.0)	O AGP	<b>Status:</b> These signals provide information from the arbiter to an AGP Master on what it may do. GST[2:0] only have meaning to the master when its GGNT(#) is asserted. When GGNT(#) is deasserted, these signals have no meaning and must be ignored. GST[2:0] are always an output from the MCH and an input to the master.  <table border="0"> <thead> <tr> <th>Encoding</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>Previously requested low priority read data (Async read for AGP 3.0 signaling mode) is being returned to the master.</td> </tr> <tr> <td>001</td> <td>Previously requested high priority read data is being returned to the master. Reserved in AGP 3.0 signaling mode.</td> </tr> <tr> <td>010</td> <td>The master is to provide low priority write data (Async write for AGP 3.0 signaling mode) for a previously queued write command.</td> </tr> <tr> <td>011</td> <td>The master is to provide high priority write data for a previously queued write command. Reserved in AGP 3.0 signaling mode.</td> </tr> <tr> <td>100</td> <td>Reserved.</td> </tr> <tr> <td>101</td> <td>Reserved.</td> </tr> <tr> <td>110</td> <td>Reserved.</td> </tr> <tr> <td>111</td> <td>The master has been given permission to start a bus transaction. The master may queue AGP requests by asserting GPIPE# (4X signaling mode) or start a PCI transaction by asserting GFRAME#.</td> </tr> </tbody> </table>	Encoding	Meaning	000	Previously requested low priority read data (Async read for AGP 3.0 signaling mode) is being returned to the master.	001	Previously requested high priority read data is being returned to the master. Reserved in AGP 3.0 signaling mode.	010	The master is to provide low priority write data (Async write for AGP 3.0 signaling mode) for a previously queued write command.	011	The master is to provide high priority write data for a previously queued write command. Reserved in AGP 3.0 signaling mode.	100	Reserved.	101	Reserved.	110	Reserved.	111	The master has been given permission to start a bus transaction. The master may queue AGP requests by asserting GPIPE# (4X signaling mode) or start a PCI transaction by asserting GFRAME#.
Encoding	Meaning																			
000	Previously requested low priority read data (Async read for AGP 3.0 signaling mode) is being returned to the master.																			
001	Previously requested high priority read data is being returned to the master. Reserved in AGP 3.0 signaling mode.																			
010	The master is to provide low priority write data (Async write for AGP 3.0 signaling mode) for a previously queued write command.																			
011	The master is to provide high priority write data for a previously queued write command. Reserved in AGP 3.0 signaling mode.																			
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110	Reserved.																			
111	The master has been given permission to start a bus transaction. The master may queue AGP requests by asserting GPIPE# (4X signaling mode) or start a PCI transaction by asserting GFRAME#.																			

## 2.5.4 AGP Strobes

Signal Name	Type	Description
GADSTB0 (2.0) GADSTBF0 (3.0)	I/O (s/t/s) AGP	<b>AD Bus Strobe-0:</b> GADSTB0 provides timing for 4X clocked data on GAD[15:0] and GC/BE[1:0]# in AGP 2.0 signaling mode. The agent that is providing data drives this signal. <b>AD Bus Strobe First-0:</b> In AGP 3.0 signaling mode GADSTBF0 strobes the first and all odd numbered data items with a low-to-high transition. It is used with GAD[15:0] and GC#/BE[1:0].
GADSTB0# (2.0) GADSTBS0 (3.0)	I/O (s/t/s) AGP	<b>AD Bus Strobe-0 Complement:</b> GADSTB0# is the differential complement to the GADSTB0 signal. It is used to provide timing for 4X clocked data in AGP 2.0 signaling mode. <b>AD Bus Strobe Second-0:</b> In AGP 3.0 signaling mode GADSTBS0 strobes the second and all even numbered data items with a low-to-high transition.
GADSTB1 (2.0) GADSTBF1 (3.0)	I/O (s/t/s) AGP	<b>AD Bus Strobe-1:</b> GADSTB1 provides timing for 4X clocked data on GAD[31:16] and GC/BE[3:2]# in AGP 2.0 signaling mode. The agent that is providing data drives this signal. <b>AD Bus Strobe First-1:</b> In AGP 3.0 signaling mode GADSTBF1 strobes the first and all odd numbered data items with a low-to-high transition. It is used with GAD[31:16], GC#/BE[3:2], DBI_HI, and DBI_LO.
GADSTB1# (2.0) GADSTBS1 (3.0)	I/O (s/t/s) AGP	<b>AD Bus Strobe-1 Complement:</b> GADSTB1# is the differential complement to the GADSTB1 signal. It is used to provide timing for 4X clocked data in AGP 2.0 signaling mode. <b>AD Bus Strobe Second-1:</b> In AGP 3.0 signaling mode GADSTBS1 strobes the second and all even numbered data items with a low-to-high transition.
GSBSTB (2.0) GSBSTBF (3.0)	I AGP	<b>Sideband Strobe:</b> GSBSTB provides timing for 4X clocked data on the GSBA[7:0] bus in AGP 2.0 signaling mode. It is driven by the AGP master after the system has been configured for 4X clocked sideband address delivery. <b>Sideband Strobe First:</b> In AGP 3.0 signaling mode GSBSTBF strobes the first and all odd numbered data items with a low-to-high transition.
GSBSTB# (2.0) GSBSTBS (3.0)	I AGP	<b>Sideband Strobe Complement:</b> GSBSTB# is the differential complement to the GSBSTB signal. It is used to provide timing for 4X clocked data in AGP 2.0 signaling mode. <b>Sideband Strobe Second:</b> In AGP 3.0 signaling mode GSBSTBS strobes the second and all even numbered data items with a low-to-high transition.

**NOTE:**

1. The term (2.0) following a signal name indicates its function in AGP 2.0 signaling mode (1.5 V swing).
2. The term (3.0) following a signal name indicates its function in AGP 3.0 signaling mode (0.8 V swing).

## 2.5.5 PCI Signals–AGP Semantics

PCI signals are redefined when used in AGP transactions carried using AGP protocol extension. For transactions on the AGP interface carried using PCI protocol, these signals completely preserve PCI 2.1 semantics. The exact roles of all PCI signals during AGP transactions are defined in the following table.

Signal Name	Type	Description
GFRAME# (2.0) GFRAME (3.0)	I/O s/t/s AGP	<b>GFRAME(#):</b> This signal is driven by the current master to indicate the beginning and duration of a standard PCI protocol ("frame based") transaction and during fast writes. It is not used, and must be inactive during AGP transactions.
GIRDY# (2.0) GIRDY (3.0)	I/O s/t/s AGP	<b>GIRDY (#):</b> This signal is used for both GFRAME(#) based and AGP transactions. During AGP transactions, it indicates the AGP compliant master is ready to provide all write data for the current transaction. Once GIRDY(#) is asserted for a write operation, the master is not allowed to insert wait states. The assertion of GIRDY(#) for reads indicates that the master is ready to transfer to a subsequent block (4 clocks) of read data. The master is <i>never</i> allowed to insert a wait state during the initial data transfer (first 4 clocks) of a read transaction. However, it may insert wait states after each 4 clock block is transferred.  <b>NOTE:</b> There is no GFRAME(#) -- GIRDY(#) relationship for AGP transactions.
GTRDY# (2.0) GTRDY (3.0)	I/O s/t/s AGP	<b>GTRDY(#):</b> This signal is used for both GFRAME(#) based and AGP transactions. During AGP transactions, it indicates the AGP compliant target is ready to provide read data for the entire transaction (when the transfer size is less than or equal to 4 clocks) or is ready to transfer the initial or subsequent block (4 clocks) of data when the transfer size is greater than 4 clocks. The target is allowed to insert wait states after each block (4 clocks) is transferred on both read and write transactions.
GSTOP# (2.0) GSTOP (3.0)	I/O s/t/s AGP	<b>GSTOP (#):</b> This signal is used during GFRAME(#) based transactions by the target to request that the master stop the current transaction. It is Not used during AGP transactions.
GDEVSEL# (2.0) GDEVSEL (3.0)	I/O s/t/s AGP	<b>Device Select:</b> During GFRAME (#) based accesses, GDEVSEL(#) is driven active by the target to indicate that it is responding to the access. It is Not used during AGP transactions.
GREQ# (2.0) GREQ (3.0)	I AGP	<b>Request:</b> This signal is an output from AGP device. Used to request access to the bus to initiate a PCI (GFRAME(#)) or AGP(GPIPE(#)) request. Not required to initiate an AGP request via SBA
GGNT# (2.0) GGNT (3.0)	O AGP	<b>Grant:</b> This signal is an output from the MCH either granting the bus to the AGP device to initiate a GFRAME(#) or GPIPE(#) access (in response to GREQ(#) active) or to indicate that data is to be transferred for a previously enqueued AGP transaction. GST[2:0] indicates the purpose of the grant.
GAD[31:0]	I/O AGP	<b>Address/Data:</b> These signals provide the address for GFRAME(#) and GPIPE(#) transactions, and the data for all transactions. They operate at a 1X data rate for GFRAME(#) based cycles, and operate at the specified channel rate (1X, 4X, or 8X) for AGP data phases and fast write data phases.
GC/BE[3:0]# (2.0) GC#/BE[3:0] (3.0)	I/O AGP	<b>Command/Byte Enables:</b> These signals provide the command during the address phase of a GFRAME(#) or GPIPE(#) transaction, and byte enables during data phases. Byte enables are not used for read data of AGP 1X and 2X and 4X and 8X reads. These signals operate at the same data rate as the GAD[31:0] signals at any given time.
GPAR (2.0) GPAR (3.0)	I/O AGP	<b>Parity:</b> GPAR is not used on AGP transactions but used during GFRAME(#) based transactions as defined by the PCI specification. GPAR is not used during fast writes. This signal contains an internal pull-up.

Signal Name	Type	Description
DBI_LO (3.0 only)	I/O AGP	<p><b>Dynamic Bus Inversion LO:</b> (AGP 3.0 only) This bit that goes along with GAD[15:0] to indicate whether GAD[15:0] must be inverted on the receiving end.</p> <ul style="list-style-type: none"> <li>DBI_LO= 0: GAD[15:0] are not inverted so receiver may use as is.</li> <li>DBI_LO= 1: GAD[15:0] are inverted so receiver must invert before use.</li> </ul> <p>The GADSTBF1 and GADSTBS1 strobes are used with the DBI_LO. Dynamic bus inversion is used in AGP 3.0 signaling mode only.</p>

**NOTES:**

- Note that PCIRST# from the ICH5 is connected to RSTIN# and is used to reset AGP interface logic within the MCH. The AGP agent will also typically use PCIRST# provided by the ICH5 as an input to reset its internal logic.
- LOCK# signal is not supported on the AGP interface (even for PCI operations).
- (2.0) following a signal name indicates its function in AGP 2.0 signaling mode (1.5 V swing)
- (3.0) following a signal name indicates its function in AGP 3.0 signaling mode (0.8 V swing)

### 2.5.5.1 PCI Pins during PCI Transactions on AGP Interface

PCI signals described in a previous table behave according to PCI 2.1 specifications when used to perform PCI transactions on the AGP interface.

## 2.6 Test Signals

Signal Name	Type	Description
TESTP[139:30]	Test Point	<b>Test Point:</b> This signal is used for XOR testing and should be routed to a VIA for testing or left as no connect.
TESTP[29:25]/ SMAB_A[5:1]	O SSTL_2	<b>Test Point:</b> TESTP[29:25] are used for XOR testing and are multiplexed with the system memory channel A signals SMAB_A[5:1]. See the <i>Intel® 848P Chipset Platform Design Guide</i> for details.
TESTP[24:17]	O SSTL_2	<b>Test Point:</b> These signals are NOT used for XOR testing and can be left as no connects.
TESTP[16:12]	O SSTL_2	<b>Test Point:</b> TESTP[16:12] are used for XOR testing and should be routed to a VIA for testing or left as no connects
TESTP[11:4]	O SSTL_2	<b>Test Point:</b> These signals are NOT used for XOR testing and can be left as no connects.
TESTP[3:0]	I/O 3.3 V GPIO	<b>Test Point:</b> This signal is used for XOR testing and should be routed to a VIA for testing or left as no connect.



## 2.7 Clocks, Reset, and Miscellaneous

Signal Name	Type	Description
HCLKP HCLKN	I CMOS	<b>Differential Host Clock In:</b> These pins receive a low voltage differential host clock from the external clock synthesizer. This clock is used by all of the MCH logic that is in the host clock domain 0.7 V.
GCLKIN	I LVTTTL (3.3 V)	<b>66 MHz Clock In:</b> This pin receives a 66 MHz clock from the clock synthesizer. This clock is used by AGP/PCI and HI clock domains. Note that this clock input is required to be 3.3 V tolerant.
RSTIN#	I LVTTTL (3.3 V)	<b>Reset In:</b> When asserted, this signal asynchronously resets the MCH logic. This signal is connected to the PCIRST# output of the ICH5. All AGP/PCI output and bi-directional signals will also tri-state compliant to PCI Revision 2.0 and 2.1 specifications. This input should have a Schmitt trigger to avoid spurious resets. Note that this input needs to be 3.3 V tolerant.
PWROK	I LVTTTL (3.3 V)	<b>Power OK:</b> When asserted, PWROK is an indication to the MCH that the core power and GCLKIN have been stable for at least 10 $\mu$ s.
EXTTS#	I LVTTTL (3.3 V)	<b>External Thermal Sensor Input:</b> This is an open-drain signal indicating an Over-Temp condition in the platform. This signal should remain asserted for as long as the Over-temp Condition exists. This input pin can be programmed to activate hardware management of memory reads and writes and/or trigger software interrupts.

## 2.8 RCOMP, VREF, VSWING

Signal Name	Type	Description
HDRVREF	I	<b>Host Data Reference Voltage:</b> This signal is a reference voltage input for the data signals of the Host AGTL+ interface.
HDRCOMP	I/O CMOS	<b>Host RCOMP:</b> This signal is used to calibrate the Host AGTL+ I/O buffers.
HDSWING	I	<b>Host Voltage Swing:</b> These signals provide a reference voltage used by the FSB RCOMP circuit.
SMVREF_A	I	<b>Memory Reference Voltage:</b> This signal is a reference voltage input for system memory interface. This signal is tied internally to SMVREF_B. Thus, only one of these signals needs to be the SMVREF and the other should be decoupled.
SMXRCOMPVOL	I	<b>Memory RCOMP:</b> This signal is used to Calibrate VOL.
SMXRCOMPVOH	I	<b>Memory RCOMP:</b> This signal is used to Calibrate VOH.
SMXRCOMP	I/O CMOS	<b>Memory RCOMP:</b> This signal is used to calibrate the memory I/O buffers.
SMVREF_B	I	<b>Memory Reference Voltage:</b> This signal is a reference voltage input for System Memory Interface. This signal is tied internally to SMVREF_A. Thus only one of these signals needs to be the SMVREF and the other should be decoupled.
SMYRCOMPVOL	I	<b>Memory RCOMP:</b> This signal is used to Calibrate VOL.
SMYRCOMPVOH	I	<b>Memory RCOMP:</b> This signal is used to Calibrate VOH.
SMYRCOMP	I/O CMOS	<b>Memory RCOMP:</b> This signal is used to calibrate the memory I/O buffers.
GVREF	I	<b>AGP Reference:</b> The reference voltage for the AGP I/O buffers is 0.75 V.
GVSWING	I	<b>AGP Voltage Swing:</b> This signal provides a reference voltage for GRCOMP in AGP mode.
GRCOMP	I/O CMOS	<b>Compensation for AGP:</b> This signal is used to calibrate the AGP buffers. This signal should be connected to ground through a 43 $\Omega$ pull-up resistor to VDDQ
HI_VREF	I	<b>HI Reference:</b> This signal is a reference voltage input for the hub interface.
HI_RCOMP	I/O CMOS	<b>Compensation for HI:</b> This signal is used to calibrate the HI I/O buffers.
HI_SWING	I	<b>HI Voltage Swing:</b> This signal provides a reference voltage used by the HI_RCOMP circuit.
CI_VREF	I	<b>CSA Reference:</b> This signal is a reference voltage input for the CSA interface.
CI_RCOMP	I/O CMOS	<b>Compensation for CSA:</b> This signal is used to calibrate the CSA I/O buffers.
CI_SWING	I	<b>CSA Voltage Swing:</b> This signal provides a reference voltage used by the CI_RCOMP circuit.

**NOTE:** Refer to the *Intel® 848P Chipset Platform Design Guide* for platform design information.

## 2.9 Power and Ground Signals

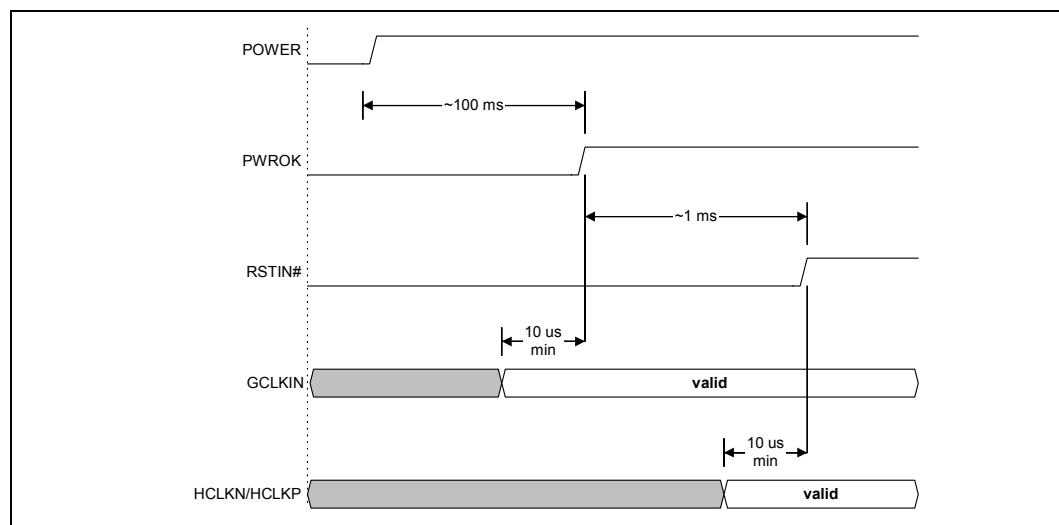
Signal Name	Description
VCC	<b>VCC Supply:</b> This is the 1.5 V core.
VSS	<b>Gnd Supply</b>
VCCA_AGP	<b>AGP PLL Power:</b> This is the 1.5 V analog AGP supply.
VCC_AGP	<b>VCC for AGP:</b> This value can be either 0.8 V or 1.5 V as the MCH supports both AGP electrical characteristics.
VCCA_FSB	<b>Analog VCC for the Host PLL:</b> This 1.5 V supply requires special filtering. Refer to the <i>Intel® 848P Chipset Platform Design Guide</i> for details.
VTT	<b>VTT Supply:</b> VTT is a FSB supply and has a range of 1.1 V–1.55 V.
VCCA_DPLL	<b>Analog VCC for Display PLL:</b> This 1.5 V supply requires special filtering. Refer to the <i>Intel® 848P Chipset Platform Design Guide</i> for details.
VCC_DAC	<b>DAC VCC Supply:</b> This is a 3.3 V VCC supply and is required for the MCH.
VCCA_DAC	<b>Analog DAC VCC:</b> This is a 1.5 V analog supply. Refer to the <i>Intel® 848P Chipset Platform Design Guide</i> for supply requirements.
VSSA_DAC	<b>Analog DAC VSS:</b> This supply should go directly to motherboard ground.
VCC_DDR	<b>VCC for System Memory:</b> VCC_DDR is 2.6 V for DDR.
VCCA_DDR	<b>Analog VCC for System Memory:</b> This signal is a 1.5 V supply for DDR. The supply requires special filtering. Refer to the <i>Intel® 848P Chipset Platform Design Guide</i> for details.

## 2.10 MCH Sequencing Requirements

Power Plane and Sequencing Requirements:

- Clock Valid Timing.
- GCLKIN must be valid at least 10  $\mu$ s prior to the rising edge of PWROK.
- HCLKN/HCLKP must be valid at least 10  $\mu$ s prior to the rising edge of RSTIN#.

Figure 3. Intel® 848P Chipset System Clock and Reset Requirements



The MCH uses the rising edge of PWROK to latch strap values. During S3, when power is not valid, the MCH requires that PWROK de-assert and then re-assert when power is valid so that it can properly re-latch the straps.

## 2.11 Signals Used As Straps

### 2.11.1 Functional Straps

Signal Name	Strap Name	Description
HA7#	FSB IOQ Depth	<p>The value on HA7# is sampled by all processor bus agents, including the MCH, on the de-asserting edge of CPURST#.</p> <p><b>NOTE:</b> For HA7#, the minimum setup time is 4 HCLKs. The minimum hold time is 2 clocks and the maximum hold time is 20 HCLKs.</p> <p>The latched value determines the maximum IOQ depth supported on the processor bus.</p> <ul style="list-style-type: none"> <li>0 (low voltage) = BUS IOQ depth on the bus is 1</li> <li>1 (high voltage) = BUS IOQ depth on the bus is the maximum of 12</li> </ul>
GPAR	AGP	<p>This strap selects the operating mode of the AGP signals (controls only AGP I/O multiplexers):</p> <ul style="list-style-type: none"> <li>0 (low voltage) = N/A</li> <li>1 (high voltage) = AGP</li> </ul> <p>The strap is flow-through while RSTIN# is asserted and latched on the de-asserting edge of RSTIN#. RSTIN# is used to make sure that the AGP card is not driving the GPAR signal when it is latched.</p>

**NOTE:**

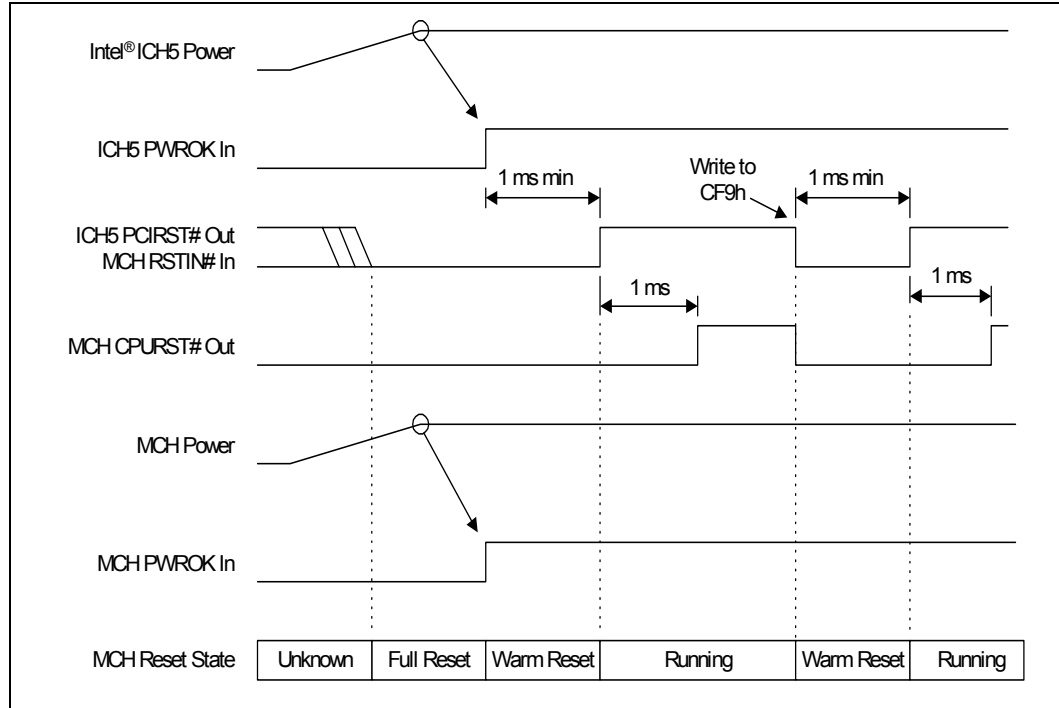
- All straps, have internal 8 k $\Omega$  pull-ups (HA7# has GTL pull-up) enabled during their sampling window. Therefore, a strap that is not connected or not driven by external logic will be sampled high.

### 2.11.2 Strap Input Signals

Signal Name	Type	Description
BSEL[1:0]	CMOS	<p><b>Core / FSB Frequency (FSBFREQ) Select Strap.</b> This strap is latched at the rising edge of PWROK. These pins have no default internal pull-up resistor</p> <p>00 = Core frequency is 100 MHz, FSB frequency is 400 MHz</p> <p>01 = Core frequency is 133 MHz, FSB frequency is 533 MHz</p> <p>10 = Core frequency is 200 MHz, FSB frequency is 800 MHz</p> <p>11 = Reserved</p>

### 2.11.3 Full and Warm Reset States

Figure 4. Full and Warm Reset Waveforms



All register bits assume their default values during full reset. PCIRST# resets all internal flops and state machines (except for a few configuration register bits). A full reset occurs when PCIRST# (MCH RSTIN#) is asserted and PWROK is deasserted. A warm reset occurs when PCIRST# (MCH RSTIN#) is asserted and PWROK is also asserted. The following table describes the reset states.

Reset State	RSTIN#	PWROK
Full Reset	L	L
Warm Reset	L	H
Does Not Occur	H	L
Normal Operation	H	H

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# Register Description

# 3

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

- Control registers I/O mapped into the processor I/O space that controls access to PCI and AGP configuration space.
- Internal configuration registers residing within the MCH are partitioned into three logical device register sets (“logical” since they reside within a single physical device). The first register set is dedicated to host-hub interface functionality (controls PCI bus 0, i.e., DRAM configuration, other chipset operating parameters, and optional features). The second register set is dedicated to host-AGP/PCI\_B bridge functions (controls AGP/PCI\_B interface configurations and operating parameters). The third register set is dedicated to host-CSA control.

This configuration scheme is necessary to accommodate the existing and future software configuration model supported by Microsoft where the host bridge functionality will be supported and controlled via dedicated and specific driver and virtual PCI-to-PCI bridge functionality will be supported via standard PCI bus enumeration configuration software. The term “virtual” is used to designate that no real physical embodiment of the PCI-to-PCI bridge functionality exists within the MCH, but that MCH’s internal configuration register sets are organized in this particular manner to create that impression to the standard configuration software.

The MCH supports PCI configuration space accesses using the mechanism denoted as Configuration Mechanism 1 in the PCI specification. The MCH internal registers (both I/O Mapped and configuration registers) are accessible by the host processor. The registers can be accessed as Byte, Word (16-bit), or DWord (32-bit) quantities, with the exception of CONFIG\_ADDRESS 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	<b>Read Only.</b> If a register is read only, writes to this register have no effect.
R/W	<b>Read/Write.</b> A register with this attribute can be read and written.
R/W/L	<b>Read/Write/Lock.</b> A register with this attribute can be read, written, and Locked.
R/WC	<b>Read/Write Clear.</b> A register bit with this attribute can be read and written. However, a write of a 1 clears (sets to 0) the corresponding bit and a write of a 0 has no effect.
R/WO	<b>Read/Write Once.</b> A register bit with this attribute can be written to only once after power up. After the first write, the bit becomes read only.
L	<b>Lock.</b> A register bit with this attribute becomes Read Only after a lock bit is set.
Reserved Bits	Some of the MCH registers described in this section contain reserved bits. These bits are labeled “Reserved”. 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 that software does not need to perform a read-merge-write operation for the Configuration Address (CONFIG_ADDRESS) register.

Term	Description
Reserved Registers	<p>In addition to reserved bits within a register, the MCH contains address locations in the configuration space of the Host-HI Bridge entity that are marked either “Reserved” or “Intel Reserved”. The MCH responds to accesses to Reserved address locations by completing the host cycle. When a Reserved register location is read, a zero value is returned. (Reserved registers can be 8, 16, or 32 bits in size). Writes to Reserved registers have no effect on the MCH.</p> <p><b>Caution:</b> Registers that are marked as “Intel Reserved” must <b>not</b> be modified by system software. Writes to “Intel Reserved” registers may cause system failure. Reads to “Intel Reserved” registers may return a non-zero value.</p>
Default Value upon a Reset	<p>Upon a reset, the MCH sets all of its internal configuration registers to predetermined default states. Some register values at reset are determined by external strapping options. The default state 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.</p>

## 3.2 Overview of the Platform Configuration Structure

In some previous chipsets, the “MCH” and the “I/O Controller Hub (ICHx)” were physically connected by PCI bus 0. From a configuration standpoint, both components appeared to be on PCI bus 0 which was also the system’s primary PCI expansion bus. The MCH contained two PCI devices while the ICHx was considered one PCI device with multiple functions.

In the 848P chipset platform the configuration structure is significantly different. The MCH and the ICH5 are physically connected by the hub interface, so, from a configuration standpoint, the hub interface is logically PCI bus 0. As a result, all devices internal to the MCH and ICHx appear to be on PCI bus 0. The system’s primary PCI expansion bus is physically attached to the ICH5 and, from a configuration perspective, appears to be a hierarchical PCI bus behind a PCI-to-PCI bridge; therefore, it has a programmable PCI Bus number. Note that the primary PCI bus is referred to as PCI\_A in this document and is **not** PCI bus 0 from a configuration standpoint. The AGP appears to system software to be a real PCI bus behind PCI-to-PCI bridges resident as devices on PCI bus 0.

The MCH contains four PCI devices within a single physical component. The configuration registers for the four devices are mapped as devices residing on PCI bus 0.

- **Device 0:** Host-HI Bridge/DRAM Controller. Logically this appears as a PCI device residing on PCI bus 0. Physically Device 0 contains the standard PCI registers, DRAM registers, the Graphics Aperture controller, configuration for HI, and other MCH specific registers.
- **Device 1:** Host-AGP Bridge. Logically this appears as a “virtual” PCI-to-PCI bridge residing on PCI bus 0. Physically Device 1 contains the standard PCI-to-PCI bridge registers and the standard AGP/PCI configuration registers (including the AGP I/O and memory address mapping).
- **Device 3:** CSA Port. Appears as a virtual PCI-CSA (PCI-to-PCI) bridge device.
- **Device 6:** Function 0: Overflow Device. The purpose of this device is to provide additional configuration register space for Device 0.



Table 3 shows the Device # assignment for the various internal MCH devices.

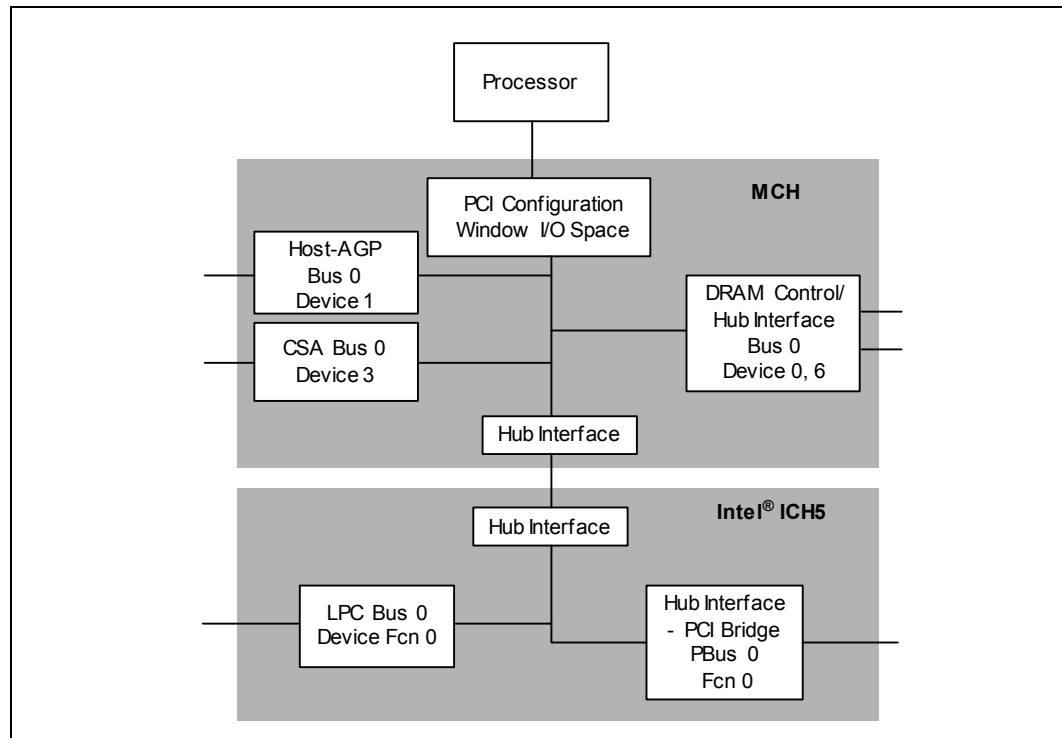
**Table 3. Internal MCH Device Assignment**

MCH Function	Bus 0, Device #
DRAM Controller/8-bit HI Controller	Device 0
Host-to-AGP Bridge (virtual PCI-to-PCI)	Device 1
Intergrated GBE (CSA)	Device 3
Overflow	Device 6

Logically, the ICH5 appears as multiple PCI devices within a single physical component also residing on PCI bus 0. One of the ICH5 devices is a PCI-to-PCI bridge. Logically, the primary side of the bridge resides on PCI 0 while the secondary side is the standard PCI expansion bus.

**Note:** A physical PCI bus 0 does not exist and the hub interface and the internal devices in the MCH and ICH5 logically constitute PCI Bus 0 to configuration software.

**Figure 5. Conceptual Intel® 848P Chipset Platform PCI Configuration Diagram**



## 3.3 Routing Configuration Accesses

The MCH supports two bus interfaces: hub interface and AGP/PCI. 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 ICH5 internal devices and Primary PCI (including downstream devices) are routed to the ICH5 via HI. AGP/PCI\_B configuration cycles are routed to AGP. The AGP/PCI\_B interface is treated as a separate PCI bus from the configuration point of view. Routing of configuration AGP/PCI\_B is controlled via the standard PCI-to-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-to-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.

### 3.3.1 Standard PCI Bus Configuration Mechanism

The PCI Bus defines a slot based “configuration space” that allows each device to contain up to eight functions with each function containing 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 2.3 specification defines the configuration mechanism to access configuration space. The configuration access mechanism makes use of the CONFIG\_ADDRESS register (at I/O address 0CF8h through 0CFBh) and CONFIG\_DATA register (at I/O address 0CFCh through 0CFFh). To reference a configuration register a DWord I/O write cycle is used to place a value into CONFIG\_ADDRESS 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. CONFIG\_ADDRESS[31] must be 1 to enable a configuration cycle. CONFIG\_DATA then becomes a window into the four bytes of configuration space specified by the contents of CONFIG\_ADDRESS. Any read or write to CONFIG\_DATA will result in the MCH translating the CONFIG\_ADDRESS into the appropriate configuration cycle.

The MCH is responsible for translating and routing the processor’s I/O accesses to the CONFIG\_ADDRESS and CONFIG\_DATA registers to internal MCH configuration registers, HI or AGP/PCI\_B.

### 3.3.2 PCI Bus 0 Configuration Mechanism

The MCH decodes the Bus Number (bits 23:16) and the Device Number fields of the CONFIG\_ADDRESS register. If the Bus Number field of CONFIG\_ADDRESS is 0 the configuration cycle is targeting a PCI Bus 0 device. The Host-HI Bridge entity within the MCH is hardwired as Device 0 on PCI Bus 0. The Host-AGP/PCI\_B Bridge entity within the MCH is hardwired as Device 1 on PCI Bus 0. Device 6 contains test configuration registers.

### 3.3.3 Primary PCI and Downstream Configuration Mechanism

If the Bus Number in the CONFIG\_ADDRESS is non-zero, and is less than the value in the Host-AGP/PCI\_B device’s Secondary Bus Number register or greater than the value in the Host-AGP/PCI\_B device’s Subordinate Bus Number register, the MCH will generate a Type 1 HI Configuration Cycle. A[1:0] of the HI request packet for the Type 1 configuration cycle will be 01.

Bits 31:2 of the CONFIG\_ADDRESS register will be translated to the A[31:2] field of the HI request packet of the configuration cycle as shown in Figure 7. This HI configuration cycle will be sent over HI.

If the cycle is forwarded to the ICH5 via HI, the ICH5 compares the non-zero Bus Number with the Secondary Bus Number and Subordinate Bus Number registers of its PCI-to-PCI bridges to determine if the configuration cycle is meant for Primary PCI, one of the ICH5's HIs, or a downstream PCI bus.

### 3.3.4 AGP/PCI\_B Bus Configuration Mechanism

From the chipset configuration perspective, AGP/PCI\_B is seen as PCI bus interfaces residing on a Secondary Bus side of the virtual PCI-to-PCI bridges referred to as the MCH Host-PCI\_B/AGP bridge. On the primary bus side, the virtual PCI-to-PCI bridge is attached to PCI Bus 0. Therefore, the Primary Bus Number register is hardwired to 0. The virtual PCI-to-PCI bridge entity converts Type 1 PCI Bus Configuration cycles on PCI Bus 0 into Type 0 or Type 1 configuration cycles on the AGP/PCI\_B interface. Type 1 configuration cycles on PCI Bus 0 that have a Bus Number that matches the Secondary Bus Number of the MCH's "virtual" Host-to-PCI\_B/AGP bridge will be translated into Type 0 configuration cycles on the PCI\_B/AGP interface. The MCH will decode the Device Number field [15:11] and assert the appropriate GAD signal as an IDSEL in accordance with the PCI-to-PCI bridge Type 0 configuration mechanism. The remaining address bits will be mapped as described in Figure 6.

Figure 6. Configuration Mechanism Type 0 Configuration Address to PCI Address Mapping

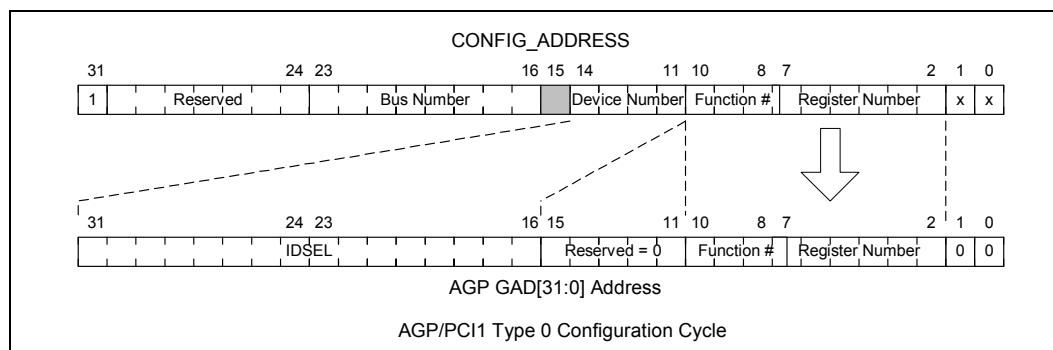
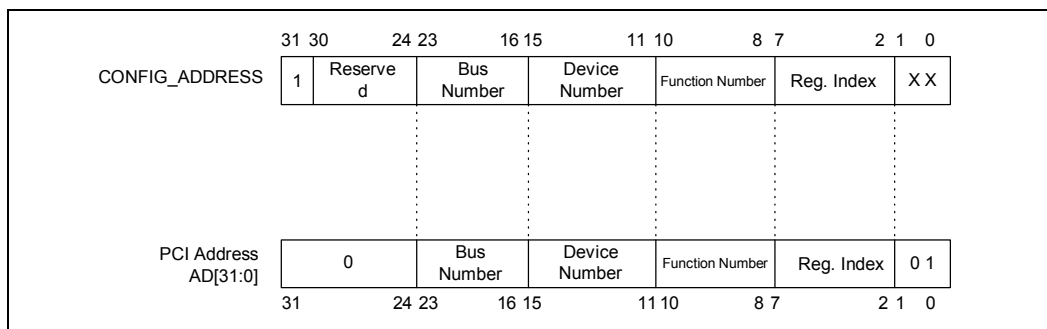


Table 4. Configuration Address Decoding

Config Address AD[15:11]	AGP GAD[31:16] IDSEL	Config Address AD[15:11]	AGP GAD[31:16] IDSEL
00000	0000 0000 0000 0001	01000	0000 0001 0000 0000
00001	0000 0000 0000 0010	01001	0000 0010 0000 0000
00010	0000 0000 0000 0100	01010	0000 0100 0000 0000
00011	0000 0000 0000 1000	01011	0000 1000 0000 0000
00100	0000 0000 0001 0000	01100	0001 0000 0000 0000
00101	0000 0000 0010 0000	01101	0010 0000 0000 0000
00110	0000 0000 0100 0000	01110	0100 0000 0000 0000
00111	0000 0000 1000 0000	01111	1000 0000 0000 0000
		1xxxx	0000 0000 0000 0000

If 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 Subordinate Bus Number register, the configuration cycle is targeting a PCI bus downstream of the targeted interface. The MCH will generate a Type 1 PCI configuration cycle on PCI\_B/AGP. The address bits will be mapped as described in Figure 7.

**Figure 7. Configuration Mechanism Type 1 Configuration Address to PCI Address Mapping**



To prepare for mapping of the configuration cycles on AGP/PCI\_B, the initialization software will go through the following sequence:

1. Scan all devices residing on the PCI Bus 0 using Type 0 configuration accesses.
2. For every device residing at bus 0 that implements PCI-PCI bridge functionality, it will configure the secondary bus of the bridge with the appropriate number and scan further down the hierarchy. This process will include the configuration of the virtual PCI-to-PCI bridges within the MCH used to map the AGP device's address spaces in a software specific manner.

**Note:** Although initial AGP platform implementations will not support hierarchical buses residing below AGP, this specification still must define this capability to support PCI-66 compatibility. Note also that future implementations of the AGP devices may support hierarchical PCI or AGP-like buses coming out of the root AGP device.

## 3.4 I/O Mapped Registers

The MCH contains two registers that reside in the processor I/O address space: the Configuration Address (CONFIG\_ADDRESS) register and the Configuration Data (CONFIG\_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.

### 3.4.1 CONFIG\_ADDRESS—Configuration Address Register

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

CONFIG\_ADDRESS 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 onto the PCI\_A bus as an I/O cycle. The CONFIG\_ADDRESS register contains the Bus Number, Device Number, Function Number, and Register Number for which a subsequent configuration access is intended.

Bit	Descriptions
31	<b>Configuration Enable (CFGE).</b> 1 = Enable 0 = Disable
30:24	Reserved.
23:16	<b>Bus Number.</b> When the Bus Number is programmed to 00h the target of the configuration cycle is a HI agent (MCH, ICH5, etc.). The configuration cycle is forwarded to HI if the Bus Number is programmed to 00h and the MCH is not the target (i.e., the device number is not equal to 0, 1, 2, 3, 6 or 7). If the Bus Number is non-zero and matches the value programmed into the Secondary Bus Number register of Device 1, a Type 0 PCI configuration cycle will be generated on AGP/PCI_B. If the Bus Number is non-zero, greater than the value in the Secondary Bus Number register of Device 1 and less than or equal to the value programmed into the Subordinate Bus Number register of Device 1 a Type 1 PCI configuration cycle will be generated on AGP/PCI_B. If the Bus Number is non-zero, and does not fall within the ranges enumerated by Device 1’s Secondary Bus Number or Subordinate Bus Number register, then a HI Type 1 configuration cycle is generated.
15:11	<b>Device Number.</b> This field selects one agent on the PCI bus selected by the Bus Number. When the Bus Number field is 00 the MCH decodes the Device Number field. The MCH is always Device Number 0 for the Host-HI bridge entity, Device Number 1 for the Host-PCI_B/AGP entity. Therefore, when the Bus Number =0 and the Device Number equals 0,1, 2, 3, 6 the internal MCH devices are selected. If the Bus Number is non-zero and matches the value programmed into the Device1 Secondary Bus Number register a Type 0 PCI configuration cycle will be generated on AGP/PCI_B. The Device Number field is decoded and the MCH asserts one and only one GADxx signal as an IDSEL. GAD16 is asserted to access Device 0, GAD17 for Device 1 and so forth up to Device 15 for which will assert AD31. All device numbers higher than 15 cause a type 0 configuration access with no IDSEL asserted, which will result in a Master Abort reported in the MCH’s virtual PCI-to-PCI bridge registers. For Bus Numbers resulting in HI configuration cycles, the MCH propagates the Device Number field as A[15:11]. For Bus Numbers resulting in AGP/PCI_B Type 1 configuration cycles, the Device Number is propagated as GAD[15:11].
10:8	<b>Function Number.</b> This field is mapped to GAD[10:8] during AGP/PCI_B configuration cycles and A[10:8] during HI configuration cycles. This allows the configuration registers of a particular function in a multi-function device to be accessed. The MCH ignores configuration cycles to its internal devices if the function number is not equal to 0.
7:2	<b>Register Number.</b> 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 GAD[7:2] during AGP/PCI_B configuration cycles and A[7:2] during HI configuration cycles.
1:0	Reserved.

### 3.4.2 CONFIG\_DATA—Configuration Data Register

I/O Address: 0CFCh  
 Default Value: 00000000h  
 Access: R/W  
 Size: 32 bits

CONFIG\_DATA is a 32-bit R/W window into configuration space. The portion of configuration space referenced by CONFIG\_DATA is determined by the contents of CONFIG\_ADDRESS.

Bit	Descriptions
31:0	<b>Configuration Data Window (CDW).</b> If bit 31 of CONFIG_ADDRESS is 1 any I/O access that to the CONFIG_DATA register will be mapped to configuration space using the contents of CONFIG_ADDRESS.

### 3.5 DRAM Controller/Host-Hub Interface Device Registers (Device 0)

**Table 5. DRAM Controller/Host-Hub Interface Device Register Address Map (Device 0) (Sheet 1 of 2)**

Address Offset	Register Symbol	Register Name	Default Value	Access
00–01h	VID	Vendor Identification	8086h	RO
02–03h	DID	Device Identification	2570h	RO
04–05h	PCICMD	PCI Command	0006h	RO, R/W
06–07h	PCISTS	PCI Status	0090h	RO, R/WC
08h	RID	Revision Identification	see register description	RO
09h	—	Intel Reserved	—	—
0Ah	SUBC	Sub-Class Code	00h	RO
0Bh	BCC	Base Class Code	06h	RO
0C	—	Intel Reserved	—	—
0Dh	MLT	Master Latency Timer	00h	RO
0Eh	HDR	Header Type	00h	RO
0Fh	—	Intel Reserved	—	—
10–13h	APBASE	Aperture Base Configuration	00000008h	RO, R/W
14–2Bh	—	Intel Reserved	—	—
2C–2Dh	SVID	Subsystem Vendor Identification	0000h	R/WO
2E–2Fh	SID	Subsystem Identification	0000h	R/WO
30–33h	—	Intel Reserved	—	—
34h	CAPPTR	Capabilities Pointer	E4h	RO
35–50h	—	Intel Reserved	—	RO
51h	AGPM	AGP Miscellaneous Config	00h	R/W
52h	—	Intel Reserved	—	—
53h	CSABCONT	CSA Basic Control R	00h	RO, R/W
54–5Fh	—	Intel Reserved	—	—
60h	FPLLCONT	FPLL Clock Control	00h	R/W, RO
61–89h	—	Intel Reserved	—	—
90h	PAM0	Programmable Attribute Map 0	00h	RO, R/W
91h	PAM1	Programmable Attribute Map 1	00h	RO, R/W
92h	PAM2	Programmable Attribute Map 2	00h	RO, R/W
93h	PAM3	Programmable Attribute Map 3	00h	RO, R/W
94h	PAM4	Programmable Attribute Map 4	00h	RO, R/W
95h	PAM5	Programmable Attribute Map 5	00h	RO, R/W
96h	PAM6	Programmable Attribute Map 6	00h	RO, R/W
97h	FDHC	Fixed DRAM Hole Control	00h	RO, R/W
98–9Ch	—	Intel Reserved	—	—

**Table 5. DRAM Controller/Host-Hub Interface Device Register Address Map (Device 0) (Sheet 2 of 2)**

Address Offset	Register Symbol	Register Name	Default Value	Access
9Dh	SMRAM	System Management RAM Control	02h	RO, R/W, L
9Eh	ESMRAMC	Extended System Management RAM Control	38h	RO, R/W, RWC, L
9Fh	—	Intel Reserved	—	—
A0–A3h	ACAPID	AGP Capability Identifier	00300002h	RO
A4–A7h	AGPSTAT	AGP Status	See register description	RO
A8–ABh	AGPCMD	AGP Command	See register description	RO, R/W
AC–AFh	—	Intel Reserved	—	—
B0–B3h	AGPCTRL	AGP Control	0000 0000h	RO, R/W
B4h	APSIZE	Aperture Size	00h	RO, R/W
B5–B7h	—	Intel Reserved	—	—
B8–BBh	ATTBASE	Aperture Translation Table	00000000h	R/W
BCh	AMTT	AGP MTT Control Register	10h	RO, R/W
BDh	LPTT	AGP Low Priority Transaction Timer	10h	R/W
BE–C3h	—	Intel Reserved	—	—
C4–C5h	TOUD	Top of Used DRAM	0400h	RO, R/W
C6–C7h	MCHCFG	MCH Configuration	0000h	R/WO, RO, R/W
C8–C9h	ERRSTS	Error Status Register	0000h	R/WC
CA–CEh	ERRCMD	Error Command	0000h	RO, R/W
CF–DDh	—	Intel Reserved	—	—
DE–DFh	SKPD	Scratchpad Data	0000h	R/W
E0–E3h	—	Intel Reserved	—	—
E4–E8h	CAPREG	Capability Identification	FF_F104_A009h	RO
E9–FFh	—	Intel Reserved	—	—



### 3.5.1 VID—Vendor Identification Register (Device 0)

Address Offset: 00–01h  
 Default Value: 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 identifies any PCI device.

Bit	Descriptions
15:0	<b>Vendor Identification (VID)—RO.</b> This register field contains the PCI standard identification for Intel, 8086h.

### 3.5.2 DID—Device Identification Register (Device 0)

Address Offset: 02–03h  
 Default Value: 2570h  
 Access: RO  
 Size: 16 bits

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

Bit	Descriptions
15:0	<b>Device Identification Number (DID)—RO.</b> This is a 16-bit value assigned to the MCH Host-HI Bridge Function 0.

### 3.5.3 PCICMD—PCI Command Register (Device 0)

Address Offset: 04–05h  
 Default Value: 0006h  
 Access: RO, R/W  
 Size: 16 bits

Since MCH Device 0 does not physically reside on PCI\_A, many of the bits are not implemented.

Bit	Descriptions
15:10	Reserved
9	<b>Fast Back-to-Back Enable (FB2B)—RO.</b> Hardwired to 0. This bit controls whether or not the master can do fast back-to-back write. Since Device 0 is strictly a target this bit is not implemented.
8	<b>SERR Enable (SERRE)—R/W.</b> This bit is a global enable bit for Device 0 SERR messaging. The MCH does not have a SERR signal. The MCH communicates the SERR condition by sending a SERR message over HI to the ICH5. 0 = Disable. SERR message is not generated by the MCH for Device 0. Note that this bit only controls SERR messaging for Device 0. Device 1 has its own SERRE bits to control error reporting for error conditions occurring on their respective devices. The control bits are used in a logical OR manner to enable the SERR HI message mechanism. 1 = Enable. MCH is enabled to generate SERR messages over HI for specific Device 0 error conditions that are individually enabled in the ERRCMD register. The error status is reported in the ERRSTS and PCISTS registers.
7	<b>Address/Data Stepping Enable (ADSTEP)—RO.</b> Hardwired to 0.
6	<b>Parity Error Enable (PERRE)—RO.</b> Hardwired to 0. PERR# is not implemented by MCH.
5	<b>VGA Palette Snoop Enable (VGASNOOP)—RO.</b> Hardwired to 0.
4	<b>Memory Write and Invalidate Enable (MWIE)—RO.</b> Hardwired to 0. The MCH will never issue memory write and invalidate commands.
3	<b>Special Cycle Enable (SCE)—RO.</b> Hardwired to 0.
2	<b>Bus Master Enable (BME)—RO.</b> Hardwired to 1. MCH is always enabled as a master on HI.
1	<b>Memory Access Enable (MAE)—RO.</b> Hardwired to 1. The MCH always allows access to main memory.
0	<b>I/O Access Enable (IOAE)—RO.</b> Hardwired to 0.

### 3.5.4 PCISTS—PCI Status Register (Device 0)

Address Offset: 06–07h  
 Default Value: 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. Since MCH Device 0 does not physically reside on PCI\_A, many of the bits are not implemented.

Bit	Descriptions
15	<b>Detected Parity Error (DPE)—RO.</b> Hardwired to 0.
14	<b>Signaled System Error (SSE)—R/WC.</b> 0 = Software sets this bit to 0 by writing a 1 to it. 1 = MCH Device 0 generated a SERR message over HI 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 ERRSTS registers.
13	<b>Received Master Abort Status (RMAS)—R/WC.</b> 0 = Software sets this bit to 0 by writing a 1 to this bit. 1 = MCH generated a HI request that receives a Master Abort completion packet or Master Abort Special Cycle.
12	<b>Received Target Abort Status (RTAS)—R/WC.</b> 0 = Software sets this bit to 0 by writing a 1 to this bit. 1 = MCH generated a HI request that receives a Target Abort completion packet or Target Abort Special Cycle.
11	<b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0. The MCH will not generate a Target Abort HI completion packet or Special Cycle.
10:9	<b>DEVSEL Timing (DEVT)—RO.</b> 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	<b>Master Data Parity Error Detected (DPD)—RO.</b> Hardwired to 0. PERR signaling and messaging are not implemented by the MCH.
7	<b>Fast Back-to-Back (FB2B)—RO.</b> 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.
6:5	Reserved
4	<b>Capability List (CLIST)—RO.</b> Hardwired to 1 to indicate to the configuration software that this device/function implements a list of new capabilities. A list of new capabilities is accessed via register CAPPTR at configuration address offset 34h. Register CAPPTR contains an offset pointing to the start address within configuration space of this device where the AGP Capability standard register resides.
3:0	Reserved

### 3.5.5 RID—Revision Identification Register (Device 0)

Address Offset: 08h  
 Default Value: See following table  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Revision Identification Number (RID)—RO.</b> This is an 8-bit value that indicates the revision identification number for the MCH Device 0. 02h = A-2 Stepping

### 3.5.6 SUBC—Sub-Class Code Register (Device 0)

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

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

Bit	Descriptions
7:0	<b>Sub-Class Code (SUBC)—RO.</b> This is an 8-bit value that indicates the category of bridge for the MCH Device 0. 00h = Host Bridge.

### 3.5.7 BCC—Base Class Code Register (Device 0)

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

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

Bit	Descriptions
7:0	<b>Base Class Code (BASEC)—RO.</b> This is an 8-bit value that indicates the Base Class Code for the MCH Device 0. 06h = Bridge device.

### 3.5.8 MLT—Master Latency Timer Register (Device 0)

Address Offset: 0Dh  
 Default Value: 00h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	Reserved

### 3.5.9 HDR—Header Type Register (Device 0)

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

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

Bit	Descriptions
7:0	<b>PCI Header (HDR)—RO.</b> Hardwired to 00h indicating that the MCH is a single function device with standard header layout.

### 3.5.10 APBASE—Aperture Base Configuration Register (Device 0)

Address Offset: 10–13h  
 Default Value: 00000008h  
 Access: RO, R/W  
 Size: 32 bits

The APBASE is a standard PCI Base Address register that is used to set the base of the graphics aperture. The standard PCI configuration mechanism defines the base address configuration register such that only a fixed amount of space can be requested (dependent on which bits are hardwired to 0 or behave as hardwired to 0). To allow for flexibility (of the aperture), an additional register called APSIZE is used as a “back-end” register to control which bits of the APBASE will behave as hardwired to 0. This register will be programmed by the MCH specific BIOS code that will run before any of the generic configuration software is run.

**Note:** Bit 1 of the AGPM register (offset 51) is used to prevent accesses to the aperture range before this register is initialized by the configuration software and the appropriate translation table structure has been established in the system memory.

Bit	Descriptions
31:28	<b>Upper Programmable Base Address (UPBITS)—R/W.</b> These bits are part of the aperture base set by configuration software to locate the base address of the graphics aperture. They correspond to bits [31:28] of the base address in the processor's address space that will cause a graphics aperture translation to be inserted into the path of any memory read or write.
27:22	<b>Middle Hardwired/Programmable Base Address (MIDBITS)—R/W.</b> These bits are part of the aperture base set by configuration software to locate the base address of the graphics aperture. They correspond to bits [27:4] of the base address in the processor's address space that will cause a graphics aperture translation to be inserted into the path of any memory read or write. These bits can behave as though they were hardwired to 0 if programmed to do so by the APSIZE bits of the APSIZE register. This will cause configuration software to understand that the granularity of the graphics aperture base address is either finer or more coarse, depending upon the bits set by MCH-specific configuration software in APSIZE.
21:4	<b>Lower Bits (LOWBITS)—RO.</b> Hardwired to 0's. This forces the minimum aperture size selectable by this register to be 4 MB, without regard to the aperture size definition enforced by the APSIZE register.
3	<b>Prefetchable (PF)—RO.</b> Hardwired to 1 identifying the graphics aperture range as a prefetchable as per the PCI specification for base address registers. This implies that there are no side effects on reads, the device returns all bytes on reads regardless of the byte enables, and the MCH may merge processor writes into this range without causing errors.
2:1	<b>Addressing Type (TYPE)—RO.</b> Hardwired to 00 indicating that address range defined by the upper bits of this register can be located anywhere in the 32-bit address space as per the PCI specification for base address registers.
0	<b>Memory Space Indicator (MSPACE)—RO.</b> Hardwired to 0 identifying the aperture range as a memory range as per the specification for PCI base address registers.

### 3.5.11 SVID—Subsystem Vendor Identification Register (Device 0)

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

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

Bit	Descriptions
15:0	<b>Subsystem Vendor ID (SUBVID)—R/WO.</b> 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.

### 3.5.12 SID—Subsystem Identification Register (Device 0)

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

This value is used to identify a particular subsystem.

Bit	Descriptions
15:0	<b>Subsystem ID (SUBID)—R/WO.</b> This field should be programmed during BIOS initialization. After it has been written once, it becomes read only.

### 3.5.13 CAPPTR—Capabilities Pointer Register (Device 0)

Address Offset: 34h  
 Default Value: E4h  
 Access: RO  
 Size: 8 bits

The CAPPTR provides the offset that is the pointer to the location of the first device capability in the capability list.

Bit	Descriptions
7:0	<b>Capabilities Pointer Address—RO.</b> This field contains the pointer to the offset of the first capability ID register block. In this case the first capability is the Product-Specific Capability, which is located at offset E4h.

### 3.5.14 AGPM—AGP Miscellaneous Configuration Register (Device 0)

Address Offset: 51h  
 Default Value: 00h  
 Access: R/W  
 Size: 8 bits

Bit	Descriptions
7:2	Reserved
1	<p><b>Aperture Access Global Enable (APEN)—R/W.</b> This bit is used to prevent access to the graphics aperture from any port (processor, HI, or AGP/PCI_B) before the aperture range is established by the configuration software and the appropriate translation table in the system memory has been initialized.</p> <p>0 = Disable. The default value is 0, so this field must be set after the system is fully configured to enable aperture accesses.</p> <p>1 = Enable.</p>
0	Reserved

### 3.5.15 CSABCONT—CSA Basic Control Register (Device 0)

Address Offset: 53h  
 Default: 00h  
 Access: R/W, RO  
 Size: 8 bits

Bit	Description
7:1	Reserved
0	<p><b>Device Not Present bit—R/W</b></p> <p>0 = Device Not Enabled</p> <p>1 = Device Enabled</p>



### 3.5.16 FPLLCONT—Front Side Bus PLL Clock Control Register (Device 0)

Address Offset: 60h  
 Default Value: 00h  
 Access: R/W, RO  
 Size: 8 bits

These register bits are used for changing DDR frequency initializing MCH memory and I/O clocks' WIO DLL delays.

Bit	Descriptions
7:5	Reserved
4	<p><b>Memory and Memory IO DLL Clock Gate (DLLCKGATE)—R/W.</b></p> <p>0 = Writing a 0 to this register bit will cleanly re-enable the memory and memory I/O clocks from the DLL outputs (Default)</p> <p>1 = Writing a 1 to this register bit will cleanly disable the memory and memory IO clocks of the chipset core and DDR interface from the DLL outputs</p> <p><b>NOTE:</b> This bit should always be written before writing to the FPLLSYNC bit</p>
3:0	Reserved

### 3.5.17 PAM[0:6]—Programmable Attribute Map Registers

Address Offset:	90–96h (PAM0–PAM6)
Default Value:	00h
Attribute:	R/W, RO
Size:	8 bits

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 are used to support these features. 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 apply to host-initiator only access to the PAM areas. The MCH will forward to system memory for any AGP, PCI, or HI initiated accesses to the PAM areas. These attributes are:

**RE Read Enable.** When RE = 1, the host read accesses to the corresponding memory segment are claimed by the MCH and directed to main memory. Conversely, when RE = 0, the host read accesses are directed to PCI\_A.

**WE Write Enable.** When WE = 1, the host write accesses to the corresponding memory segment are claimed by the MCH and directed to main memory. Conversely, when WE = 0, the host write accesses are directed to PCI\_A.

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

Each PAM register controls two regions, typically 16 KB in size. Each of these regions has a 4-bit field. The four bits that control each region have the same encoding and defined in the following table.

Bits [7, 3] Reserved	Bits [6, 2] Reserved	Bits [5, 1] WE	Bits [4, 0] RE	Description
X	X	0	0	Disabled DRAM is disabled and all accesses are directed to the hub interface. The MCH does not respond as a PCI target for any read or write access to this area.
X	X	0	1	Read Only. Reads are forwarded to DRAM and writes are forwarded to the hub interface for termination. This write protects the corresponding memory segment. The MCH will respond as an AGP or the hub interface target for read accesses but not for any write accesses.
X	X	1	0	Write Only. Writes are forwarded to DRAM and reads are forwarded to the hub interface for termination. The MCH will respond as an AGP or hub interface target for write accesses but not for any read accesses.
X	X	1	1	Read/Write. This is the normal operating mode of main memory. Both read and write cycles from the host are claimed by the MCH and forwarded to DRAM. The MCH will respond as an AGP or the hub interface target for both read and write accesses.

At the time that a HI or AGP accesses to the PAM region may occur, the targeted PAM segment must be programmed to be both readable and writable.

As an example, consider BIOS that is implemented on the expansion bus. During the initialization process, the BIOS can be shadowed in main memory to increase the system performance. When BIOS is shadowed in system 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 system 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. Figure 8 and Table 6 show the PAM registers and the associated attribute bits.

Figure 8. PAM Register Attributes

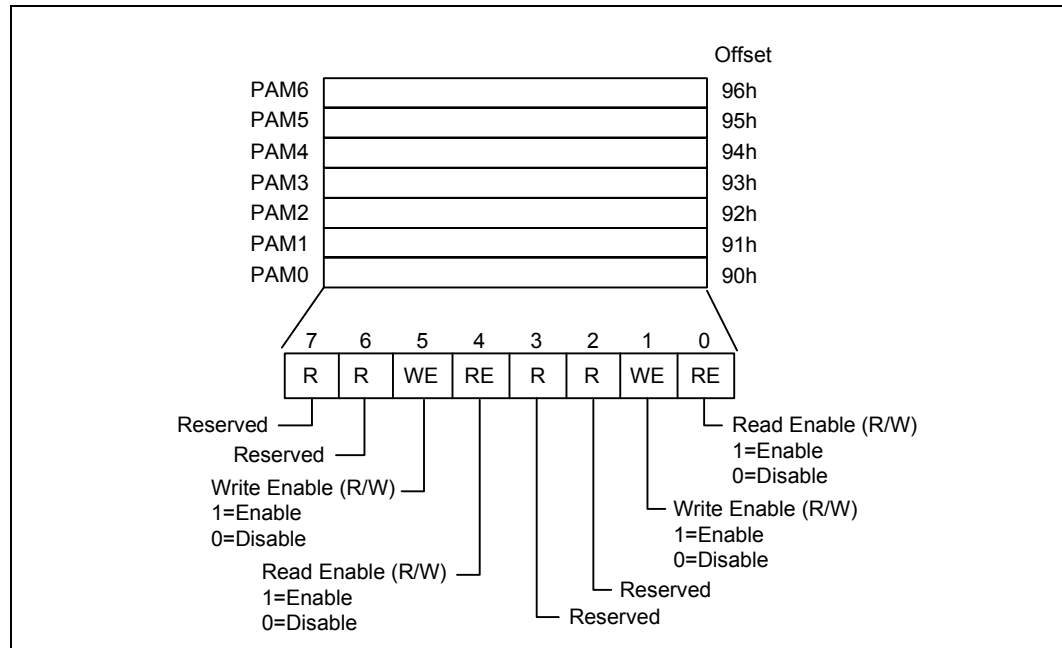


Table 6. PAM Register Attributes

PAM Reg	Attribute Bits				Memory Segment	Comments	Offset
PAM0[3:0]	Reserved						90h
PAM0[7:6]	Reserved						90h
PAM0[5:4]	R	R	WE	RE	0F0000h–0FFFFFh	BIOS Area	90h
PAM1[1:0]	R	R	WE	RE	0C0000h–0C3FFFh	ISA Add-on BIOS	91h
PAM1[7:4]	R	R	WE	RE	0C4000h–0C7FFFh	ISA Add-on BIOS	91h
PAM2[1:0]	R	R	WE	RE	0C8000h–0CBFFFh	ISA Add-on BIOS	92h
PAM2[7:4]	R	R	WE	RE	0CC000h–0CFFFFh	ISA Add-on BIOS	92h
PAM3[1:0]	R	R	WE	RE	0D0000h–0D3FFFh	ISA Add-on BIOS	93h
PAM3[7:4]	R	R	WE	RE	0D4000h–0D7FFFh	ISA Add-on BIOS	93h
PAM4[1:0]	R	R	WE	RE	0D8000h–0DBFFFh	ISA Add-on BIOS	94h
PAM4[7:4]	R	R	WE	RE	0DC000h–0DFFFFh	ISA Add-on BIOS	94h
PAM5[1:0]	R	R	WE	RE	0E0000h–0E3FFFh	BIOS Extension	95h
PAM5[7:4]	R	R	WE	RE	0E4000h–0E7FFFh	BIOS Extension	95h
PAM6[1:0]	R	R	WE	RE	0E8000h–0EBFFFh	BIOS Extension	96h
PAM6[7:4]	R	R	WE	RE	0EC000h–0EFFFFh	BIOS Extension	96h

For details on overall system address mapping scheme, see Chapter 4.

### DOS Application Area (00000h–9FFFh)

The DOS area is 640 KB in size, and it is further divided into two parts. The 512-KB area at 0 to 7FFFFh is always mapped to the system memory controlled by the MCH, while the 128-KB address range from 080000 to 09FFFFh can be mapped to PCI\_A or to system memory. By default this range is mapped to system memory and can be declared as a system memory hole (accesses forwarded to PCI\_A) via MCH FDHC configuration register.

### Video Buffer Area (A0000h–BFFFFh)

Attribute bits do not control this 128-KB area. The host-initiated cycles in this region are always forwarded to either PCI\_A or AGP unless this range is accessed in SMM mode. **Routing of accesses is controlled by the Legacy VGA control mechanism of the virtual PCI-to-PCI bridge device embedded within the MCH.**

This area can be programmed as SMM area via the SMRAM register. When used as a SMM space, this range cannot be accessed from the HI or AGP.

### Expansion Area (C0000h–DFFFFh)

This 128-KB area is divided into eight, 16-KB segments, that can be assigned with different attributes via PAM control register as defined by [Table 6](#).

### Extended System BIOS Area (E0000h–EFFFFh)

This 64-KB area is divided into four, 16-KB segments, which can be assigned with different attributes via PAM control register as defined by [Table 6](#).

### System BIOS Area (F0000h–FFFFFh)

This area is a single, 64-KB segment, which can be assigned with different attributes via PAM control register as defined by [Table 6](#).

## 3.5.18 FDHC—Fixed Memory (ISA) Hole Control Register (Device 0)

Address Offset: 97h  
 Default Value: 00h  
 Access: R/W, RO  
 Size: 8 bits

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

Bit	Descriptions
7	<b>Hole Enable (HEN)—R/W.</b> This field enables a memory hole in system memory space. The DRAM that lies “behind” this space is not remapped. 0 =No memory hole. 1 =Memory hole from 15 MB to 16 MB.
6:0	Reserved

### 3.5.19 SMRAM—System Management RAM Control Register (Device 0)

Address Offset: 9Dh  
 Default Value: 02h  
 Access: R/W, RO, Lock  
 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. Also, the open bit must be reset before the lock bit is set.

Bit	Descriptions
7	Reserved
6	<b>SMM Space Open (D_OPEN)—R/W.</b> 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	<b>SMM Space Closed (D_CLS)—R/W.</b> 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	<b>SMM Space Locked (D_LCK)—R/W.</b> 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 with security. The BIOS can use the D_OPEN function to initialize SMM space and then use D_LCK to “lock down” SMM space in the future so that no application software (or BIOS itself) can violate the integrity of SMM space, even if the program has knowledge of the D_OPEN function.
3	<b>Global SMRAM Enable (G_SMRARE)—R/W/L.</b> If set to 1, Compatible SMRAM functions are enabled, providing 128 KB of DRAM accessible at the A0000h address while in SMM (ADS# with SMM decode). To enable Extended SMRAM function this bit has to be set to 1. Refer to the section on SMM for more details. Once D_LCK is set, this bit becomes read only.
2:0	<b>Compatible SMM Space Base Segment (C_BASE_SEG)—RO.</b> 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 HI. Since the MCH supports only the SMM space between A0000h and BFFFFh, this field is hardwired to 010.

### 3.5.20 ESMRAMC—Extended System Management RAM Control (Device 0)

Address Offset: 9Eh  
 Default Value: 38h  
 Access: R/W, R/WC, RO, Lock  
 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.

Bit	Descriptions
7	<b>Enable High SMRAM (H_SMRAME)—R/W/L.</b> This bit controls the SMM memory space location (i.e., above 1 MB or below 1 MB). When G_SMRAME is 1 and H_SMRAME (this bit) is set to 1, the high SMRAM memory space is enabled. SMRAM accesses within the range 0FEDA0000h to 0FEDBFFFFh are remapped to DRAM addresses within the range 000A0000h to 000BFFFFh. Once D_LCK has been set, this bit becomes read only.
6	<b>Invalid SMRAM Access (E_SMERR)—R/WC.</b> 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.  <b>NOTE:</b> Software must write a 1 to this bit to clear it.
5	<b>SMRAM Cacheable (SM_CACHE)—RO.</b> Hardwired to 1.
4	<b>L1 Cache Enable for SMRAM (SM_L1)—RO.</b> Hardwired to 1.
3	<b>L2 Cache Enable for SMRAM (SM_L2)—RO.</b> Hardwired to 1.
2:1	<b>TSEG Size (TSEG_SZ)—R/W.</b> This field selects the size of the TSEG memory block if enabled. Memory from the top of used system memory space (TOUD) to TOUD + Tseg_size 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. 00 = Reserved 01 = Reserved 10 = TOUD + 512 KB 11 = TOUD + 1 MB
0	<b>TSEG Enable (T_EN)—R/W/L.</b> Enabling of 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.

### 3.5.21 ACAPID—AGP Capability Identifier Register (Device 0)

Address Offset: A0h–A3h  
 Default Value: 00300002h  
 Access: RO  
 Size: 32 bits

This register provides standard identifier for AGP capability.

Bit	Descriptions
31:24	Reserved
23:20	<b>Major AGP Revision Number (MAJREV)—RO.</b> These bits provide a major revision number of AGP specification to which this version of MCH conforms. This field is hardwired to a value of 0011b (i.e., implying Rev 3.x).
19:16	<b>Minor AGP Revision Number (MINREV)—RO.</b> These bits provide a minor revision number of AGP specification to which this version of MCH conforms. This number is hardwired to value of 0000 which implies that the revision is x.0. Together with major revision number this field identifies the MCH as an AGP Rev 3.0 compliant device.
15:8	<b>Next Capability Pointer (NCAPTR)—RO.</b> AGP capability is the first and the last capability described via the capability pointer mechanism and therefore these bits are hardwired to 0 to indicate the end of the capability linked list.
7:0	<b>AGP Capability ID (CAPID)—RO.</b> This field identifies the linked list item as containing AGP registers. This field has a value of 0000_0010b assigned by the PCI SIG.

### 3.5.22 AGPSTAT—AGP Status Register (Device 0)

Address Offset: A4–A7h  
 Default Value: 1F004217h in AGP 2.0  
 1F004A13h in AGP 3.0 mode  
 Access: RO  
 Size: 32 bits

This register reports AGP device capability/status.

Bit	Descriptions
31:24	<b>Request Queue (RQ)—RO.</b> Hardwired to 1Fh to indicate a maximum of 32 outstanding AGP command requests can be handled by the MCH. This field contains the maximum number of AGP command requests the MCH is configured to manage.
23:16	Reserved
15:13	<b>ARQSZ—RO.</b> LOG2 of the optimum asynchronous request size in bytes minus 4 to be used with the target. The MASTER should attempt to issue a group of sequential back-to-back asynchronous requests that total to this size and for which the group is naturally aligned. Optimum_request_size = 2 ^ (ARQSZ+4). Hardwired to 010 to indicate 64 B
12:10	<b>CAL_Cycle—RO.</b> This field specifies the required period for MCH-initiated bus cycles for calibrating I/O buffers. Hardwired to 010 to indicate 64 ms.
9	<b>SideBand Addressing Support (SBA)—RO.</b> Hardwired to 1 indicating that the MCH supports sideband addressing.
8:6	Reserved

Bit	Descriptions
5	<b>Greater Than Four Gigabyte Support (GT4GIG)—RO.</b> Hardwired to 0 indicating that the MCH does not support addresses greater than 4 GB.
4	<b>Fast Write Support (FW)—RO.</b> Hardwired to 1 indicating that the MCH supports fast writes from the processor to the AGP master.
3	<b>AGP 3.0 mode (AGP 30_MOD)—RO.</b> This bit is set by the hardware on the assertion of PWROK based on the AGP 3.0 detection via the VREF comparator on the GVREF pin. In AGP 2.0 mode, GVREF is driven to 0.75 V, while in AGP 3.0 mode, GVREF is driven to 0.35 V. Note that the output of the Vref comparator is used “live” prior to the assertion of PWROK and used to select the appropriate pull-up, pull-down or termination on the I/O buffer depending on the mode selected. 0 = AGP 2.0 (1.5 V signaling) mode. 1 = AGP 3.0 signaling mode.
2:0	<b>Data Rate Support (RATE)—RO.</b> After reset, the MCH reports its data transfer rate capability. <b>In AGP 2.0 Mode:</b> <ul style="list-style-type: none"> <li>• Bit 0 identifies if AGP device supports 1X data transfer mode,</li> <li>• Bit 1 identifies if AGP device supports 2X data transfer mode, (unsupported)</li> <li>• Bit 2 identifies if AGP device supports 4X data transfer.</li> </ul> <b>In AGP 3.0 Mode:</b> <ul style="list-style-type: none"> <li>• Bit 0 identifies if AGP device supports 4X data transfer mode,</li> <li>• Bit 1 identifies if AGP device supports 8X data transfer mode,</li> <li>• Bit 2 is reserved.</li> </ul> <b>NOTES:</b> <ol style="list-style-type: none"> <li>1. In AGP 3.0 mode (AGP_MODE=1) these bits are 011 indicating that both 4X and 8X modes are supported.</li> <li>2. In AGP 2.0 mode these bits are 111 indicating that 4X, 2X and 1X modes are supported. (2X not supported)</li> </ol>



### 3.5.23 AGPCMD—AGP Command Register (Device 0)

Address Offset: A8–ABh  
 Default Value: 00000000h in 2.0 mode  
                   0000A00h in 3.0 mode  
 Access: RO, R/W  
 Size: 32 bits

This register provides control of the AGP operational parameters.

Bit	Descriptions
31:13	Reserved
12:10	<p><b>PCAL_Cycle—R/W.</b> This field is programmed with the period for MCH-initiated bus cycles for calibrating I/O buffers for both master and target. This value is updated with the smaller of the value in CAL_CYCLE from Master's and Target's AGPSTAT.CAL_CYCLE. PCAL_CYCLE is set to 111 by software only if both Target and Master have AGPSTAT.CAL_CYCLE = 111.</p> <p>000 = 4 ms            001 = 16 ms            010 = 64 ms (default)            011 = 256 ms            100–110 = Reserved            111 = Calibration Cycle Not Needed</p>
9	<p><b>Side Band Addressing Enable (SBAEN)—R/W.</b> This bit is ignored in AGP 3.0 mode to allow legacy 2.0 software to work. (When AGP 3.0 is detected, sideband addressing mechanism is automatically enabled by the hardware.)</p> <p>0 = Disable.            1 = Enable. Side band addressing mechanism is enabled.</p>
8	<p><b>AGP Enable (AGPEN)—R/W.</b></p> <p>0 = Disable. MCH ignores all AGP operations, including the sync cycle. Any AGP operations received while this bit is set to 1 will be serviced, even if this bit is reset to 0. If this bit transitions from 1 to 0 on a clock edge in the middle of an SBA command being delivered in 1X mode, the command will be issued.</p> <p>1 = Enable. MCH responds to AGP operations delivered via PIPE#, or to operations delivered via SBA if the AGP Side Band Enable bit is also set to 1.</p>
7:6	Reserved
5	<p><b>Greater Than Four Gigabyte Enable (GT4GIGE)—RO.</b> Hardwired to 0. The MCH, as an AGP target, does not support addressing greater than 4 GB.</p>
4	<p><b>Fast Write Enable (FWEN)—R/W.</b></p> <p>0 = Disable. When this bit is cleared, or when the data rate bits are set to 1X mode, the memory write transactions from the MCH to the AGP master use standard PCI protocol.</p> <p>1 = Enable. When this bit is set, the MCH will use the fast write protocol for memory write transactions from the MCH to the AGP master. Fast writes will occur at the data transfer rate selected by the data rate bits (2:0) in this register.</p>
3	Reserved

Bit	Descriptions
2:0	<p><b>Data Rate Enable (DRATE)—R/W.</b> The setting of these bits determines the AGP data transfer rate. One (and only one) bit in this field must be set to indicate the desired data transfer rate. The same bit must be set on both master and target.</p> <p><b>AGP 2.0</b>            001= 1X Transfer Mode (for AGP 2.0 signaling)            010= 2X Transfer Mode (NOT SUPPORTED)            100= 4X Transfer Mode (for AGP 2.0 signaling)</p> <p><b>AGP 3.0</b>            001= 4X transfer mode (for AGP 3.0 signaling)            010= 8X Transfer mode (for AGP 3.0 signaling)            100= reserved</p>

### 3.5.24 AGPCTRL—AGP Control Register (Device 0)

Address Offset: B0-B3h  
 Default Value: 00000000h  
 Access: RO, R/W  
 Size: 32 bits

This register provides for additional control of the AGP interface.

Bit	Descriptions
31:8	Reserved
7	<p><b>GTLB Enable (GTLBEN)— R/W.</b>            0 = Disable (default). The GTLB is flushed by clearing the valid bits associated with each entry. In this mode of operation:            — All accesses that require translation bypass the GTLB            — All requests that are positively decoded to the graphics aperture force the MCH to access the translation table in main memory before completing the request            — Valid translation table entry fetches will not be cached in the GTLB            — Invalid translation table entry fetches will still be cached in the GTLB (ejecting the least recently used entry).            1 = Enable. Normal operations of the Graphics Translation Lookaside Buffer.</p> <p><b>NOTE:</b> This bit can be changed dynamically (i.e., while an access to GTLB occurs); however, the completion of the configuration write that asserts or deasserts this bit will be delayed pending a complete flush of all dirty entries from the write buffer. This delay will be incurred because this bit is used as a mechanism to signal the chipset that the graphics aperture translation table is about to be modified or has completed modifications. In the first case, all dirty entries need to be flushed before the translation table is changed. In the second case, all dirty entries need to be flushed because one of them is likely to be a translation table entry which must be made visible to the GTLB by flushing it to memory.</p>
6:1	Reserved
0	<p><b>4X Override (OVER4X)—R/W.</b> This back-door register bit allows the BIOS to force 1X mode for AGP 2.0 and 4X mode for AGP 3.0. Note that this bit must be set by the BIOS before AGP configuration.            0 = No override            1 = The RATE[2:0] bit in the AGPSTS register will be read as a 001.</p>

### 3.5.25 APSIZE—Aperture Size Register (Device 0)

Address Offset: B4h  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

This register determines the effective size of the graphics aperture used for a particular MCH configuration. This register can be updated by the MCH-specific BIOS configuration sequence before the PCI standard bus enumeration sequence takes place. If the register is not updated then a default value will select an aperture of maximum size (i.e., 256 MB). The size of the table that will correspond to a 256-MB aperture is not practical for most applications and therefore these bits must be programmed to a smaller practical value that will force adequate address range to be requested via APBASE register from the PCI configuration software.

Bit	Descriptions
7:6	Reserved
5:0	<p><b>Graphics Aperture Size (APSIZE)—R/W.</b> Each bit in APSIZE[5:0] operates on similarly ordered bits in APBASE[27:22] of the Aperture Base configuration register. When a particular bit of this field is 0 it forces the similarly ordered bit in APBASE[27:22] to behave as hardwired to 0. When a particular bit of this field is set to 1 it allows corresponding bit of the APBASE[27:22] to be read/write accessible. Default The default value (APSIZE[5:0]=000000b) forces the default APBASE[27:22] to read as 000000b (i.e., all bits respond as hardwired to 0). This provides the maximum aperture size of 256 MB. As another example, programming APSIZE[5:0] to 111000b hardwires APBASE[24:22] to 000b and enables APBASE[27:25] to be read/write programmable.</p> <p>000000 = 256-MB Aperture Size                      100000 = 128-MB Aperture Size                      110000 = 64-MB Aperture Size                      111000 = 32-MB Aperture Size                      111100 = 16-MB Aperture Size                      111110 = 8-MB Aperture Size                      111111 = 4-MB Aperture Size</p>

### 3.5.26 ATTBASE—Aperture Translation Table Register (Device 0)

Address Offset: B8–BBh  
 Default Value: 00000000h  
 Access: RO, R/W  
 Size: 32 bits

This register provides the starting address of the Graphics Aperture Translation Table Base located in main DRAM. This value is used by the MCH's Graphics Aperture address translation logic (including the GTLB logic) to obtain the appropriate address translation entry required during the translation of the aperture address into a corresponding physical DRAM address. The ATTBASE register may be dynamically changed.

Bit	Descriptions
31:12	<b>Aperture Translation Table Base (TTABLE)—R/W.</b> This field contains a pointer to the base of the translation table used to map memory space addresses in the aperture range to addresses in main memory. Note that it should be modified only when the GTLB has been disabled.
11:0	Reserved

### 3.5.27 AMTT—AGP MTT Control Register (Device 0)

Address Offset: BCh  
 Default Value: 10h  
 Access: RO, R/W  
 Size: 8 bits

AMTT is an 8-bit register that controls the amount of time that the MCH's arbiter allows AGP/PCI master to perform multiple back-to-back transactions. The MCH's AMTT mechanism is used to optimize the performance of the AGP master (using PCI semantics) that performs multiple back-to-back transactions to fragmented memory ranges (and as a consequence it can not use long burst transfers). The AMTT mechanism applies to the processor-AGP/PCI transactions as well and it assures the processor of a fair share of the AGP/PCI interface bandwidth.

The number of clocks programmed in the AMTT represents the guaranteed time slice (measured in 66 MHz clocks) allotted to the current agent (either AGP/PCI master or Host bridge) after which the AGP arbiter will grant the bus to another agent. The default value of AMTT is 00h and disables this function. The AMTT value can be programmed with 8-clock granularity. For example, if the AMTT is programmed to 18h, then the selected value corresponds to the time period of 24 AGP (66 MHz) clocks. Set by BIOS.

Bit	Descriptions
7:3	<b>Multi-Transaction Timer Count Value (MTTC)—R/W.</b> The number programmed into these bits represents the time slice (measured in eight, 66 MHz clock granularity) allotted to the current agent (either AGP/PCI master or Host bridge) after which the AGP arbiter will grant the bus to another agent.
2:0	Reserved

### 3.5.28 LPTT—AGP Low Priority Transaction Timer Register (Device 0)

Address Offset: BDh  
 Default Value: 10h  
 Access: RO, R/W  
 Size: 8 bits

LPTT is an 8-bit register similar in function to AMTT. This register is used to control the minimum tenure on the AGP for low priority data transaction (both reads and writes) issued using PIPE# or SB mechanisms.

The number of clocks programmed in the LPTT represents the guaranteed time slice (measured in 66 MHz clocks) allotted to the current low priority AGP transaction data transfer state. This does not necessarily apply to a single transaction but it can span over multiple low-priority transactions of the same type. After this time expires the AGP arbiter may grant the bus to another agent if there is a pending request. The LPTT does not apply in the case of high-priority request where ownership is transferred directly to high-priority requesting queue. The default value of LPTT is 00h and disables this function. The LPTT value can be programmed with 8-clock granularity. For example, if the LPTT is programmed to 10h, then the selected value corresponds to the time period of 16 AGP (66 MHz) clocks.

Bit	Descriptions
7:3	<b>Low Priority Transaction Timer Count Value (LPTTC)—R/W.</b> The number of clocks programmed in these bits represents the time slice (measured in eight 66 MHz clock granularity) allotted to the current low priority AGP transaction data transfer state.
2:0	Reserved

### 3.5.29 TOUD—Top of Used DRAM Register (Device 0)

Address Offset: C4–C5h  
 Default Value: 0400h  
 Access: RO, R/W  
 Size: 16 bits

Bit	Descriptions
15:3	<p><b>Top of Usable Dram (TOUD)—R/W.</b> This register contains bits 31:19 of the maximum system memory address that is usable by the operating system. Address bits 31:19 imply a memory granularity of 512 KB. Configuration software should set this value to either the maximum amount of usable memory (minus TSEG, graphics stolen memory and CSA stolen memory) in the system or to the minimum address allocated for PCI memory or the graphics aperture, (minus TSEG, graphics stolen memory) whichever is smaller. Address bits 18:0 are assumed to be 0000h for the purposes of address comparison.</p> <p>This register must be set to at least 0400h, for a minimum of 64 MB of system memory. To calculate the value of TOUD, configuration software should set this value to the <b>smaller</b> of the following 2 cases:</p> <ul style="list-style-type: none"> <li>The maximum amount of usable memory in the system minus optional TSEG.</li> <li>The address allocated for PCI memory or the graphics aperture minus optional TSEG.</li> </ul> <p><b>NOTE:</b> Even if the OS does not need any PCI space, TOUD should never be programmed above FEC0_0000h. If TOUD is programmed above this, address ranges that are reserved will become accessible to applications.</p>
2:0	Reserved

### 3.5.30 MCHCFG—MCH Configuration Register (Device 0)

Address Offset: C6–C7h  
 Default Value: 0000h  
 Access: R/W, RO  
 Size: 16 bits

Bit	Descriptions															
15:13	<p><b>Number of Stop Grant Cycles (NSG)—R/W.</b> This field represents the number of Stop Grant transactions expected on the FSB bus before a Stop Grant Acknowledge packet is sent to the ICH5. This field is programmed by the BIOS after it has enumerated the processors and before it has enabled Stop Clock generation in the ICH5. Once this field has been set, it should not be modified. Note that each enabled thread within each processor will generate Stop Grant Acknowledge transactions.</p> <p>000 = HI Stop Grant sent after 1 FSB Stop Grant            001 = HI Stop Grant sent after 2 FSB Stop Grants            010–111= Reserved</p>															
12	Reserved															
11:10	<p><b>System Memory Frequency Select (SMFREQ)—R/W.</b> The reset value of these bits is 00. The DDR memory frequency is determined by the following table, and partly determined by the FSB frequency.</p> <table border="0"> <tr> <td>FSBFREQ[1:0] =00</td> <td>SMFREQ[11:10]=01</td> <td>System Memory DDR set to 266 MHz</td> </tr> <tr> <td>FSBFREQ[1:0] =01</td> <td>SMFREQ[11:10]=00</td> <td>System Memory DDR set to 266 MHz</td> </tr> <tr> <td>FSBFREQ[1:0] =01</td> <td>SMFREQ[11:10]=01</td> <td>System Memory DDR set to 333 MHz</td> </tr> <tr> <td>FSBFREQ[1:0] =10</td> <td>SMFREQ[11:10]=01</td> <td>System Memory DDR set to 333 (320) MHz</td> </tr> <tr> <td>FSBFREQ[1:0] =10</td> <td>SMFREQ[11:10]=10</td> <td>System Memory DDR set to 400 MHz</td> </tr> </table> <p>All others are Intel Reserved</p> <p>Note that memory I/O clock always runs at 2x the frequency of the memory clock.</p> <p><b>NOTE:</b> When writing a new value to this register, software must perform a clock synchronization sequence to apply the new timings. The new value does not get applied until this is completed.</p>	FSBFREQ[1:0] =00	SMFREQ[11:10]=01	System Memory DDR set to 266 MHz	FSBFREQ[1:0] =01	SMFREQ[11:10]=00	System Memory DDR set to 266 MHz	FSBFREQ[1:0] =01	SMFREQ[11:10]=01	System Memory DDR set to 333 MHz	FSBFREQ[1:0] =10	SMFREQ[11:10]=01	System Memory DDR set to 333 (320) MHz	FSBFREQ[1:0] =10	SMFREQ[11:10]=10	System Memory DDR set to 400 MHz
FSBFREQ[1:0] =00	SMFREQ[11:10]=01	System Memory DDR set to 266 MHz														
FSBFREQ[1:0] =01	SMFREQ[11:10]=00	System Memory DDR set to 266 MHz														
FSBFREQ[1:0] =01	SMFREQ[11:10]=01	System Memory DDR set to 333 MHz														
FSBFREQ[1:0] =10	SMFREQ[11:10]=01	System Memory DDR set to 333 (320) MHz														
FSBFREQ[1:0] =10	SMFREQ[11:10]=10	System Memory DDR set to 400 MHz														
9:6	Reserved															
5	<p><b>MDA Present (MDAP)—R/W.</b> This bit works with the VGA Enable bits in the BCTRL1 register of Device 1 to control the routing of processor-initiated transactions targeting MDA compatible I/O and memory address ranges. This bit should not be set if Device 1's VGA Enable bit is not set. If Device 1's VGA enable bit is not set, then accesses to I/O address range x3BCh–x3BFh are forwarded to HI. If 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 AGP if the address is within the corresponding IOBASE and IOLIMIT and ISA enable bit is not set; otherwise, they are forwarded to HI. MDA resources are defined as the following:</p> <p>Memory: 0B0000h–0B7FFFh            I/O: 3B4h, 3B5h, 3B8h, 3B9h, 3BAh, 3BFh,            (including ISA address aliases, A[15:10] are not used in decode)</p> <p>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.</p> <p>The following table shows the behavior for all combinations of MDA and VGA:</p> <table border="0"> <thead> <tr> <th>VGA</th> <th>MDA</th> <th>Behavior</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>All References to MDA and VGA go to HI.</td> </tr> <tr> <td>0</td> <td>1</td> <td>Illegal Combination (DO NOT USE).</td> </tr> <tr> <td>1</td> <td>0</td> <td>All References to VGA go to Device 1. MDA-only references (I/O address 3BFh and aliases) will go to HI.</td> </tr> <tr> <td>1</td> <td>1</td> <td>VGA References go to AGP/PCI; MDA References go to HI.</td> </tr> </tbody> </table>	VGA	MDA	Behavior	0	0	All References to MDA and VGA go to HI.	0	1	Illegal Combination (DO NOT USE).	1	0	All References to VGA go to Device 1. MDA-only references (I/O address 3BFh and aliases) will go to HI.	1	1	VGA References go to AGP/PCI; MDA References go to HI.
VGA	MDA	Behavior														
0	0	All References to MDA and VGA go to HI.														
0	1	Illegal Combination (DO NOT USE).														
1	0	All References to VGA go to Device 1. MDA-only references (I/O address 3BFh and aliases) will go to HI.														
1	1	VGA References go to AGP/PCI; MDA References go to HI.														

Bit	Descriptions
4	Reserved
3	<p><b>AGP Mode (AGP)—RO.</b> This reflects the GPAR strap value. Note that the strap value is sampled on the assertion of PWROK.</p> <p>0 = Reserved 1 = AGP</p>
2	<p><b>FSB IOQ Depth (IOQD)—RO.</b> This bit reflects the HA7# strap value. It indicates the depth of the FSB IOQ. When the strap is sampled low, this bit will be a 0 and the FSB IOQ depth is set to 1. When the strap is sampled high, this bit will be a 1 and the FSB IOQ depth is set to the maximum (12 on the bus, 12 on the MCH).</p> <p>0 = 1 deep 1 = 12 on the bus, 12 on the MCH</p>
1:0	<p><b>FSB Frequency Select (FSBFREQ)—RO.</b> The default value of this bit is set by the strap assigned to the BSEL[1:0] pins and is latched at the rising edge of PWROK.</p> <p>00 = Core Frequency is 100 MHz and the FSB frequency is 400 MHz 01 = Core Frequency is 133 MHz and the FSB frequency is 533 MHz 10 = Core Frequency is 200 MHz and the FSB frequency is 800 MHz 11 = Reserved</p>

### 3.5.31 ERRSTS—Error Status Register (Device 0)

Address Offset: C8–C9h  
 Default Value: 0000h  
 Access: R/WC  
 Size: 16 bits

This register is used to report various error conditions via the SERR HI messaging mechanism. A SERR HI message 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.

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

Bit	Descriptions
15:10	Reserved
9	<b>Non-DRAM Lock Error (NDLOCK)—R/WC.</b> 0 = No Lock operation detected. 1 = MCH has detected a lock operation to memory space that did not map into DRAM.
8	<b>Software Generated SMI Flag—R/WC.</b> 0 = Source of an SMI was NOT the Device 2 Software SMI Trigger 1 = Source of an SMI was the Device 2 Software SMI Trigger.
7:6	Reserved
5	<b>MCH Detects Unimplemented HI Special Cycle (HIAUSC)—R/WC</b> 0 = No unimplemented Special Cycle on HI detected. 1 = MCH detects an Unimplemented Special Cycle on HI.
4	<b>AGP Access Outside of Graphics Aperture Flag (OOGF)—R/WC</b> 0 = No AGP access to an address that is outside of the graphics aperture range. 1 = AGP access occurred to an address that is outside of the graphics aperture range.
3	<b>Invalid AGP Access Flag (IAAF)—R/WC</b> 0 = No invalid AGP access. 1 = AGP access was attempted outside of the graphics aperture and either to the 640 KB – 1 MB range or above the top of memory.
2	<b>Invalid Graphics Aperture Translation Table Entry (ITTEF)—R/WC</b> 0 = No invalid graphics aperture translation table entry. 1 = Invalid translation table entry was returned in response to an AGP access to the graphics aperture.
1	<b>MCH Detects Unsupported AGP Command—R/WC.</b> 0 = No unsupported AGP command detected. 1 = Bogus or unsupported command is received by the AGP target in the MCH.
0	Reserved



### 3.5.32 ERRCMD—Error Command Register (Device 0)

Address Offset: CA–CBh  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

This register controls the MCH responses to various system errors. Since the MCH does not have a SERR# signal, SERR messages are passed from the MCH to the ICH5 over HI. When a bit in this register is set, a SERR message will be generated on HI when the corresponding flag is set in the ERRSTS register. The actual generation of the SERR message is globally enabled for Device 0 via the PCI Command register.

Bit	Descriptions
15:10	Reserved
9	<b>SERR on Non-DRAM Lock (LCKERR)—R/W.</b> 0 = Disable 1 = Enable. MCH generates a HI SERR special cycle when a processor lock cycle is detected that does not hit system memory.
8:7	Reserved
6	<b>SERR on Target Abort on HI Exception (TAHLA)—R/W.</b> 0 = Reporting of this condition is disabled. 1 = MCH generates a SERR special cycle over HI when an MCH originated HI cycle is completed with a Target Abort completion packet or special cycle.
5	<b>SERR on Detecting HI Unimplemented Special Cycle (HIAUSCERR)—R/W.</b> 0 = MCH does not generate a SERR message for this event. SERR messaging for Device 0 is globally enabled in the PCICMD register. 1 = MCH generates a SERR message over HI when an Unimplemented Special Cycle is received on the HI.
4	<b>SERR on AGP Access Outside of Graphics Aperture (OOGF)—R/W.</b> 0 = Reporting of this condition is disabled. 1 = Enable. MCH generates a SERR special cycle over HI when an AGP access occurs to an address outside of the graphics aperture.
3	<b>SERR on Invalid AGP Access (IAAF)—R/W.</b> 0 = Invalid AGP Access condition is not reported. 1 = MCH generates a SERR special cycle over HI when an AGP access occurs to an address outside of the graphics aperture and either to the 640 KB – 1 MB range or above the top of memory.
2	<b>SERR on Invalid Translation Table Entry (ITTEF)—R/W.</b> 0 = Reporting of this condition is disabled. 1 = MCH generates a SERR special cycle over HI when an invalid translation table entry was returned in response to an AGP access to the graphics aperture.
1	<b>SERR on MCH Detects Unsupported AGP Command—R/W.</b> 0 = MCH Detects Unsupported AGP command will <b>not</b> generate a SERR. 1 = MCH generates a SERR when an Unsupported AGP command is detected.
0	Reserved

### 3.5.33 SKPD—Scratchpad Data Register (Device 0)

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

Bit	Descriptions
15:0	<b>Scratchpad (SCRTCH)—R/W.</b> These bits are R/W storage bits that have no effect on the MCH functionality.

### 3.5.34 CAPREG—Capability Identification Register (Device 0)

Address Offset: E4–E9h  
 Default: 00000106A009h  
 Access: RO  
 Size: 48 bits

The Capability Identification register uniquely identifies chipset capabilities.

Bit	Descriptions
47:28	Reserved
27:24	<b>CAPREG Version—RO.</b> This field has the value 0001b to identify the first revision of the CAPREG definition.
23:16	<b>Cap_length—RO.</b> This field has the value 06h indicating the structure length.
15:8	<b>Next Pointer—RO.</b> This field has the value A0h pointing to the next capabilities register, AGP Capability Identifier register (ACAPID). If AGP is disabled, this field has the value 00h signifying the end of the capabilities linked list.
7:0	<b>CAP_ID—RO.</b> This field has the value 09h to identify the CAP_ID assigned by the PCI SIG for Vendor Dependent CAP_PTR.

## 3.6 PCI-to-AGP Bridge Registers (Device 1)

Device 1 is the virtual PCI-to-AGP bridge. [Table 7](#) provides the register address map. The register descriptions in this section are arranged by ascending offset address.

**Table 7. PCI-to-Virtual Bridge Configuration Register Address Map (Device 1)**

Address Offset	Register Symbol	Register Name	Default Value	Access
00–01h	VID1	Vendor Identification	8086h	RO
02–03h	DID1	Device Identification	2571h	RO
04–05h	PCICMD1	PCI Command	0000h	RO, R/W
06–07h	PCISTS1	PCI Status	00A0h	RO, R/WC
08h	RID1	Revision Identification	see register description	RO
09h	—	Reserved	—	—
0Ah	SUBC1	Sub-Class Code	04h	RO
0Bh	BCC1	Base Class Code	06h	RO
0Ch	—	Reserved	—	—
0Dh	MLT1	Master Latency Timer	00h	RO, R/W
0Eh	HDR1	Header Type	01h	RO
0F–17h	—	Reserved	—	—
18h	PBUSN1	Primary Bus Number	00h	RO
19h	SBUSN1	Secondary Bus Number	00h	R/W
1Ah	SUBUSN1	Subordinate Bus Number	00h	R/W
1Bh	SMLT1	Secondary Bus Master Latency Timer	00h	RO, R/W
1Ch	IOBASE1	I/O Base Address	F0h	RO, R/W
1Dh	IOLIMIT1	I/O Limit Address	00h	RO, R/W
1E–1Fh	SSTS1	Secondary Status	02A0h	RO, R/WC
20–21h	MBASE1	Memory Base Address	FFF0h	RO, R/W
22–23h	MLIMIT1	Memory Limit Address	0000h	RO, R/W
24–25h	PMBASE1	Prefetchable Memory Base Address	FFF0h	RO, R/W
26–27h	PMLIMIT1	Prefetchable Memory Limit Address	0000h	RO, R/W
28–3Dh	—	Reserved	—	—
3Eh	BCTRL1	Bridge Control	00h	RO, R/W
3Fh	—	Reserved	—	—
40h	ERRCMD1	Error Command	00h	RO, R/W
41–FFh	—	Reserved	—	—

### 3.6.1 VID1—Vendor Identification Register (Device 1)

Address Offset: 00–01h  
 Default Value: 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.

Bit	Descriptions
15:0	<b>Vendor Identification Device 1 (VID1)—RO.</b> This register field contains the PCI standard identification for Intel 8086h.

### 3.6.2 DID1—Device Identification Register (Device 1)

Address Offset: 02–03h  
 Default Value: 2571h  
 Access: RO  
 Size: 16 bits

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

Bit	Descriptions
15:0	<b>Device Identification Number (DID)—RO.</b> A 16-bit value assigned to the MCH Device 1.

### 3.6.3 PCICMD1—PCI Command Register (Device 1)

Address Offset: 04–05h  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

Bit	Descriptions
15:10	Reserved
9	<b>Fast Back-to-Back Enable (FB2B)—RO.</b> Hardwired to 0.
8	<b>SERR Message Enable (SERRE)—R/W.</b> This bit is a global enable bit for Device 1 SERR messaging. The MCH communicates the SERR# condition by sending a SERR message to the ICH5. 0 = Disable. SERR message is not generated by the MCH for Device 1. 1 = Enable. MCH is enabled to generate SERR messages over HI for specific Device 1 error conditions that are individually enabled in the BCTRL1 register. The error status is reported in the PCISTS1 register.
7	<b>Address/Data Stepping (ADSTEP)—RO.</b> Hardwired to 0.
6	<b>Parity Error Enable (PERRE)—RO.</b> Hardwired to 0. Parity checking is not supported on the primary side of this device.
5	Reserved
4	<b>Memory Write and Invalidate Enable (MWIE)—RO.</b> Hardwired to 0.
3	<b>Special Cycle Enable (SCE)—RO.</b> Hardwired to 0.
2	<b>Bus Master Enable (BME)—R/W.</b> 0 = Disable. AGP Master initiated Frame# cycles will be ignored by the MCH. The result is a master abort. Ignoring incoming cycles on the secondary side of the PCI-to-PCI bridge effectively disabled the bus master on the primary side. (default) 1 = Enable. AGP master initiated Frame# cycles will be accepted by the MCH if they hit a valid address decode range. This bit has no affect on AGP Master originated SBA or PIPE# cycles.
1	<b>Memory Access Enable (MAE)—R/W.</b> 0 = Disable. All of Device 1's memory space is disabled. 1 = Enable. Enables the Memory and Pre-fetchable memory address ranges defined in the MBASE1, MLIMIT1, PMBASE1, and PMLIMIT1 registers.
0	<b>IO Access Enable (IOAE)—R/W.</b> 0 = Disable. All of Device 1'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 IOBASE1, and IOLIMIT1 registers.

### 3.6.4 PCISTS1—PCI Status Register (Device 1)

Address Offset: 06–07h  
 Default Value: 00A0h  
 Access: RO, R/WC  
 Size: 16 bits

PCISTS1 is a 16-bit status register that reports the occurrence of error conditions associated with primary side of the virtual PCI-to-PCI bridge in the MCH.

Bit	Descriptions
15	<b>Detected Parity Error (DPE)—RO.</b> Hardwired to 0. Parity is not supported on the primary side of this device.
14	<b>Signaled System Error (SSE)—R/WC.</b> 0 = Software clears this bit by writing a 1 to it. 1 = MCH Device 1 generated a SERR message over HI for any enabled Device 1 error condition. Device 1 error conditions are enabled in the ERRCMD, PCICMD1 and BCTRL1 registers. Device 1 error flags are read/reset from the ERRSTS and SSTS1 register.
13	<b>Received Master Abort Status (RMAS)—RO.</b> Hardwired to 0. The concept of a master abort does not exist on primary side of this device.
12	<b>Received Target Abort Status (RTAS)—RO.</b> Hardwired to 0. The concept of a target abort does not exist on primary side of this device.
11	<b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0. The concept of a target abort does not exist on primary side of this device.
10:9	<b>DEVSEL# Timing (DEVT)—RO.</b> The MCH does not support subtractive decoding devices on bus 0. This bit field is therefore hardwired to 00 to indicate that Device 1 uses the fastest possible decode.
8	<b>Data Parity Detected (DPD)—RO.</b> Hardwired to 0. Parity is not supported on the primary side of this device.
7	<b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 1. This indicates that the AGP/PCI_B interface always supports fast back-to-back writes.
6	Reserved
5	<b>66/60 MHz capability (CAP66)—RO.</b> Hardwired to 1. The AGP/PCI bus is 66 MHz capable.
4:0	Reserved

### 3.6.5 RID1—Revision Identification Register (Device 1)

Address Offset: 08h  
 Default Value: See following table  
 Access: RO  
 Size: 8 bits

This register contains the revision number of the MCH Device 1.

Bit	Descriptions
7:0	<b>Revision Identification Number (RID)—RO.</b> This is an 8-bit value that indicates the revision identification number for the MCH Device 1. It is always the same as the value in RID. 02h = A-2 Stepping

### 3.6.6 SUBC1—Sub-Class Code Register (Device 1)

Address Offset: 0Ah  
 Default Value: 04h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Sub-Class Code (SUBC)—RO.</b> This is an 8-bit value that indicates the category of bridge for Device 1 of the MCH. 04h = PCI to PCI bridge.

### 3.6.7 BCC1—Base Class Code Register (Device 1)

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

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

Bit	Descriptions
7:0	<b>Base Class Code (BASEC)—RO.</b> This is an 8-bit value that indicates the Base Class Code for the MCH Device 1. 06h = Bridge device.

### 3.6.8 MLT1—Master Latency Timer Register (Device 1)

Address Offset: 0Dh  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

This functionality is not applicable. It is described here since these bits should be implemented as read/write to prevent standard PCI-to-PCI bridge configuration software from getting “confused.”

Bit	Descriptions
7:3	<b>Scratchpad MLT (NA7.3)—R/W.</b> These bits return the value with which they are written; however, they have no internal function and are implemented as a scratchpad merely to avoid confusing software.
2:0	Reserved

### 3.6.9 HDR1—Header Type Register (Device 1)

Address Offset: 0Eh  
 Default Value: 01h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Header Type Register (HDR)—RO.</b> Hardwired to 01h to indicate that MCH Device 1 is a single function device with bridge header layout.

### 3.6.10 PBUSN1—Primary Bus Number Register (Device 1)

Address Offset: 18h  
 Default Value: 00h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Primary Bus Number (PBUSN)—RO.</b> Configuration software typically programs this field with the number of the bus on the primary side of the bridge. Since Device 1 is an internal device and its primary bus is always 0, these bits are read only and are hardwired to 00h.



### 3.6.11 SBUSN1—Secondary Bus Number Register (Device 1)

Address Offset: 19h  
 Default Value: 00h  
 Access: R/W  
 Size: 8 bits

This register identifies the bus number assigned to the second bus side of the virtual PCI-to-PCI bridge; that is, to PCI\_B/AGP. This number is programmed by the PCI configuration software to allow mapping of configuration cycles to PCI\_B/AGP.

Bit	Descriptions
7:0	<b>Secondary Bus Number (SBUSN)—RO.</b> This field is programmed by configuration software with the bus number assigned to PCI_B.

### 3.6.12 SUBUSN1—Subordinate Bus Number Register (Device 1)

Address Offset: 1Ah  
 Default Value: 00h  
 Access: R/W  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Subordinate Bus Number (BUSN)—R/W.</b> This register is programmed by configuration software with the number of the highest subordinate bus that lies behind the Device 1 bridge. When only a single PCI device resides on the AGP/PCI_B segment, this register will contain the same value as the SBUSN1 register.

### 3.6.13 SMLT1—Secondary Bus Master Latency Timer Register (Device 1)

Address Offset: 1Bh  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

This register control the bus tenure of the MCH on AGP/PCI the same way Device 0 MLT controls the access to the PCI\_A bus.

Bit	Descriptions
7:3	<b>Secondary MLT Counter Value (MLT)—R/W.</b> Programmable, default = 0 (SMLT disabled)
2:0	Reserved

### 3.6.14 IOBASE1—I/O Base Address Register (Device 1)

Address Offset: 1Ch  
 Default Value: F0h  
 Access: RO, R/W  
 Size: 8 bits

This register controls the processor-to-PCI\_B/AGP I/O access routing based on the following formula:

$$\text{IO\_BASE} \leq \text{address} \leq \text{IO\_LIMIT}$$

Only upper four 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.

Bit	Descriptions
7:4	<b>I/O Address Base (IOBASE)—R/W.</b> This field corresponds to A[15:12] of the I/O addresses passed by bridge 1 to AGP/PCI_B.
3:0	Reserved

### 3.6.15 IOLIMIT1—I/O Limit Address Register (Device 1)

Address Offset: 1Dh  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

This register controls the processor-to-PCI\_B/AGP I/O access routing based on the following formula:

$$\text{IO\_BASE} \leq \text{address} \leq \text{IO\_LIMIT}$$

Only the upper four 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.

Bit	Descriptions
7:4	<b>I/O Address Limit (IOLIMIT)—R/W.</b> This field corresponds to A[15:12] of the I/O address limit of Device 1. Devices between this upper limit and IOBASE1 will be passed to AGP/PCI_B.
3:0	Reserved

### 3.6.16 SSTS1—Secondary Status Register (Device 1)

Address Offset: 1E–1Fh  
 Default Value: 02A0h  
 Access: RO, R/WC  
 Size: 16 bits

SSTS1 is a 16-bit status register that reports the occurrence of error conditions associated with the secondary side (i.e., PCI\_B/AGP side) of the virtual PCI-to-PCI bridge in the MCH.

Bit	Descriptions
15	<p><b>Detected Parity Error (DPE)—R/WC.</b>            0 = No parity error detected.            1 = MCH detected a parity error in the address or data phase of PCI_B/AGP bus transactions.</p> <p><b>NOTE:</b> Software clears this bit by writing a 1 to it.</p>
14	<p><b>Received System Error (RSE)—RO.</b> Hardwired to 0 since the MCH does not have a SERR# signal pin on the AGP interface.</p>
13	<p><b>Received Master Abort Status (RMAS)—R/WC.</b>            0 = No master abort by MCH to terminate a Host-to-PCI_B/AGP Transaction.            1 = MCH terminated a Host-to-PCI_B/AGP transaction with an unexpected master abort.</p> <p><b>NOTE:</b> Software clears this bit by writing a 1 to it.</p>
12	<p><b>Received Target Abort Status (RTAS)—R/WC.</b>            0 = No target abort to terminate MCH-initiated transaction on PCI_B/AGP.            1 = MCH-initiated transaction on PCI_B/AGP is terminated with a target abort.</p> <p><b>NOTE:</b> Software clears this bit by writing a 1 to it.</p>
11	<p><b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0. The MCH does not generate target abort on PCI_B/AGP.</p>
10:9	<p><b>DEVSEL# Timing (DEVT)—RO.</b> This 2-bit field indicates the timing of the DEVSEL# signal when the MCH responds as a target on PCI_B/AGP, and is hard-wired to the value 01b (medium) to indicate the time when a valid DEVSEL# can be sampled by the initiator of the PCI cycle.</p>
8	<p><b>Master Data Parity Error Detected (DPD)—RO.</b> Hardwired to 0. MCH does not implement G_PERR# signal on PCI_B.</p>
7	<p><b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 1. The MCH, as a target, supports fast back-to-back transactions on PCI_B/AGP.</p>
6	Reserved
5	<p><b>66/60 MHz capability (CAP66)—RO.</b> Hardwired to 1 to indicate that the AGP/PCI_B bus is capable of 66 MHz operation.</p>
4:0	Reserved

### 3.6.17 MBASE1—Memory Base Address Register (Device 1)

Address Offset: 20–21h  
 Default Value: FFF0h  
 Access: RO, R/W  
 Size: 16 bits

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

$$\text{MEMORY\_BASE} \leq \text{address} \leq \text{MEMORY\_LIMIT}$$

The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32-bit address. The bottom 4 bits of this register are read only and return 0's 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. Thus, the bottom of the defined memory address range will be aligned to a 1-MB boundary.

Bit	Descriptions
15:4	<b>Memory Address Base (MBASE)— R/W.</b> This field corresponds to A[31:20] of the lower limit of the memory range that will be passed by the Device 1 bridge to AGP/PCI_B.
3:0	Reserved

### 3.6.18 MLIMIT1—Memory Limit Address Register (Device 1)

Address Offset: 22–23h  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

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

$$\text{MEMORY\_BASE} \leq \text{address} \leq \text{MEMORY\_LIMIT}$$

The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32-bit address. The bottom 4 bits of this register are read only and return 0's 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 FFFFh. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block.

**Note:** Memory range covered by MBASE and MLIMIT registers are used to map non-prefetchable PCI\_B/AGP 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 processor-AGP memory access performance.

**Note:** 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.

Bit	Descriptions
15:4	<b>Memory Address Limit (MLIMIT)—R/W.</b> 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 1 bridge to AGP/PCI_B.
3:0	Reserved

### 3.6.19 PMBASE1—Prefetchable Memory Base Address Register (Device 1)

Address Offset: 24–25h  
 Default Value: FFF0h  
 Access: RO, R/W  
 Size: 16 bits

This register controls the processor-to-PCI\_B prefetchable memory accesses routing based on the following formula:

$$\text{PREFETCHABLE\_MEMORY\_BASE} \leq \text{address} \leq \text{PREFETCHABLE\_MEMORY\_LIMIT}$$

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 0's 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. Thus, the bottom of the defined memory address range will be aligned to a 1-MB boundary.

Bit	Descriptions
15:4	<b>Prefetchable Memory Address Base (PMBASE)—R/W.</b> This field corresponds to A[31:20] of the lower limit of the address range passed by bridge Device 1 across AGP/PCI_B.
3:0	Reserved

### 3.6.20 PMLIMIT1—Prefetchable Memory Limit Address Register (Device 1)

Address Offset: 26–27h  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

This register controls the processor-to-PCI\_B prefetchable memory accesses routing based on the following formula:

$$\text{PREFETCHABLE\_MEMORY\_BASE} \leq \text{address} \leq \text{PREFETCHABLE\_MEMORY\_LIMIT}$$

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 0's 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 FFFFh. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block. Note that prefetchable memory range is supported to allow segregation by the configuration software between the memory ranges that must be defined as UC and the ones that can be designated as a USWC (i.e., prefetchable) from the processor perspective.

Bit	Descriptions
15:4	<b>Prefetchable Memory Address Limit (PMLIMIT)—R/W.</b> This field corresponds to A[31:20] of the upper limit of the address range passed by bridge Device 1 across AGP/PCI_B.
3:0	Reserved

### 3.6.21 BCTRL1—Bridge Control Register (Device 1)

Address Offset: 3Eh  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

This register provides extensions to the PCICMD1 register that are specific to PCI-to-PCI bridges. The BCTRL1 provides additional control for the secondary interface (i.e., PCI\_B/AGP) as well as some bits that affect the overall behavior of the virtual PCI-to-PCI bridge in the MCH, (e.g., VGA compatible address ranges mapping).

Bit	Descriptions
7	<b>Fast Back-to-Back Enable (FB2BEN)—RO.</b> Hardwired to 0. The MCH does not generate fast back-to-back cycles as a master on AGP.
6	<b>Secondary Bus Reset (SRESET)—RO.</b> Hardwired to 0. The MCH does not support generation of reset via this bit on the AGP.
5	<b>Master Abort Mode (MAMODE)—RO.</b> Hardwired to 0. Thus, when acting as a master on AGP/ PCI_B, the MCH will discard writes and return all 1's during reads when a master abort occurs.
4	Reserved
3	<b>VGA Enable (VGAEN)—R/W.</b> This bit controls the routing of processor-initiated transactions targeting VGA compatible I/O and memory address ranges. This bit works in conjunction with the MCHCFG[MDAP] bit (offset C6h) as described in <a href="#">Table 8</a> . 0 = Disable 1 = Enable
2	<b>ISA Enable (ISAEN)—R/W.</b> This bit modifies the response by the MCH to an I/O access issued by the processor that targets 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 are mapped to PCI_B/AGP. (default) 1 = The MCH does not forward to PCI_B/AGP any I/O transactions addressing the last 768 bytes in each 1 KB block, even if the addresses are within the range defined by the IOBASE and IOLIMIT registers. Instead of going to PCI_B/AGP, these cycles are forwarded to HI where they can be subtractively or positively claimed by the ISA bridge.
1	<b>SERR Enable (SERREN)—RO.</b> Hardwired to 0. This bit normally controls forwarding SERR# on the secondary interface to the primary interface. The MCH does not support the SERR# signal on the AGP/PCI_B bus.
0	<b>Parity Error Response Enable (PEREN)—R/W.</b> This bit controls the MCH's response to data phase parity errors on PCI_B/AGP. G_PERR# is not implemented by the MCH. 0 = Address and data parity errors on PCI_B/AGP are not reported via the MCH HI SERR messaging mechanism. Other types of error conditions can still be signaled via SERR messaging independent of this bit's state. 1 = Address and data parity errors detected on PCI_B are reported via the HI SERR messaging mechanism, if further enabled by SERRE1.

The bit field definitions for VGAEN and MDAP are detailed in [Table 8](#).

**Table 8. VGAEN and MDAP Field Definitions**

VGAEN	MDAP	Description
0	0	All References to MDA and VGA space are routed to HI
0	1	Illegal combination
1	0	All VGA references are routed to this bus. MDA references are routed to HI
1	1	All VGA references are routed to this bus. MDA references are routed to HI

### 3.6.22 ERRCMD1—Error Command Register (Device 1)

Address Offset: 40h  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits

Bit	Descriptions
7:1	Reserved
0	<p><b>SERR on Receiving Target Abort (SERTA)—R/W.</b></p> <p>0 = The MCH does not assert a SERR message upon receipt of a target abort on PCI_B. SERR messaging for Device 1 is globally enabled in the PCICMD1 register.</p> <p>1 = The MCH generates a SERR message over HI upon receiving a target abort on PCI_B.</p>



### 3.7 PCI-to-CSA Bridge Registers (Device 3)

This device is the virtual PCI-to-CSA bridge. This section contains the PCI configuration registers listed in order of ascending offset address. [Table 9](#) provides the configuration register address map for this device.

**Table 9. PCI-to-CSA Bridge Configuration Register Address Map (Device 3)**

Address Offset	Register Symbol	Register Name	Default Value	Access
00–01h	VID3	Vendor Identification	8086h	RO
02–03h	DID3	Device Identification	2573h	RO
04–05h	PCICMD3	PCI Command	0000h	RO,R/W
06–07h	PCISTS3	PCI Status	00A0h	RO,R/WC
08h	RID3	Revision Identification	see register description	RO
09	—	Reserved	—	—
0Ah	SUBC3	Sub-Class Code	04h	RO
0Bh	BCC3	Base Class Code	06h	RO
0Ch	—	Reserved	—	—
0Dh	MLT3	Master Latency Timer	00h	RO,R/W
0Eh	HDR3	Header Type	01h	RO
0F–17h	—	Reserved	—	—
18h	PBUSN3	Primary Bus Number	00h	R/W
19h	SBUSN3	Secondary Bus Number	00h	R/W
1Ah	SUBUSN3	Subordinate Bus Number	00h	R/W
1Bh	SMLT3	Secondary Bus Master Latency Timer	00h	RO,R/W
1Ch	IOBASE3	I/O Base Address	F0h	RO,R/W
1Dh	IOLIMIT3	I/O Limit Address	00h	RO,R/W
1E–1Fh	SSTS3	Secondary Status	02A0h	RO,R/WC
20–21h	MBASE3	Memory Base Address	FFF0h	RO,R/W
22–23h	MLIMIT3	Memory Limit Address	0000h	RO,R/W
24–25h	PMBASE3	Prefetchable Memory Base Limit Address	FFF0h	RO,R/W
26–27h	PMLIMIT3	Prefetchable Memory Limit Address	0000h	RO,R/W
28–3Dh	—	Reserved	—	—
3Eh	BCTRL3	Bridge Control	00h	RO,R/W
3Fh	—	Reserved	—	—
40h	ERRCMD3	Error Command	00h	RO,R/W
41–4Fh	—	Reserved	—	—
50–53h	CSACNTRL	CSA Control	0E04 2802h	RO,R/W
54–FFh	—	Intel Reserved	—	—

### 3.7.1 VID3—Vendor Identification Register (Device 3)

Address Offset: 00h–01h  
 Default Value: 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.

Bit	Description
15:0	<b>Vendor Identification Number—RO.</b> This is a 16-bit value assigned to Intel.

### 3.7.2 DID3—Device Identification Register (Device 3)

Address Offset: 02h–03h  
 Default Value: 2573h  
 Access: RO  
 Size: 16 bits

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

Bit	Description
15:0	<b>Device Identification Number—RO.</b> This is a 16-bit value assigned to the MCH Device 3.

### 3.7.3 PCICMD3—PCI Command Register (Device 3)

Address Offset: 04h–05h  
 Default: 0000h  
 Access: RO, R/W  
 Size: 16 bits

Bit	Description
15:10	Reserved
9	<b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 0.
8	<b>SERR# Enable (SERRE)—R/W.</b> This bit is a global enable bit for Device 3 SERR messaging. The MCH communicates the SERR# condition by sending a SERR message to the Intel® ICH5. 0 = Disable. SERR message is not generated by the MCH for Device 3. 1 = Enable. The MCH is enabled to generate SERR messages over HI for specific Device 3 error conditions that are individually enabled in the BCTRL3 register. The error status is reported in the PCISTS3 register.
7	<b>Address/Data Stepping (ADSTEP)—RO.</b> Hardwired to 0.
6	<b>Parity Error Enable (PERRE)—RO.</b> Hardwired to 0. Parity checking is not supported on the primary side of this device.
5	Reserved
4	<b>Memory Write and Invalidate Enable (MWIE)—RO.</b> Hardwired to 0.
3	<b>Special Cycle Enable (SCE)—RO.</b> Hardwired to 0.
2	<b>Bus Master Enable (BME)—R/W.</b> This bit is not functional. It is a R/W bit for compatibility with compliance testing software.
1	<b>Memory Access Enable (MAE)—R/W.</b> This bit must be set to 1 to enable the memory and pre-fetchable memory address ranges defined in the MBASE3, MLIMIT3, PMBASE3, and PMLIMIT3 registers. 0 = Disable (default). 1 = Enable.
0	<b>I/O Access Enable (IOAE)—R/W.</b> This bit must be set to 1 to enable the I/O address range defined in the IOBASE3 and IOLIMIT3 registers. 0 = Disable (default). 1 = Enable.

### 3.7.4 PCISTS3—PCI Status Register (Device 3)

Address Offset: 06h–07h  
 Default Value: 00A0h  
 Access: RO, R/WC  
 Size: 16 bits

PCISTS3 is a 16-bit status register that reports the occurrence of error conditions associated with primary side of the virtual PCI-to-PCI bridge in the MCH.

Bit	Description
15	<b>Detected Parity Error (DPE)—RO.</b> Hardwired to 0. Parity is not supported on the primary side of this device.
14	<b>Signaled System Error (SSE)—R/WC.</b> 0 = Software clears this bit by writing a 1 to it. 1 = The MCH Device 3 generated a SERR message over HI for an enabled Device 3 error condition. Device 3 error conditions are enabled in the ERRCMD, PCICMD3, and BCTRL3 registers. Device 3 error flags are read/reset from the ERRSTS and SSTS3 register.
13	<b>Received Master Abort Status (RMAS)—RO.</b> Hardwired to 0. The concept of a master abort does not exist on the primary side of this device.
12	<b>Received Target Abort Status (RTAS)—RO.</b> Hardwired to 0. The concept of a target abort does not exist on the primary side of this device.
11	<b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0. The concept of a target abort does not exist on the primary side of this device.
10:9	<b>DEVSEL# Timing (DEVT)—RO.</b> Hardwired to 00b. MCH does not support subtractive decoding devices on bus 0. The value 00b indicates that Device 3 uses the fastest possible decode.
8	<b>Data Parity Detected (DPD)—R/WC.</b> Hardwired to 0. Parity Error Response is hardwired to disabled (and the MCH does not support any parity detection on the primary side of this device).
7	<b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 1. The interface always supports fast back-to-back writes.
6	Reserved
5	<b>66/60 MHz PCI Capable (CAP66)—RO.</b> Hardwired to 1 indicating CSA is 66 MHz capable.
4:0	Reserved

### 3.7.5 RID3—Revision Identification Register (Device 3)

Address Offset: 08h  
 Default Value: See following table  
 Access: RO  
 Size: 8 bits

This register contains the revision number of the MCH Device 3.

Bit	Description
7:0	<b>Revision Identification Number—RO.</b> This is an 8-bit value that indicates the revision identification number for the MCH Device 3. It is always the same as the value in RID. 02h = A-2 Stepping

### 3.7.6 SUBC3—Class Code Register (Device 3)

Address Offset: 0Ah  
 Default Value: 04h  
 Access: RO  
 Size: 8 bits

This register contains the Sub-Class Code for the MCH Device 3.

Bit	Description
7:0	<b>Sub-Class Code (SUBC)—RO.</b> This is an 8-bit value that indicates the category of bridge for the MCH Device 3. 04h = PCI-to-PCI bridge.

### 3.7.7 BCC3—Base Class Code Register (Device 3)

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

This register contains the Base Class Code of the MCH Device 3.

Bit	Description
7:0	<b>Base Class Code (BASEC)—RO.</b> This is an 8-bit value that indicates the Base Class Code for the MCH Device 3. 06h = Bridge device.

### 3.7.8 MLT3—Master Latency Timer Register (Device 3)

Address Offset: 0Dh  
 Default Value: 00h  
 Access: RO, RW  
 Size: 8 bits

This functionality is not applicable. It is described here since these bits should be implemented as a read/write to prevent standard PCI-to-PCI bridge configuration software from getting “confused.”

Bit	Description
7:3	<b>Scratchpad MLT (NA7:3)—R/W.</b> These bits return the value with which they are written; however, they have no internal function and are implemented as a Scratchpad merely to avoid confusing software.
2:0	Reserved

### 3.7.9 HDR3—Header Type Register (Device 3)

Address Offset: 0Eh  
 Default Value: 01h  
 Access: RO  
 Size: 8 bits

This register identifies the header layout of the configuration space.

Bit	Description
7:0	<b>Header Type Register (HDR)—RO.</b> 01h = MCH Device 3 is a single function device with bridge header layout.

### 3.7.10 PBUSN3—Primary Bus Number Register (Device 3)

Address Offset: 18h  
 Default Value: 00h  
 Access: RO  
 Size: 8 bits

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

Bit	Description
7:0	<b>Primary Bus Number (BUSN)—RO.</b> Configuration software typically programs this field with the number of the bus on the primary side of the bridge. Since Device 3 is an internal device and its primary bus is always 0, these bits are read only and are hardwired to 00h.

### 3.7.11 SBUSN3—Secondary Bus Number Register (Device 3)

Address Offset: 19h  
 Default Value: 00h  
 Access: R/W  
 Size: 8 bits

This register identifies the bus number assigned to the second bus side of the virtual PCI-to-PCI bridge (i.e., to CSA). This number is programmed by the PCI configuration software to allow mapping of configuration cycles to CSA.

Bit	Description
7:0	<b>Secondary Bus Number (BUSN)—R/W.</b> This field is programmed by configuration software with the bus number assigned to CSA.

### 3.7.12 SMLT3—Secondary Bus Master Latency Timer Register (Device 3)

Address Offset: 1Bh  
 Default Value: 00h  
 Access: RO  
 Size: 8 bits.

Bit	Description
7:0	Reserved

### 3.7.13 IOBASE3—I/O Base Address Register (Device 3)

Address Offset: 1Ch  
 Default Value: F0h  
 Access: RO, R/W  
 Size: 8 bits

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

$$IO\_BASE \leq address \leq IO\_LIMIT$$

Only the upper four 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.

Bit	Description
7:4	<b>I/O Address Base (IOBASE)—R/W.</b> This field corresponds to A[15:12] of the I/O addresses passed by bridge 1 to CSA.
3:0	Reserved

### 3.7.14 IOLIMIT3—I/O Limit Address Register (Device 3)

Address Offset: 1Dh  
 Default Value: 00h  
 Access: RO, RW  
 Size: 8 bits

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

$$IO\_BASE \leq address \leq IO\_LIMIT$$

Only the upper four 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.

Bit	Description
7:4	<b>I/O Address Limit (IOLIMIT)—R/W.</b> This field corresponds to A[15:12] of the I/O address limit of Device 3. Devices between this upper limit and IOBASE3 will be passed to CSA.
3:0	Reserved

### 3.7.15 SSTS3—Secondary Status Register (Device 3)

Address Offset: 1E–1Fh  
 Default Value: 02A0h  
 Access: RO, RWC  
 Size: 16 bits

SSTS3 is a 16 bit status register that reports the occurrence of error conditions associated with the secondary side (i.e., CSA side) of the virtual PCI-to-CSA bridge in the MCH.

**Note:** For R/WC bits, software must write a 1 to clear bits that are set.

Bit	Description
15	<b>Detected Parity Error (DPE)—RO.</b> Hardwired to 0 since parity is not supported on the CSA interface.
14	<b>Received System Error (RSE)—R/WC.</b> 0 = No system error signaled by CSA device. 1 = The CSA device signals a system error to the MCH.
13	<b>Received Master Abort Status (RMAS)—R/WC.</b> 0 = No master abort by MCH to terminate a Host-to-CSA transaction. 1 = The MCH terminated a Host-to-CSA with an unexpected master abort.
12	<b>Received Target Abort Status (RTAS)—R/WC.</b> 0 = No target abort for MCH-initiated transaction on CSA. 1 = MCH-initiated transaction on CSA was terminated with a target abort.
11	<b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0. The MCH does not generate target abort on CSA.
10:9	<b>DEVSEL# Timing (DEVT)—RO.</b> Hardwired to 01b. This 2-bit field indicates the timing of the DEVSEL# signal when the MCH responds as a target on CSA. The value 01b (medium) indicates the time when a valid DEVSEL# can be sampled by initiator of the PCI cycle.
8	<b>Master Data Parity Detected (DPD)—RO.</b> Hardwired to 0. MCH does not implement G_PERR# signal on CSA.
7	<b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 1. MCH, as a target, supports fast back-to-back transactions on CSA.
6	Reserved
5	<b>66/60 MHz PCI Capable (CAP66)—RO.</b> Hardwired to 1. CSA is 66 MHz capable.
4:0	Reserved



### 3.7.16 MBASE3—Memory Base Address Register (Device 3)

Address Offset: 20–21h  
 Default Value: FFF0h  
 Access: RO, RW  
 Size: 16 bits

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

$$\text{MEMORY\_BASE} \leq \text{address} \leq \text{MEMORY\_LIMIT}$$

The Upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32-bit address. The bottom 4 bits of this register are read only and return 0's 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. Thus, the bottom of the defined memory address range will be aligned to 1-MB boundary.

Bit	Description
15:4	<b>Memory Address Limit (MLIMIT)— R/W.</b> This bit corresponds to A[31:20] of the lower limit of the memory range that will be passed by Device 3 bridge to CSA.
3:0	Reserved

### 3.7.17 MLIMIT3—Memory Limit Address Register (Device 3)

Address Offset: 22–23h  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

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

$$\text{MEMORY\_BASE} \leq \text{address} \leq \text{MEMORY\_LIMIT}$$

The upper 12 bits of the register are read/write and correspond to the upper 12 address bits A[31:20] of the 32-bit address. The bottom 4 bits of this register are read only and return 0's 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 FFFFh. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block.

**Note:** Memory ranges covered by MBASE and MLIMIT registers are used to map non-prefetchable CSA 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 processor-CSA memory access performance.

**Note:** 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.

Bit	Description
15:4	<b>Memory Address Limit (MLIMIT)—R/W.</b> 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 3 bridge to CSA.
3:0	Reserved

### 3.7.18 PMBASE3—Prefetchable Memory Base Address Register (Device 3)

Address Offset: 24–25h  
 Default Value: FFF0h  
 Access: R/W, RO  
 Size: 16 bits

This register controls the processor-to-CSA prefetchable memory accesses routing based on the following formula:

$$\text{PREFETCHABLE\_MEMORY\_BASE} \leq \text{address} \leq \text{PREFETCHABLE\_MEMORY\_LIMIT}$$

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 0's 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. Thus, the bottom of the defined memory address range will be aligned to a 1-MB boundary.

Bit	Description
15:4	<b>Prefetchable Memory Address Base (PMBASE)—R/W.</b> This field corresponds to A[31:20] of the lower limit of the address range passed by bridge Device 3 across CSA.
3:0	Reserved

### 3.7.19 PMLIMIT3—Prefetchable Memory Limit Address Register (Device 3)

Address Offset: 26–27h  
 Default Value: 0000h  
 Access: R/W, RO  
 Size: 16 bits

This register controls the processor-to-CSA prefetchable memory accesses routing based on the following formula:

$$\text{PREFETCHABLE\_MEMORY\_BASE} \leq \text{address} \leq \text{PREFETCHABLE\_MEMORY\_LIMIT}$$

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 0's 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 FFFFh. Thus, the top of the defined memory address range will be at the top of a 1-MB aligned memory block. Note that prefetchable memory range is supported to allow segregation by the configuration software between the memory ranges that must be defined as UC and the ones that can be designated as a USWC (i.e., prefetchable) from the processor perspective.

Bit	Description
15:4	<b>Prefetchable Memory Address Limit (PMLIMIT)—R/W.</b> This field corresponds to A[31:20] of the upper limit of the address range passed by bridge Device 3 across CSA.
3:0	Reserved

### 3.7.20 BCTRL3—Bridge Control Register (Device 3)

Address Offset: 3Eh  
 Default Value: 00h  
 Access: R/W, RO  
 Size: 8 bits

Bit	Description
7	<b>Fast Back-to-Back Enable (FB2BEN)—RO.</b> Hardwired to 0. The MCH does not generate fast back-to-back cycles as a master on AGP.
6	<b>Secondary Bus reset (SREST)—RO.</b> Hardwired to 0. The MCH does not support generation of reset via this bit on the AGP.
5	<b>Master Abort Mode (MAMODE)—RO.</b> Hardwired to 0. This means that when acting as a master on CSA, the MCH will discard writes and return all 1's during reads when a Master Abort occurs.
4	Reserved
3	<b>VGA Enable (VGAEN)—R/W.</b> This bit controls the routing of processor-initiated transactions targeting VGA compatible I/O and memory address ranges. This bit works in conjunction with the MCHCFG[MDAP] bit (Device 0, offset C6h) as described in <a href="#">Table 10</a> . 0 = Disable 1 = Enable
2	<b>ISA Enable (ISAEN)—R/W.</b> This bit modifies the response by the MCH to an I/O access issued by the processor that targets ISA I/O addresses. This applies only to I/O addresses that are enabled by the IOBASE and IOLIMIT registers. 0 = Disable. All addresses defined by the IOBASE and IOLIMIT for processor I/O transactions will be mapped to CSA. (default) 1 = Enable. The MCH does not forward to CSA 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 CSA, these cycles are forwarded to HI where they can be subtractively or positively claimed by the ISA bridge.
1	<b>SERR Enable (SERREN)—RO.</b> Hardwired to 0. This bit normally controls forwarding SERR# on the secondary interface to the primary interface. The MCH does not support the SERR# signal on the CSA Bus.
0	<b>Parity Error Response Enable (PEREN)—RO.</b> Hardwired to 0.

**Table 10. VGAEN and MDAP Definitions**

VGAEN	MDAP	Description
0	0	All References to MDA and VGA space are routed to HI.
0	1	Illegal combination
1	0	All VGA references are routed to this bus. MDA references are routed to HI.
1	1	All VGA references are routed to this bus. MDA references are routed to HI.

### 3.7.21 ERRCMD3—Error Command Register Registers (Device 3)

Address Offset: 40h  
 Default Value: 00h  
 Access: R/W, RO  
 Size: 8 bits

Bit	Description
7:1	Reserved
0	<b>SERR on Receiving Target Abort (SERTA)—R/W.</b> 0 = The MCH does not assert a SERR message upon receipt of a target abort on CSA. 1 = The MCH generates a SERR message over CSA upon receiving a target abort on CSA. SERR messaging for Device 3 is globally enabled in the PCICMD3 register.

### 3.7.22 CSACNTRL—CSA Control Registers (Device 3)

Address Offset: 50–53h  
 Default Value: 0E042802h  
 Access: R/W, RO  
 Size: 32 bits

Bit	Description
31:29	<b>First Subordinate CSA (CSA_SUB_FIRST)—R/W.</b> This field stores the lowest subordinate CI hub number.
28	Reserved
27:25	<b>Last Subordinate CSA (CSA_SUB_LAST)—R/W.</b> This field stores the highest subordinate CSA hub number.
24:16	Reserved
15:14	<b>CSA Width (CSA_WIDTH)—R/W.</b> This field describes the used width of the data bus. 00 = 8 bit 01 = Reserved 10 = Reserved 11 = Reserved
13:0	Reserved

## 3.8 Overflow Configuration Registers (Device 6)

Device 6 is the Overflow Device for Device 0. The registers in this section are arranged in ascending order of the address offset. Table 11 provides the configuration register address map.

**Table 11. Overflow Device Configuration Register Address Map (Device 6)**

Address Offset	Register Symbol	Register Name	Default Value	Access
00–01h	VID6	Vendor Identification	8086h	RO
02–03h	DID6	Device Identification	2576h	RO
04–05h	PCICMD6	PCI Command Register	0000h	RO, R/W
06–07h	PCISTS6	PCI Status Register	0080h	RO
08h	RID6	Revision Identification	see register description	RO
09h	—	Reserved	—	—
0Ah	SUBC6	Sub-Class Code	80h	RO
0Bh	BCC6	Base Class Code	08h	RO
0Ch–0Dh	—	Reserved	—	—
0Eh	HDR6	Header Type	00h	RO
0Fh	—	Reserved	—	—
10–13h	BAR6	Base Address	00000000h	RO
14–2Bh	—	Reserved	—	—
2C–2Dh	SVID6	Subsystem Vendor Identification	0000h	R/WO
2E–2Fh	SID6	Subsystem Identification	0000h	R/WO
30–E6h	—	Reserved	—	—
E7–FFh	—	Reserved	—	—

### 3.8.1 VID6—Vendor Identification Register (Device 6)

Address Offset: 00–01h  
 Default Value: 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 identifies any PCI device.

Bit	Descriptions
15:0	<b>Vendor Identification (VID)—RO.</b> This register field contains the PCI standard identification for Intel.

### 3.8.2 DID6—Device Identification Register (Device 6)

Address Offset: 02–03h  
 Default Value: 2576h  
 Access: RO  
 Size: 16 bits

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

Bit	Descriptions
15:0	<b>Device Identification Number (DID)—RO.</b> This is a 16-bit value assigned to the MCH Host-HI Bridge Function 0.

### 3.8.3 PCICMD6—PCI Command Register (Device 6)

Address Offset: 04–05h  
 Default Value: 0000h  
 Access: RO, R/W  
 Size: 16 bits

Since MCH Device 0 does not physically reside on PCI\_A, many of the bits are not implemented.

Bit	Descriptions
15:10	Reserved
9	<b>Fast Back-to-Back Enable (FB2B)—RO.</b> Hardwired to 0.
8	<b>SERR Enable (SERRE)—RO.</b> Hardwired to 0.
7	<b>Address/Data Stepping Enable (ADSTEP)—RO.</b> Hardwired to 0.
6	<b>Parity Error Enable (PERRE)—RO.</b> Hardwired to 0.
5	<b>VGA Palette Snoop Enable (VGASNOOP)—RO.</b> Hardwired to 0.
4	<b>Memory Write and Invalidate Enable (MWIE)—RO.</b> Hardwired to 0.
3	<b>Special Cycle Enable (SCE)—RO.</b> Hardwired to 0.
2	<b>Bus Master Enable (BME)—RO.</b> Hardwired to 0.
1	<b>Memory Access Enable (MAE)—R/W.</b> Set this bit to 1 to enable Device 6 memory space accesses. 0 = Disable (default). 1 = Enable.
0	<b>I/O Access Enable (IOAE)—R/W.</b> This bit must be set to 1 to enable the I/O address range defined in the IOBASE3 and IOLIMIT3 registers. 0 = Disable (default). 1 = Enable.

### 3.8.4 PCISTS6—PCI Status Register (Device 6)

Address Offset: 06–07h  
 Default Value: 0080h  
 Access: RO  
 Size: 16 bits

PCISTS6 is a 16-bit status register that reports the occurrence of error events on Device 6, Function 0's PCI interface. Since MCH Device 6 does not physically reside on PCI\_0, many of the bits are not implemented.

Bit	Descriptions
15	<b>Detected Parity Error (DPE)—RO.</b> Hardwired to 0.
14	<b>Signaled System Error (SSE)—RO.</b> Hardwired to 0.
13	<b>Received Master Abort Status (RMAS)—RO.</b> Hardwired to 0.
12	<b>Received Target Abort Status (RTAS)—RO.</b> Hardwired to 0.
11	<b>Signaled Target Abort Status (STAS)—RO.</b> Hardwired to 0.
10:9	<b>DEVSEL Timing (DEVT)—RO.</b> Hardwired to 00. Device 6 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	<b>Master Data Parity Error Detected (DPD)—RO.</b> Hardwired to 0.
7	<b>Fast Back-to-Back (FB2B)—RO.</b> Hardwired to 1. 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	Reserved

### 3.8.5 RID6—Revision Identification Register (Device 6)

Address Offset: 08h  
 Default Value: See following table  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Revision Identification Number (RID)—RO.</b> This is an 8-bit value that indicates the revision identification number for the MCH Device 6. 02h = A-2 Stepping



### 3.8.6 SUBC6—Sub-Class Code Register (Device 6)

Address Offset: 0Ah  
 Default Value: 80h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Sub-Class Code (SUBC)—RO.</b> This is an 8-bit value that indicates the category of device for Device 6. 80h = Other system peripherals.

### 3.8.7 BCC6—Base Class Code Register (Device 6)

Address Offset: 0Bh  
 Default Value: 08h  
 Access: RO  
 Size: 8 bits

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

Bit	Descriptions
7:0	<b>Base Class Code (BASEC)—RO.</b> This is an 8-bit value that indicates the category of device for Device 6. 08h = Other system peripherals.

### 3.8.8 HDR6—Header Type Register (Device 6)

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

This register identifies the header layout of the configuration space.

Bit	Descriptions
7:0	<b>PCI Header (HDR)—RO.</b> This field indicates single function device with standard header layout.

### 3.8.9 BAR6—Memory Delays Base Address Register (Device 6)

Address Offset: 10–13h  
 Default Value: 00000000h  
 Access: RO, R/W  
 Size: 32 bits

This register is a standard PCI scheme to claim a memory-mapped address range. This memory-mapped address range can be enabled once the relevant enable bit in the PCI command register is set to 1.

Bit	Descriptions
31:12	<b>Memory base Address—R/W.</b> Set by the OS, these bits correspond to address signals [31:13].
11:4	<b>Address Mask—RO.</b> Hardwired to 00h to indicate 4-KB address range. This reserves 4 KB of memory-mapped address space.
3	<b>Prefetchable—RO.</b> This read only bit indicates the prefetchability of the requested memory address range. 0 = Not prefetchable. The memory range is not prefetchable and may have read side effects. 1 = Prefetchable. The memory address range is prefetchable (i.e., has no read side effects and returns all bytes on reads regardless of byte enables) and byte merging of write transactions is allowed.
2:1	<b>Memory Type (TYPE)—RO.</b> Hardwired to 00b to indicate that address range defined by the upper bits of this register can be located anywhere in the 32-bit address space as per the PCI specification for base address registers.
0	<b>Memory Space Indicator (MSPACE)—RO.</b> Hardwired to 0 to identify memory space.

### 3.8.10 SVID6—Subsystem Vendor Identification Register (Device 6)

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

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

Bit	Descriptions
15:0	<b>Subsystem Vendor ID (SUBVID)—R/WO.</b> 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.

### 3.8.11 SID6—Subsystem Identification Register (Device 6)

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

This value is used to identify a particular subsystem.

Bit	Descriptions
15:0	<b>Subsystem ID (SUBID)—R/WO.</b> This field should be programmed during BIOS initialization. After it has been written once, it becomes read only.

### 3.9 Device 6 Memory-Mapped I/O Register Space

The DRAM timing and delay registers are located in the memory-mapped register (MMR) space of Device 6. Table 12 provides the register address map for this set of registers.

**Note:** All accesses to these memory-mapped registers must be made as a single DWord (4 bytes) or less. Access must be aligned on a natural boundary.

**Table 12. Device 6 Memory-Mapped I/O Register Address Map**

Byte Address Offset	Register Symbol	Register Name	Default Value	Access
0000h	DRB0	DRAM row 0 Boundary	01h	RO, RW
0001h	DRB1	DRAM row 1 Boundary	01h	RO, RW
0002h	DRB2	DRAM row 2 Boundary	01h	RO, RW
0003h	DRB3	DRAM row 3 Boundary	01h	RO, RW
0004h	DRB4	DRAM row 4 Boundary	01h	RO, RW
0005h	DRB5	DRAM row 5 Boundary	01h	RO, RW
0006h	DRB6	DRAM row 6 Boundary	01h	RO, RW
0007h	DRB7	DRAM row 7 Boundary	01h	RO, RW
0008–000Bh	—	Intel Reserved	—	—
0010h	DRA0,1	DRAM row 0,1 Attribute	00h	RO, RW
0011h	DRA2,3	DRAM row 2,3 Attribute	00h	RO, RW
0012h	DRA4,5	DRAM row 4,5 Attribute	00h	RO, RW
0013h	DRA6,7	DRAM row 6,7 Attribute	00h	RO, RW
0014–005Fh	—	Intel Reserved	—	—
0060–0063h	DRT	DRAM Timing	0000 0000h	RW
0064–0067h	—	Intel Reserved	—	—
0068–006Bh	DRC	DRAM Controller Mode	0001 0001h	RW, RO
006C–FFFFh	—	Intel Reserved	—	—

### 3.9.1 DRB[0:7]—DRAM Row Boundary Register (Device 6, MMR)

Address Offset: 0000h–0007h (DRB0–DRB7)  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits for each register

The DRAM row Boundary registers define the upper boundary address of each DRAM row. Each row has its own single-byte DRB register. The granularity of these registers is 64 MB. For example, a value of 1 in DRB0 indicates that 64 MB of DRAM has been populated in the first row. When in single-channel mode, all four DRB registers are used. In this case, DRB[3:0] are used for the rows populated, then DRB[7:4] are programmed to the same value as DRB[3].

Row0: 0000h  
 Row1: 0001h  
 Row2: 0002h  
 Row3: 0003h  
 Row4: 0004h, reserved  
 Row5: 0005h, reserved  
 Row6: 0006h, reserved  
 Row7: 0007h, reserved  
 0008h, reserved  
 0009h, reserved  
 000Ah, reserved  
 000Bh, reserved  
 000Ch, reserved  
 000Dh, reserved  
 000Eh, reserved  
 000Fh, reserved

DRB0 = Total memory in Row0 (in 64-MB increments)  
 DRB1 = Total memory in Row0 + Row1 (in 64-MB increments)  
 DRB2 = Total memory in Row0 + Row1 + Row2 (in 64-MB increments)  
 DRB3 = Total memory in Row0 + Row1 + Row2 + Row3 (in 64-MB increments)  
 DRB4 = DRB3  
 DRB5 = DRB3  
 DRB6 = DRB3  
 DRB7 = DRB3

Each row is represented by a byte. Each byte has the following format:

Bit	Description
7	Reserved
6:0	<b>DRAM Row Boundary Address—R/W.</b> This 7-bit value defines the upper and lower addresses for each DRAM row. This 7-bit value is compared against address lines 0,31:26 (0 concatenated with the address bits 31:26) to determine to which row the incoming address is directed. Default= 0000001b

### 3.9.2 DRA— DRAM Row Attribute Register (Device 6, MMR)

Address Offset: 0010h–0013h  
 Default Value: 00h  
 Access: RO, R/W  
 Size: 8 bits for each register

The DRAM Row Attribute registers define the page sizes to be used when accessing different rows or pairs of rows. The minimum page size of 4 KB occurs when in single-channel mode and either 128-Mb, x16 devices are populated or 256-Mb, x16 devices are populated. Each nibble of information in the DRA registers describes the page size of a row or pair of rows: When in single-channel mode, registers 10h and 11h are used to specify page sizes for channel A and registers 12h and 13h must be left at the default value.

Row0, 1: 0010h  
 Row2, 3: 0011h  
 Row4, 5: Default  
 Row6, 7: Default

7	6	4	3	2	0
Rsvd	Row Attribute for Row 1		Rsvd	Row Attribute for Row 0	

7	6	4	3	2	0
Rsvd	Row Attribute for Row 3		Rsvd	Row Attribute for Row 2	

7	6	4	3	2	0
Rsvd	Row Attribute for Row 5		Rsvd	Row Attribute for Row 4	

7	6	4	3	2	0
Rsvd	Row Attribute for Row 7		Rsvd	Row Attribute for Row 6	

Bit	Description
7	Reserved
6:4	<b>Row Attribute for Odd-Numbered Row—R/W.</b> This field defines the page size of the corresponding row. If the associated row is not populated, this field must be left at the default value. 000 = 4 KB 001 = 8 KB 010 = 16 KB 011 = Reserved Others = Reserved
3	Reserved
2:0	<b>Row Attribute for Even-Numbered Row—R/W.</b> This field defines the page size of the corresponding row. If the associated row is not populated, this field must be left at the default value. 000 = 4 KB 001 = 8 KB 010 = 16 KB 011 = Reserved Others = Reserved

### 3.9.3 DRT—DRAM Timing Register (Device 6, MMR)

Address Offset: 0060h–0063h  
 Default Value: 00000000h  
 Access: R/W  
 Size: 32 bits

This register controls the timing of micro-commands. When in virtual single-channel mode, the timing fields specified here apply even if two back-to-back cycles are to different physical channels. That is, the controller acts as if the two cycles are to the same physical channel.

Bit	Description
31:11	Reserved
10	<p><b>Activate to Precharge Delay (<math>t_{RAS}</math>) Max—R/W.</b> These bits control the number of DRAM clocks for <math>t_{RAS}</math> maximum.</p> <p>0 = 120 micro-seconds            1 = 70 micro-seconds</p> <p>Note: DDR333 DRAM requires a shorter <math>t_{RAS}</math> (max) of 70 <math>\mu</math>s</p>
9:7	<p><b>Activate to Precharge delay (<math>t_{RAS}</math>), Min—R/W.</b> These bits control the number of DRAM clocks for <math>t_{RAS}</math> minimum.</p> <p>000 = 10 DRAM clocks            001 = 9 DRAM clocks            010 = 8 DRAM clocks            011 = 7 DRAM clocks            100 = 6 DRAM clocks            101 = 5 DRAM clocks            others = Reserved</p>
6:5	<p><b>CAS# Latency (<math>t_{CL}</math>)—R/W.</b></p> <p>00 = 2.5 DRAM clocks            01 = 2 DRAM clocks            10 = 3 DRAM clocks            11 = Reserved</p>
4	Reserved
3:2	<p><b>DRAM RAS# to CAS# Delay (<math>t_{RCD}</math>)—R/W.</b> This bit controls the number of clocks inserted between an activate command and a read or write command to that bank.</p> <p>00 = 4 DRAM clocks            01 = 3 DRAM clocks            10 = 2 DRAM clocks            11 = Reserved</p>
1:0	<p><b>DRAM RAS# Precharge (<math>t_{RP}</math>)—R/W.</b> This bit controls the number of clocks that are inserted between a precharge command and an activate command to the same bank.</p> <p>00 = 4 DRAM clocks            01 = 3 DRAM clocks            10 = 2 DRAM clocks            11 = Reserved</p>

### 3.9.4 DRC—DRAM Controller Mode Register (Device 6, MMR)

Address Offset: 0068h–006Bh  
 Default Value: 00000001h  
 Access: R/W, RO  
 Size: 32 bits

Bit	Description
31:30	Reserved
29	<b>Initialization Complete (IC)—R/W.</b> This bit is used for communication of the software state between the memory controller and the BIOS. 1 = BIOS sets this bit to 1 after initialization of the DRAM memory array is complete.
28:23	Reserved
22:21	<b>Number of Channels (CHAN)—R/W.</b> The MCH memory controller modes of operation. 00 = Single-channel 01 = Reserved 10 = Reserved 11 = Reserved
20:11	Reserved
10:8	<b>Refresh Mode Select (RMS)—R/W.</b> This field determines whether refresh is enabled and, if so, at what rate refreshes will be executed. 000 = Reserved 001 = Refresh enabled. Refresh interval 15.6 $\mu$ sec 010 = Refresh enabled. Refresh interval 7.8 $\mu$ sec 011 = Refresh enabled. Refresh interval 64 $\mu$ sec 111 = Refresh enabled. Refresh interval 64 clocks (fast refresh mode) Other = Reserved
7	Reserved

Bit	Description
6:4	<p><b>Mode Select (SMS)—R/W.</b> These bits select the special operational mode of the DRAM interface. The special modes are intended for initialization at power up. Note that FCSEN (fast CS#) must be set to 0 while SMS cycles are performed. It is expected that BIOS may program FCSEN to possible 1 only after initialization.</p> <p>000 = Post Reset state – When the MCH exits reset (power-up or otherwise), the mode select field is cleared to 000.</p> <p>During any reset sequence, while power is applied and reset is active, the MCH de-asserts all CKE signals. After internal reset is de-asserted, CKE signals remain de-asserted until this field is written to a value different than 000. On this event, all CKE signals are asserted.</p> <p>During suspend (S3, S4), MCH internal signal triggers DRAM controller to flush pending commands and enter all rows into self-refresh mode. As part of resume sequence, the MCH will be reset – which will clear this bit field to 000 and maintain CKE signals de-asserted. After internal reset is de-asserted, CKE signals remain de-asserted until this field is written to a value different than 000. On this event, all CKE signals are asserted.</p> <p>001 = NOP Command Enable – All processor cycles to DRAM result in a NOP command on the DRAM interface.</p> <p>010 = All Banks Pre-charge Enable – All processor cycles to DRAM result in an “all banks precharge” command on the DRAM interface.</p> <p>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 DRAM address lines in order to specify the command sent. Host address HA[13:3] are mapped to memory address SMA[5:1].</p> <p>100 = Extended Mode Register Set Enable – All processor cycles to DRAM result in an “extended mode register set” command on the DRAM interface. Host address lines are mapped to DRAM address lines in order to specify the command sent. Host address lines are mapped to DRAM address lines in order to specify the command sent. Host address HA[13:3] are mapped to memory address SMA[5:1].</p> <p>101 = Reserved</p> <p>110 = CBR Refresh Enable – In this mode all processor cycles to DRAM result in a CBR cycle on the DRAM interface</p> <p>111 = Normal operation</p>
3:2	Reserved
1:0	<p><b>DRAM Type (DT)—RO.</b> This field select between supported DRAM types.</p> <p>00 = Reserved</p> <p>01 = Dual data rate DRAM</p> <p>Other = Reserved</p>



# System Address Map

# 4

A processor system based on the 848P chipset supports 2 GB of addressable memory space and 64 KB+3 of addressable I/O space. There is a programmable memory address space under the 1-MB region that is divided into regions that can be individually controlled with programmable attributes such as disable, read/write, write only, or read only. Attribute programming is described in [Chapter 3](#). This section focuses on how the memory space is partitioned and the use of the separate memory regions.

The Pentium 4 processor with 512-KB L2 cache on 0.13 micron process in a 478-pin package processor family and the Pentium 4 processor 90 nm process support addressing of memory ranges larger than 4 GB. The MCH claims any processor access over 4 GB and terminates the transaction without forwarding it to the hub interface or AGP (discarding the data terminates writes). For reads, the MCH returns all 0's on the host bus. Note that the 848P chipset platform does not support the PCI Dual Address Cycle Mechanism; therefore, the platform does not allow addressing of greater than 4 GB on either the hub interface or AGP interface.

In the following sections, it is assumed that all of the compatibility memory ranges reside on the hub interface/PCI. The exception to this rule is VGA ranges, that may be mapped to AGP. In the absence of more specific references, cycle descriptions referencing PCI should be interpreted as the hub interface/PCI, while cycle descriptions referencing AGP are related to the AGP bus.

The 848P chipset memory map includes a number of programmable ranges.

**Note:** All of these ranges must be unique and non-overlapping. There are no hardware interlocks to prevent problems in the case of overlapping ranges. Accesses to overlapped ranges may produce indeterminate results.

## 4.1 System Memory Address Ranges

The MCH provides a maximum system memory address decode space of 4 GB. The MCH does not remap APIC memory space. The MCH does not limit system memory space in hardware. **It is the BIOS or system designers responsibility to limit memory population so that adequate PCI, AGP, High BIOS, and APIC memory space can be allocated.** [Figure 9](#) provides a simplified system memory address map. [Figure 10](#) provides additional details on mapping specific memory regions as defined and supported by the MCH.

Figure 9. Memory System Address Map

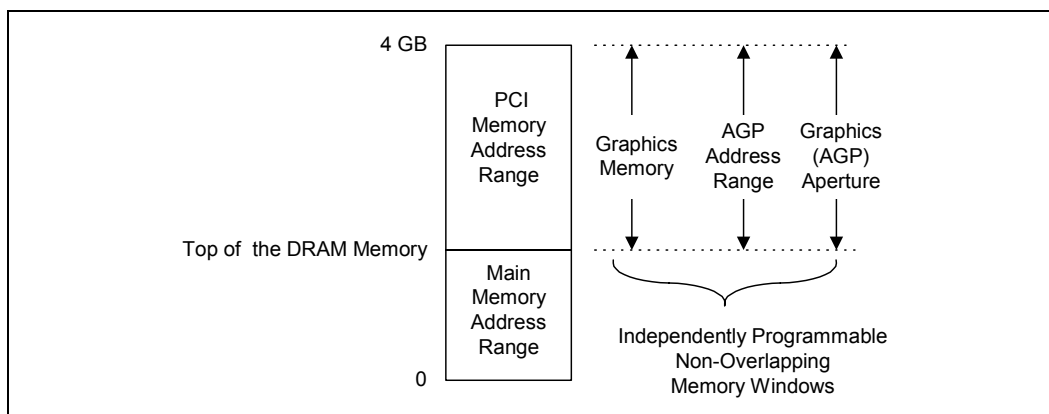
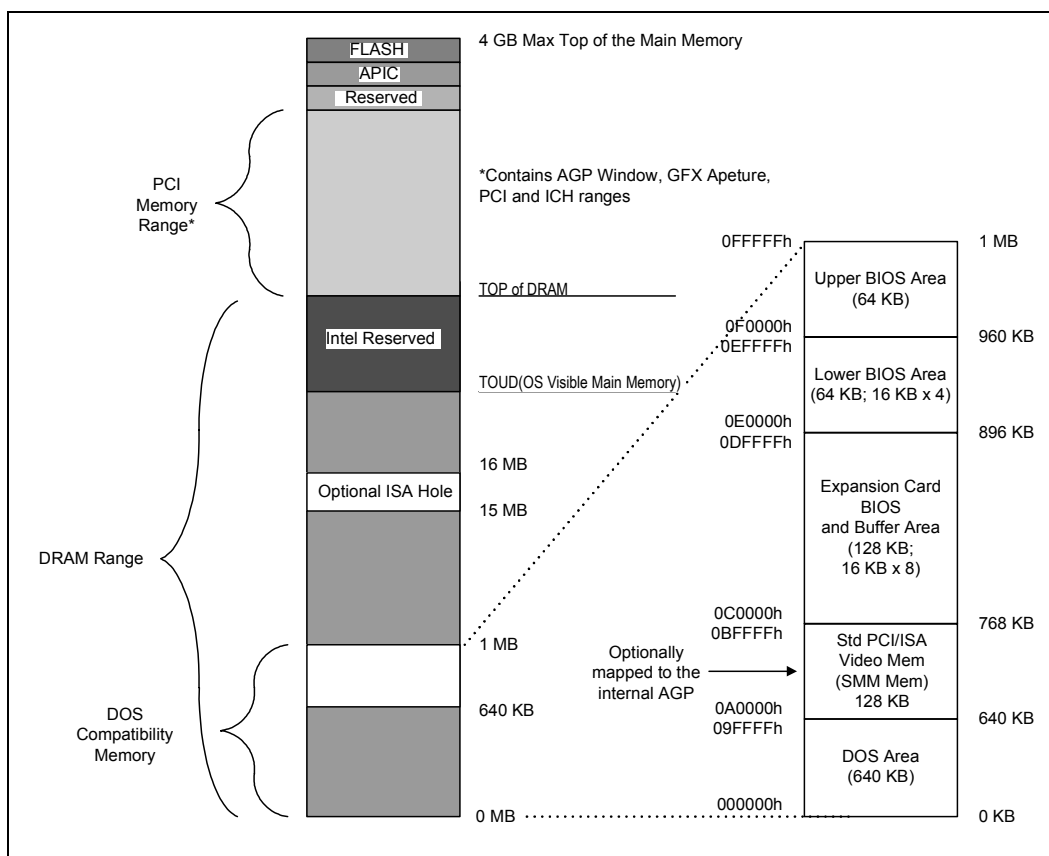


Figure 10. Detailed Memory System Address Map



## 4.2 Compatibility Area

This area is divided into the following address regions:

- 0–640 KB Microsoft\* MS-DOS Area.
- 640–768 KB video buffer area.
- 768–896 KB in 16-KB sections (total of eight sections) – Expansion Area.
- 896–960 KB in 16-KB sections (total of four sections) – Extended System BIOS Area.
- 960 KB–1 MB memory (BIOS Area) – System BIOS area.

There are fifteen memory segments in the compatibility area (see [Table 13](#)). Thirteen of the memory ranges can be enabled or disabled independently for both read and write cycles.

**Table 13. Memory Segments and Their Attributes**

Memory Segments	Attributes	Comments
000000h–09FFFFh	Fixed: always mapped to main DRAM	0 to 640 KB – MS-DOS* Region
0A0000h–0BFFFFh	mapped to hub interface or AGP: configurable as SMM space	Video Buffer (physical DRAM configurable as SMM space)
0C0000h–0C3FFFh	WE RE	Add-on BIOS
0C4000h–0C7FFFh	WE RE	Add-on BIOS
0C8000h–0CBFFFh	WE RE	Add-on BIOS
0CC000h–0CFFFFh	WE RE	Add-on BIOS
0D0000h–0D3FFFh	WE RE	Add-on BIOS
0D4000h–0D7FFFh	WE RE	Add-on BIOS
0D8000h–0DBFFFh	WE RE	Add-on BIOS
0DC000h–0DFFFFh	WE RE	Add-on BIOS
0E0000h–0E3FFFh	WE RE	BIOS Extension
0E4000h–0E7FFFh	WE RE	BIOS Extension
0E8000h–0EBFFFh	WE RE	BIOS Extension
0EC000h–0EFFFFh	WE RE	BIOS Extension
0F0000h–0FFFFFFh	WE RE	BIOS Area

### **DOS Area (00000h–9FFFFh)**

The DOS area is 640 KB in size and is always mapped to the main memory controlled by the MCH.

### **Legacy VGA Ranges (A0000h–BFFFFh)**

The legacy 128-KB VGA memory range A0000h–BFFFFh (Frame Buffer) can be mapped to AGP/PCI\_B (Device 1) and/or to the hub interface, depending on the programming of the VGA steering bits. Priority for VGA mapping is constant in that the MCH always decodes internally mapped devices first. The MCH always positively decodes internally mapped devices, namely the AGP/PCI\_B. Subsequent decoding of regions mapped to AGP/PCI\_B or the hub interface depends on the Legacy VGA configurations bits (VGA Enable and MDAP). This region is also the default for SMM space.

### **Compatible SMRAM Address Range (A0000h–BFFFFh)**

When compatible SMM space is enabled, SMM-mode processor accesses to this range are routed to physical system memory at this address. Non-SMM-mode processor accesses to this range are considered to be to the video buffer area as described above. AGP and hub interface originated cycles to enabled SMM space are not allowed and are considered to be to the video buffer area.

### **Monochrome Adapter (MDA) Range (B0000h–B7FFFh)**

Legacy support requires the ability to have a second graphics controller (monochrome) in the system. Accesses in the standard VGA range are forwarded to AGP/PCI\_B and the hub interface (depending on configuration bits). Since the monochrome adapter may be mapped to anyone of these devices, the MCH must decode cycles in the MDA range and forward them either to AGP/PCI\_B, or to the hub interface. This capability is controlled by VGA steering bits and the legacy 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 the either the AGP/PCI\_B or the hub interface.

### **Expansion Area (C0000h–DFFFFh)**

This 128-KB 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. Memory that is disabled is not remapped.

### **Extended System BIOS Area (E0000h–EFFFFh)**

This 64-KB area 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 the hub interface. Typically, this area is used for RAM or ROM. Memory segments that are disabled are not remapped elsewhere.

### **System BIOS Area (F0000h–FFFFFFh)**

This area 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 the hub interface. By manipulating the read/write attributes, the MCH can “shadow” BIOS into the main memory. When disabled, this segment is not remapped.

## 4.3 Extended Memory Area

This memory area covers 100000h (1 MB) to FFFFFFFFh (4 GB – 1) address range and it is divided into the following regions:

- Main system memory from 1 MB to the Top of Memory; maximum of 2-GB system memory.
- AGP or PCI memory space from the Top of Memory to 4 GB, with two specific ranges:
  - APIC Configuration Space from FEC0\_0000h (4 GB-20 MB) to FECF\_FFFFh and FEE0\_0000h to FEEF\_FFFFh
  - High BIOS area from 4 GB to 4 GB – 2 MB

### Main System DRAM Address Range (0010\_0000h to Top of Main Memory)

The address range from 1 MB to the top of main memory is mapped to main system memory address range controlled by the MCH. The Top of Main Memory (TOMM) is limited to 4 GB. All accesses to addresses within this range will be forwarded by the MCH to the system memory unless a hole in this range is created using the fixed hole as controlled by the FDHC register. Accesses within this hole are forwarded to the hub interface.

The MCH provides a maximum system memory address decode space of 4 GB. The MCH does not remap APIC memory space. The MCH does not limit system memory address space in hardware.

#### 4.3.1 15-MB–16-MB Window

A hole can be created at 15 MB–16 MB as controlled by the fixed hole enable (FDHC register) in Device 0 space. Accesses within this hole are forwarded to the hub interface. The range of physical system memory disabled by opening the hole is not remapped to the Top of the memory – that physical system memory space is not accessible. This 15 MB–16 MB hole is an optionally enabled ISA hole. Video accelerators originally used this hole. There is no inherent BIOS request for the 15 MB–16 MB hole.

#### 4.3.2 Pre-Allocated Memory

Voids of physical addresses that are not accessible as general system memory and reside within system memory address range (< TOSM) are created for SMM-mode and legacy VGA graphics compatibility. For VGA graphics compatibility, pre-allocated memory is only required in non-local memory configurations. **It is the responsibility of BIOS to properly initialize these regions.** Table 14 details the location and attributes of the regions. Enabling/Disabling these ranges are described in the MCH Control Register Device 0 (GC).

**Table 14. Pre-Allocated Memory**

Memory Segments	Attributes	Comments
00000000h–03E7FFFFh	R/W	Available system memory 62.5 MB
03E80000h–03EFFFFFFh	SMM mode only - processor reads	TSEG address range
03E80000h–03EFFFFFFh	SMM mode only - processor reads	TSEG Pre-allocated memory
03F00000h– 03FFFFFFh	R/W	Pre-allocated graphics VGA memory.

## Extended SMRAM Address Range (HSEG and TSEG)

The HSEG and TSEG SMM transaction address spaces reside in this extended memory area.

### HSEG

SMM-mode processor accesses to enabled HSEG are remapped to 000A0000h–000BFFFFh. Non-SMM-mode processor accesses to enabled HSEG are considered invalid and are terminated immediately on the FSB. The exceptions to this rule are Non-SMM-mode write back cycles that are remapped to SMM space to maintain cache coherency. AGP and hub interface originated cycles to enabled SMM space are not allowed. Physical DRAM behind the HSEG transaction address is not remapped and is not accessible.

### TSEG

TSEG can be up to 1 MB in size and is the first block after the top of usable physical memory. SMM-mode processor accesses to enabled TSEG access the physical system memory at the same address. Non-SMM-mode processor accesses to enabled TSEG are considered invalid and are terminated immediately on the FSB. The exceptions to this rule are Non-SMM-mode write back cycles that are directed to the physical SMM space to maintain cache coherency. AGP and hub interface originated cycles to enabled SMM space are not allowed.

The size of the SMRAM space is determined by the USMM value in the SMRAM register. When the extended SMRAM space is enabled, non-SMM processor accesses and all other accesses in this range are forwarded to the hub interface. When SMM is enabled, the amount of memory available to the system is equal to the amount of physical system memory minus the value in the TSEG register.

## PCI Memory Address Range (Top of Main Memory to 4 GB)

The address range from the top of main system memory to 4 GB (top of physical memory space supported by the MCH) is normally mapped via the hub interface to PCI.

As a memory controller hub, there is one exception to this rule.

- Addresses decoded to MMIO for DRAM RCOMP configuration registers.

As an AGP configuration, there are two exceptions to this rule.

- Addresses decoded to the AGP memory window defined by the MBASE, MLIMIT, PMBASE, and PMLIMIT registers are mapped to AGP.
- Addresses decoded to the graphics aperture range defined by the APBASE and APSIZE registers are mapped to the main system memory.

**Caution:** There are two sub-ranges within the PCI memory address range defined as APIC configuration space and High BIOS address range. Similarly, as an AGP device, the AGP memory window and graphics aperture window **MUST NOT** overlap with these two ranges. These ranges are described in detail in the following paragraphs.

### APIC Configuration Space (FEC0\_0000h–FECF\_FFFFh, FEE0\_0000h– FEEF\_FFFFh)

This range is reserved for APIC configuration space that includes the default I/O APIC configuration space. The default Local APIC configuration space is FEE0\_0000h to FEEF\_0FFFh.

Processor accesses to the Local APIC configuration space do not result in external bus activity since the Local APIC configuration space is internal to the processor. However, an MTRR must be programmed to make the Local APIC range uncacheable (UC). The Local APIC base address in each processor should be relocated to the FEC0\_0000h (4 GB–20 MB) to FECF\_FFFFh range so that one MTRR can be programmed to 64 KB for the Local and I/O APICs. The I/O APIC(s) usually reside in the ICH5 portion of the chipset or as a stand-alone component(s).

I/O APIC units will be located beginning at the default address FEC0\_0000h. The first I/O APIC will be located at FEC0\_0000h. Each I/O APIC unit is located at FEC0\_x000h where *x* is I/O APIC unit number 0 through F(hex). This address range will be normally mapped to the hub interface.

**Note:** There is no provision to support an I/O APIC device on AGP.

The address range between the APIC configuration space and the High BIOS (FED0\_0000h to FFDF\_FFFFh) is always mapped to the hub interface.

### High BIOS Area (FFE0\_0000h–FFFF\_FFFFh)

The top 2 MB of the extended memory region is reserved for system BIOS (High BIOS), extended BIOS for PCI devices, and the A20 alias of the system BIOS. The processor begins execution from the High BIOS after reset. This region is mapped to the hub interface so that the upper subset of this region aliases to the 16 MB–256 KB range. The actual address space required for the BIOS is less than 2 MB but the minimum processor MTRR range for this region is 2 MB so that full 2 MB must be considered.

## 4.4 AGP Memory Address Ranges

The MCH can be programmed to direct memory accesses to the AGP bus interface when addresses are within either of two ranges specified via registers in MCH's Device 1 configuration space. The first range is controlled via the Memory Base Register (MBASE) and Memory Limit Register (MLIMIT) registers. The second range is controlled via the Prefetchable Memory Base (PMBASE) and Prefetchable Memory Limit (PMLIMIT) registers

Conceptually, address decoding for each range follows the same basic concept. The top 12 bits of the respective Memory Base and Memory Limit registers correspond to address bits A[31:20] of a memory address. For the purpose of address decoding, the MCH assumes that address bits A[19:0] of the memory base are zero and that address bits A[19:0] of the memory limit address are FFFFFh. This forces each memory address range to be aligned to 1-MB boundary and to have a size granularity of 1 MB.

The MCH positively decodes memory accesses to AGP memory address space as defined by the following equations:

$$\text{Memory\_Base\_Address} \leq \text{Address} \leq \text{Memory\_Limit\_Address}$$

$$\text{Prefetchable\_Memory\_Base\_Address} \leq \text{Address} \leq \text{Prefetchable\_Memory\_Limit\_Address}$$

The window size is programmed by the plug-and-play configuration software. The window size depends on the size of memory claimed by the AGP device. Normally, these ranges reside above the Top-of-Main Memory and below High BIOS and APIC address ranges. They normally reside above the top of memory (TOUD) so they do not steal any physical system memory space.

It is essential to support a separate prefetchable range in order to apply USWC attribute (from the processor point of view) to that range. The USWC attribute is used by the processor for write combining.

Note that the MCH Device 1 memory range registers described above are used to allocate memory address space for any devices on AGP that requires such a window. These devices would include the AGP device, PCI-66 MHz/1.5 V agents, and multifunctional AGP devices where one or more functions are implemented as PCI devices.

The PCICMD1 register can override the routing of memory accesses to AGP. In other words, the memory access enable bit must be set in the Device 1 PCICMD1 register to enable the memory base/limit and prefetchable base/limit windows.



# Functional Description

# 5

This chapter describes the MCH interfaces and functional units including the processor system bus interface, the AGP interface, system memory controller, power management, and clocking.

## 5.1 Processor Front Side Bus (FSB)

The MCH can use a single mPGA478 processor (Pentium 4 processor with 512-KB L2 cache on 0.13 micron process in a 478-pin package or the Pentium 4 processor on 90 nm process). The MCH supports a FSB frequency of 400 MHz, 533 MHz, and 800 MHz using a scalable FSB VTT voltage and on-die termination. The MCH supports 32-bit host addressing, decoding up to 4 GB of the processor's memory address space. Host-initiated I/O cycles are decoded to the AGP/PCI\_B, hub interface, or the MCH configuration space. Host-initiated memory cycles are decoded to the AGP/PCI\_B, hub interface, or system memory. All memory accesses from the host interface that hit the graphics aperture are translated using an AGP address translation table. AGP/PCI\_B device accesses to non-cacheable system memory are not snooped on the host bus. Memory accesses initiated from AGP/PCI\_B using PCI semantics and from the hub interface to system memory will be snooped on the host bus.

### 5.1.1 FSB Overview

The MCH supports the Pentium 4 processor subset of the Enhanced Mode Scalable Bus. The cache line size is 64 bytes. Source synchronous transfers are used for the address and data signals. At 100 MHz, 133 MHz, and 200 MHz bus clock the address signals are double pumped to run at 200 MHz, 266 MHz, and 400 MHz and a new address can be generated every other bus clock. At 100 MHz, 133 MHz, and 200 MHz bus clock, the data signals are quad pumped to run at 400 MHz, 533 MHz, and 800 MHz and an entire 64-B cache line can be transferred in two bus clocks.

The MCH integrates AGTL+ termination resistors on die. The MCH has an IOQ depth of 12. The MCH supports one outstanding deferred transaction on the FSB.

### 5.1.2 FSB Dynamic Bus Inversion

The MCH supports Dynamic Bus Inversion (DBI) when driving and when receiving data from the processor. DBI limits the number of data signals that are driven to a low voltage on each quad pumped data phase. This decreases the worst-case power consumption of the MCH. DINV[3:0]# indicate if the corresponding 16 bits of data are inverted on the bus for each quad pumped data phase:

DINV[3:0]#	Data Bits
DINV0#	HD[15:0]#
DINV1#	HD[31:16]#
DINV2#	HD[47:32]#
DINV3#	HD[63:48]#

When the processor or the MCH drive data, each 16-bit segment is analyzed. If more than 8 of the 16 signals would normally be driven low on the bus, the corresponding DINV# signal will be asserted and the data will be inverted prior to being driven on the bus. When the processor or the MCH receives data, it monitors DINV[3:0]# to determine if the corresponding data segment should be inverted.

### 5.1.3 FSB Interrupt Overview

Pentium 4 processors support FSB interrupt delivery. They do **not** support the APIC serial bus interrupt delivery mechanism. Interrupt-related messages are encoded on the FSB as “Interrupt Message Transactions.” In the 848P chipset platform FSB interrupts may originate from the processor on the system bus, or from a downstream device on the hub interface, or AGP. In the later case the MCH drives the “Interrupt Message Transaction” onto the system bus.

In the 848P chipset environment the ICH5 contains IOxAPICs, and its interrupts are generated as upstream hub interface memory writes. Furthermore, PCI 2.3 defines MSIs (Message Signaled Interrupts) that are also in the form of memory writes. A PCI 2.3 device may generate an interrupt as an MSI cycle on its PCI bus instead of asserting a hardware signal to the IOxAPIC. The MSI may be directed to the IOxAPIC which in turn generates an interrupt as an upstream hub interface memory write. Alternatively, the MSI may be directed directly to the FSB. The target of an MSI is dependent on the address of the interrupt memory write. The MCH forwards inbound hub interface and AGP/PCI (PCI semantic only) memory writes to address 0FEEEx\_xxxxh to the FSB as “Interrupt Message Transactions.”

### 5.1.4 Upstream Interrupt Messages

The MCH accepts message-based interrupts from PCI (**PCI semantics only**) or its hub interface and forwards them to the FSB as Interrupt Message Transactions. The interrupt messages presented to the MCH are in the form of memory writes to address 0FEEEx\_xxxxh. At the hub interface or PCI interface, the memory write interrupt message is treated like any other memory write; it is either posted into the inbound data buffer (if space is available) or retried (if data buffer space is not immediately available). Once posted, the memory write from PCI or the hub interface to address 0FEEEx\_xxxxh is decoded as a cycle that needs to be propagated by the MCH to the FSB as an Interrupt Message Transaction.

## 5.2 System Memory Controller

The MCH can be configured to support DDR266, DDR333, and DDR400 memory in single channel mode. This includes support for:

- Up to 2 GB of 266 MHz DDR DRAM, 333 MHz DDR DRAM, and 400 MHz DDR DRAM
- DDR266, DDR333 and DDR400 unbuffered 184-pin DDR DRAM DIMMs
- DIMMs supported are single-sided and/or double-sided
- Byte masking on writes through data masking

**Table 15. System Memory Capacity**

DRAM Technology	Smallest Increments	Largest Increments	Maximum Capacity (2 DS DIMMs)
128 Mb	64 MB	256 MB	512 MB
256 Mb	128 MB	512 MB	1024 MB
512 Mb	256 MB	1024 MB	2048 MB

**NOTE:** The *Smallest Increments* column also represents the smallest possible single DIMM capacity.

## 5.2.1 DRAM Technologies and Organization

- All standard 128-Mb, 256-Mb, and 512-Mb technologies and addressing are supported for x16 and x8 devices
- All supported devices have 4 banks
- The MCH supports page sizes. Page size is individually selected for every row
  - 4 KB, 8 KB, 16 KB for single-channel mode
- There can be a maximum of four rows populated (two double-sided DIMMs)
- Mixed mode DDR DS-DIMMs (x8 and x16 on same DIMM) are not supported
- By using 512-Mb technology, the largest memory capacity is 2 GB (64M x 8b x 8 devices x 4 rows = 2 GB)
- By using 128-Mb technology, the smallest memory capacity is 64 MB (8M x 16b x 4 devices x 1 rows = 64 MB)

## 5.2.2 Memory Operating Mode

### 5.2.2.1 Dynamic Addressing Mode

When the MCH is configured to operate in this mode, FSB-to-memory bus address mapping undergoes a significant change compared to that of a linear operating mode (normal operating mode). In non-dynamic mode, the row selection (row indicates the side of a DIMM) via chip select signals is accomplished based on the size of the row. For example, for 512-Mb, 16Mx8x4b has a row size of 512 MB selected by CS0# and only four open pages can be maintained for the full 512 MB. This lowers the memory performance (increases read latencies) if most of the memory cycles are targeted to that single row, resulting in opening and closing of accessed pages in that row.

Dynamic addressing mode minimizes the overhead of opening/closing pages in memory banks allowing for row switching to be done less often.

Data will be accessed in chunks of 64 bits (8 B) from the memory channels. For Dynamic Mode operation, the requirement is to have even number of rows (side of the DIMM) populated. Dynamic mode operation can be enabled with one single-sided (SS), two SS or two double-sided (DS).

### 5.2.2.2 Linear Mode

This mode is the normal mode of operation for the MCH.

### 5.2.3 Memory Address Translation and Decoding

The address translation and decoding for the MCH is provided in Table 16 through Table 17. The supported DIMM configurations are listed in the following bullets. Refer to Section 5.2.4 for details about the configurations being double-sided versus single-sided.

- Technology 128 Mbit – 16Mx8 – page size of 8 KB – row size of 128 MB
- Technology 128 Mbit – 8Mx16 – page size of 4 KB – row size of 64 MB
- Technology 256 Mbit – 32Mx8 – page size of 8 KB – row size of 256 MB
- Technology 256 Mbit – 16Mx16 – page size of 4 KB – row size of 128 MB
- Technology 512 Mbit – 32Mx16 – page size of 8 KB – row size of 256 MB
- Technology 512 Mbit – 64Mx8 – page size of 16 KB – row size of 512 MB

**Note:** In Table 16 through Table 17 A0, A1, ... refers to memory address MA0, MA1, .... The table cell contents refers to host address signals HAx.

**Table 16. DRAM Address Translation (Single-Channel Mode) (Non-Dynamic Mode)**

Tech.	Config.	Row size Page size	Row / Column / Bank		Addr	BA1	BA0	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
128Mb	8Mx16	64MB	12x9x2	Row	25	13	12		16	15	14	25	24	23	22	21	20	19	18	17
		4KB		Col		13	12			AP		11	10	9	8	7	6	5	4	3
128Mb	16Mx8	128MB	12x10x2	Row	26	14	13		16	15	26	25	24	23	22	21	20	19	18	17
		8KB		Col		14	13			AP	12	11	10	9	8	7	6	5	4	3
256Mb	16Mx16	128MB	13x9x2	Row	26	13	12	26	16	15	14	25	24	23	22	21	20	19	18	17
		4KB		Col		13	12			AP		11	10	9	8	7	6	5	4	3
256Mb	32Mx8	256MB	13x10x2	Row	27	14	13	27	16	15	26	25	24	23	22	21	20	19	18	17
		8KB		Col		14	13			AP	12	11	10	9	8	7	6	5	4	3
512Mb	32Mx16	256MB	13x10x2	Row	27	14	13	27	16	15	26	25	24	23	22	21	20	19	18	17
		8KB		Col		14	13			AP	12	11	10	9	8	7	6	5	4	3
512Mb	64Mx8	512MB	13x11x2	Row	28	15	14	28	16	27	26	25	24	23	22	21	20	19	18	17
		16KB		Col		15	14		13	AP	12	11	10	9	8	7	6	5	4	3

**Table 17. DRAM Address Translation (Single-Channel Mode) (Dynamic Mode)**

Tech.	Config.	Row size Page size	Row / Column / Bank	Addr	BA1	BA0	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	
128Mb	8Mx16	64MB	12x9x2	Row	25	12	18		16	13	14	27	26	23	22	21	25	24	15	17
		4KB		Col		12	18			AP		11	10	9	8	7	6	5	4	3
128Mb	16Mx8	128MB	12x10x2	Row	26	18	13		16	14	26	28	27	23	22	21	25	24	15	17
		8KB		Col		18	13			AP	12	11	10	9	8	7	6	5	4	3
256Mb	16Mx16	128MB	13x9x2	Row	26	12	18	26	16	13	14	28	27	23	22	21	25	24	15	17
		4KB		Col		12	18			AP		11	10	9	8	7	6	5	4	3
256Mb	32Mx8	256MB	13x10x2	Row	27	18	13	27	16	14	26	25	24	23	22	21	29	28	15	17
		8KB		Col		18	13			AP	12	11	10	9	8	7	6	5	4	3
512Mb	32Mx16	256MB	13x10x2	Row	27	18	13	27	16	14	26	25	24	23	22	21	29	28	15	17
		8KB		Col		18	13			AP	12	11	10	9	8	7	6	5	4	3
512Mb	64Mx8	512MB	13x11x2	Row	28	14	18	28	16	27	26	25	24	23	22	21	30	29	15	17
		16KB		Col		14	18		13	AP	12	11	10	9	8	7	6	5	4	3

### 5.2.4 Memory Organization and Configuration

In the following discussion the term “row” refers to a set of memory devices that are simultaneously selected by a chip select signal. The MCH supports a maximum of four rows of memory. For the purposes of this discussion, a “side” of a DIMM is equivalent to a “row” of DRAM devices.

The memory bank address lines and the address lines allow the MCH to support 64-bit wide x8 and x16 DIMMs using 128-Mb, 256-Mb, and 512-Mb DRAM technology.

For the DDR DRAM interface, [Table 18](#) lists the supported configurations. Note that the MCH supports configurations defined in the JEDEC DDR DIMM specification only (A,B,C). Non-JEDEC standard DIMMs (e.g., double-sided x16 DDR DRAM DIMMs) are not supported. More information on DIMM configurations can be found in the *JEDEC DDR DIMM specification*.

**Table 18. Supported DDR DIMM Configurations**

Density	128 Mbit		256 Mbit		512 Mbit	
Device Width	x8	x16	x8	x16	x8	x16
Single / Double	SS/DS	SS/DS	SS/DS	SS/DS	SS/DS	SS/DS
184 pin DDR DIMMs	128/256 MB	64 MB/NA	256/512 MB	128 MB/NA	512/1024 MB	256 MB/NA

## 5.2.5 Configuration Mechanism for DIMMS

Detection of the type of DRAM installed on the DIMM is supported via Serial Presence Detect (SPD) mechanism as defined in the JEDEC DIMM specification. This uses the SCL, SDA, and SA[2:0] pins on the DIMMs to detect the type and size of the installed DIMMs. No special programmable modes are provided on the MCH for detecting the size and type of memory installed. Type and size detection must be done via the serial presence detection pins and is required to configure the MCH.

### 5.2.5.1 Memory Detection and Initialization

Before any cycles to the memory interface can be supported, the MCH DRAM registers must be initialized. The MCH must be configured for operation with the installed memory types. Detection of memory type and size is accomplished via the System Management Bus (SMBus) interface on the ICH5. This two-wire bus is used to extract the DRAM type and size information from the Serial Presence Detect port on the DRAM DIMMs. DRAM DIMMs contain a 5-pin Serial Presence Detect interface, including SCL (serial clock), SDA (serial data), and SA[2:0]. Devices on the SMBus bus have a 7-bit address. For the DRAM DIMMs, the upper four bits are fixed at 1010. The lower three bits are strapped on the SA[2:0] pins. SCL and SDA are connected to the System Management Bus on the ICH5. Thus, data is read from the Serial Presence Detect port on the DIMMs via a series of I/O cycles to the ICH5. BIOS needs to determine the size and type of memory used for each of the rows of memory to properly configure the MCH memory interface.

### 5.2.5.2 SMBus Configuration and Access of the Serial Presence Detect Ports

For more details, refer to the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5R (ICH5R) Datasheet*.

### 5.2.5.3 Memory Register Programming

This section provides an overview of how the required information for programming the DRAM registers is obtained from the Serial Presence Detect ports on the DIMMs. The Serial Presence Detect ports are used to determine Refresh Rate, SMA and SMD Buffer Strength, Row Type (on a row-by-row basis), DRAM Timings, Row Sizes, and Row Page Sizes. [Table 19](#) lists a subset of the data available through the on board Serial Presence Detect ROM on each DIMM.

**Table 19. Data Bytes on DIMM Used for Programming DRAM Registers**

Byte	Function
2	Memory type (DDR DRAM)
3	Number of row addresses, not counting bank addresses
4	number of column addresses
5	Number of banks of DRAM (single- or double-sided DIMM)
11	ECC, non-ECC (MCH does not support ECC)
12	Refresh rate
17	Number of banks on each device

[Table 19](#) is only a subset of the defined SPD bytes on the DIMMs. These bytes collectively provide enough data for programming the MCH DRAM registers.

## 5.2.6 Memory Thermal Management

The MCH provides a thermal management method that selectively reduces reads and writes to DRAM when the access rate crosses the allowed thermal threshold.

Read and write thermal management operate independently, and have their own 64-bit register to control operation. Memory reads typically causes power dissipation in the DRAM chips while memory writes typically causes power dissipation in the MCH.

### 5.2.6.1 Determining When to Thermal Manage

Thermal management may be enabled by one of two mechanisms:

- Software forcing throttling via the SRT (SWT) bit.
- Counter Mechanism.

## 5.3 Accelerated Graphics Port (AGP)

The MCH supports AGP 3.0 with limited AGP 2.0 compatibility. Electrical characteristics are supported for AGP 3.0 (0.8 V swing) and the AGP 2.0 (1.5 V swing). The MCH may be operated in 1X and 4X for AGP 2.0 modes at 1.5 V electrical characteristics. The 3.3 V electrical characteristics are not supported.

The MCH has a 32 deep AGP request queue. The MCH integrates two fully-associative 10-entry Translation Look-aside Buffers. This 20 entry buffer is used for both reads and writes.

See the AGP Revision 3.0 specification for additional details about the AGP interface.

## 5.3.1 MCH AGP Support

Table 20. AGP Support Matrix

Parameter	AGP 3.0	AGP 2.0	Comments
Data Rate	4X or 8X	4X, or 1X	MCH does not Support AGP 2X
Electricals	0.8 V swing, parallel terminated	1.5 V swing serial terminated	
Signal Polarity	Most control signals active high	Most control signals active low	This change was necessary to eliminate current flow in the idle state. Parallel termination has a large current flow for a high level.
Hi / Low priority commands	Only low priority (renamed Async)	High and low priority commands supported.	High priority does not have a good usage model.
Strobe Protocol	Strobe First – Strobe Second Protocol	Strobe – Strobe# protocol.	
Long transactions	Removed	Supported	
PIPE# support	No	Yes	SBA required for AGP 3.0
Calibration Cycle	Required	No	New to AGP 3.0.
Dynamic Bus Inversion	Yes	No	New to AGP 3.0
Coherency	Required for AGP accesses outside of the aperture, and for FRAME-based accesses	Required only for FRAME-based accesses.	

## 5.3.2 Selecting between AGP 3.0 and AGP 2.0

The MCH supports both AGP 3.0 and limited AGP 2.0, allowing a “Universal AGP 3.0 motherboard” implementation. Whether AGP 2.0 or AGP 3.0 mode is used is determined by the graphics card installed. An AGP 2.0 card will put the system into AGP 2.0 mode. An AGP 3.0 card will put the system into AGP 3.0 mode. The mode is selected during RESET by a hardware mechanism that is described in the [Section 5.3.3.1](#).

The mode determines the electrical mode, and may not be dynamically changed once the system powers up.

## 5.3.3 AGP 3.0 Downshift (4X Data Rate) Mode

AGP 3.0 supports both an 8X data rate and a 4X data rate. The purpose of the 4X data rate is to allow a fallback mode when board routing or other reasons make the 8X data rate marginal. Some AGP 4X graphics cards currently fall back to a 2X data rate when board layout or other issues arise. This is referred as “downshift” mode, since AGP 2X is not supported any card falling back to 2X will be running in a non supported mode.

When in AGP 3.0 mode in the 4X data rate, all of the AGP 3.0 protocols are used.



**Table 21. AGP 3.0 Downshift Mode Parameters**

Parameter	AGP 2.0 Signaling, All Data Rates	AGP 3.0 Signaling, 4X Data Rate	AGP 3.0 Signaling, 8X Data Rate
Data rate	1X, 4X	4X	8X
VREF level	0.75 V	0.35 V	0.35 V
Signaling	2.0 (1.5 V)	3.0 signaling (0.8 V swing)	3.0 signaling (0.8 V swing)
Polarity of GREQ, GGNT, GDEVSEL, GFRAME, GIRDT, GTRDY, GSTOP, RBF, WBF	Active low	Active high	Active high
Polarity of SBA	normal (111 = idle)	inverted (000 = idle)	inverted (000 = idle)
GCBE polarity	GC/BE#	GC#/BE	GC#/BE
Strobe definition	Strobe Strobe#	StrobeFirst StrobeSecond	StrobeFirst StrobeSecond
DBI used?	No	Disabled on xmit	Yes
PIPE# allowed	Yes	No	No
Commands supported	AGP 2.0 commands	AGP 3.0 commands	AGP 3.0 commands
Isoch supported	No	(Not supported)	No
Calibration cycles included	No	Yes	Yes

### 5.3.3.1 Mechanism for Detecting AGP 2.0, AGP 3.0

Two new signals are provided in the AGP 3.0 specification to allow for detection of an AGP 3.0 capable graphics card by the motherboard and an AGP 3.0 capable motherboard by the graphics card, respectively.

The signals are:

- GC\_DET#: Pulled low by an AGP 3.0 graphics card; left floating by an AGP 2.0 graphics card.
- MB\_DET#: Pulled low by an AGP 3.0 motherboard; left floating by an AGP 2.0 motherboard.

The AGP 3.0 capable motherboard uses GC\_DET# to determine whether to generate VREF of 0.75 V (floating GC\_DET# for AGP 2.0 graphics card), or 0.35 V (GC\_DET# low) to the graphics card. This is sent to the graphics card via the VREFCG pin on the AGP connector.

Similarly, the AGP 3.0 capable graphics card uses MB\_DET# to determine whether to generate VREF of 0.75 V (floating MB\_DET# on AGP 2.0 motherboard), or 0.35 V (MB\_DET# low) to the motherboard. The card could also use this pin as a strap to determine AGP 2.0 or AGP 3.0 mode. Note, however, that VREFCG is not used by the MCH.

The MCH detects whether the graphics card connected is AGP 2.0 or AGP 3.0 via the voltage level driven into the GVREF pin (0.35 V {< 0.55 V} = AGP 3.0, 0.75 V {> 0.55 V} = AGP 2.0). GVREF is driven by VREFCG on the motherboard.

An AGP 2.0 card tri-states GPAR and leaves GC\_DET# pin unconnected. GVREF = 0.75 V, and GPAR is weakly pulled high during assertion of  $\overline{\text{PWROK}}$ , and the value 1 is latched into MCHCFG.3 strap bit to select AGP. AGP 3.0 detect value latched on assertion of PWROK = 0 indicating AGP 2.0 mode.

An AGP 3.0 card terminates GPAR low, and pulls GC\_DET# low, causing the VREF generator to drive 0.35 V to GVREF. Note that during the assertion of PWROK, GPAR = 0 and AGP 3.0 detect = 1. To work correctly, when AGP 3.0 detect = 1, AGP must be selected (i.e., when AGP 3.0 detect = 1, AGP strap value must also be 1, regardless of the value on GPAR).

**Table 22. Pin and Strap Values Selecting AGP 2.0 and AGP 3.0**

Card Plugged Into AGP Connector	Pull-up/Termination on GPAR Pin Prior to Assertion of PWROK	GPAR value on PWROK Assertion	AGP 3.0 Detect Value on PWROK Assertion	MCHCFG.3 Strap Bit (AGP)	AGPSTAT.3 Strap Bit (AGP 3.0 Detect)
AGP 2.0 card	pull-up	1	0 (0.75 V)	1	0
AGP 3.0 card <sup>(1)</sup>	termination to ground	0	1 (0.35 V)	1	1

**NOTE:**

1. Difference between GPAR and MCHCFG.3 value.

### 5.3.4 AGP Target Operations

As an initiator, the MCH does not initiate cycles using AGP enhanced protocols. The MCH supports AGP target interface to main memory only. The MCH supports interleaved AGP and PCI transactions. AGP 2.0 and AGP 3.0 support different command types, as indicated in [Table 23](#).

**Table 23. AGP 3.0 Commands Compared to AGP 2.0**

C/BE[3:0]# (GC#/BE[3:0]) Encoding	AGP 2.0 Command	AGP 3.0 Command
0000	Read (Low Priority)	Read (Asynchronous)
0001	Read (High Priority)	Reserved
0010	Reserved	Reserved
0011	Reserved	ISOCH Read (NOT SUPPORTED)
0100	Write (Low Priority)	Write (Asynchronous)
0101	Write (High Priority)	Reserved
0110	Reserved	ISOCH Write, Unfenced (NOT SUPPORTED)
0111	Reserved	ISOCH Write, Fenced (NOT SUPPORTED)
1000	Long Read (Low Priority)	Reserved
1001	Long Read (High Priority)	Reserved
1010	Flush (Low Priority)	Flush
1011	Reserved	Reserved
1100	Fence (Low Priority)	Fence (for reads and writes)
1101	Reserved (was DAC cycle)	Reserved (was DAC cycle)
1110	Reserved	Isch Align (NOT SUPPORTED)
1111	Reserved	Reserved

### 5.3.5 AGP Transaction Ordering

High priority reads and writes are not checked for conflicts between themselves or normal priority reads and writes. AGP commands (delivered via PIPE# or SBA, not FRAME#) snoop the global SDRAM write buffer.

**Table 24. Supported Data Rates**

Data Rate	Signaling Level		
	0.8 V	1.5 V	3.3 V
PCI-66	Yes	Yes	No
1X AGP	Yes	Yes	No
2X AGP	No	See Note	No
4X AGP	Yes	Yes	No
8X AGP	Yes	No	No

**Note:** AGP 2X is **not** supported on the MCH.

### 5.3.6 Support for PCI-66 Devices

The MCH's AGP interface may be used as a PCI-66 MHz interface with the following restrictions:

1. Support for 1.5 V operation only.
2. Support for only one device. The MCH will not provide arbitration or electrical support for more than one PCI-66 device.
3. The PCI-66 device must meet the AGP 2.0 electrical specification.
4. The MCH does not provide full PCI-to-PCI bridge support between AGP/PCI and the hub interface. Traffic between AGP and hub interface is limited to hub interface-to-AGP memory writes.
5. LOCK# signal is not present. Neither inbound nor outbound locks are supported.
6. SERR# / PERR# signals are not present.
7. 16 clock Subsequent Data Latency timer (instead of 8).

### 5.3.7 8X AGP Protocol

The MCH supports 1X and 4X AGP operation in 2.0 mode and 4X and 8X in 3.0 mode. Bit 3 of the AGP status register is set to 0 in 2.0 mode, and 1 in 3.0 mode. The MCH indicates that it supports 8X data transfers in AGP 3.0 mode through RATE[1] of the AGP status register. When DATA\_RATE[1] of the AGP Command Register is set to 1 during system initialization, the MCH will perform AGP read and write data transactions using 8X protocol. This bit is set once during initialization and the data transfer rate cannot be change dynamically.

The 8X data transfer protocol provides 2.1 GB/s transfer rates. In 8X mode, 32 bytes of data are transferred during each 66 MHz clock period. The minimum throttleable block size remains four 66 MHz clocks which means 128 bytes of data is transferred per block.

### 5.3.7.1 Fast Writes

The fast write (FW) transaction is from the core logic to the AGP master acting as a PCI target. This type of access is required to pass data/control directly to the AGP master instead of placing the data into system memory and then having the AGP master read the data. For 1X transactions, the protocol simply follows the PCI bus specification. However, for higher speed transactions (4X or 8X), FW transactions follow a combination for PCI and AGP bus protocols for data movement.

The MCH only supports the AGP 1.5 V connector, which permits a 1.5 V AGP add-in card to be supported by the system.

### 5.3.7.2 PCI Semantic Transactions on AGP

The MCH accepts and generates PCI semantic transactions on the AGP bus. The MCH guarantees that PCI semantic accesses to DRAM are kept coherent with the processor caches by generating snoops to the processor bus.

## 5.4 Power Management

The MCH power management support includes:

- ACPI supported
- System States: S0, S1 (desktop), S3, S4, S5, C0, C1, C2 (desktop)

### 5.4.1 Supported ACPI States

The MCH supports the following ACPI States:

- Processor
  - C0 Full On.
  - C1 Auto Halt.
  - C2-Desktop Stop Grant. Clock to processor still running. Clock stopped to processor core.
- System
  - G0/S0 Full On.
  - G1/S1 Stop Grant, Desktop S1, same as C2.
  - G1/S2 Not supported.
  - G1/S3 Suspend to RAM (STR). Power and context lost to chipset.
  - G1/S4 Suspend to Disk (STD). All power lost (except wakeup logic on ICH5).
  - G2/S5 Soft off. Requires total system reboot.
  - G3 Mechanical Off. All power lost (except real time clock).

## 5.5 Thermal Management

To meet the thermal requirements, The MCH implements the following thermal management mechanisms. The mechanisms will manage the reads and writes cycles of the DRAM interface, thus ensuring that the temperature can return to the normal operating range.

### Hardware-Based Thermal Management

The number of hexwords transferred over the DRAM interface are tracked per row. The tracking mechanism takes into account that the DRAM devices consume different levels of power based on cycle type, that is, page hit/miss/empty. If at any time during a monitoring window if the programmed threshold is exceeded the activity on the DRAM interface is reduced, and thus helps in lowering the power and temperature.

### Software-Based Thermal Management

This is used when the external thermal sensor in the system interrupts the processor to engage a software routine for thermal management.

### 5.5.1 External Thermal Sensor Interface Overview

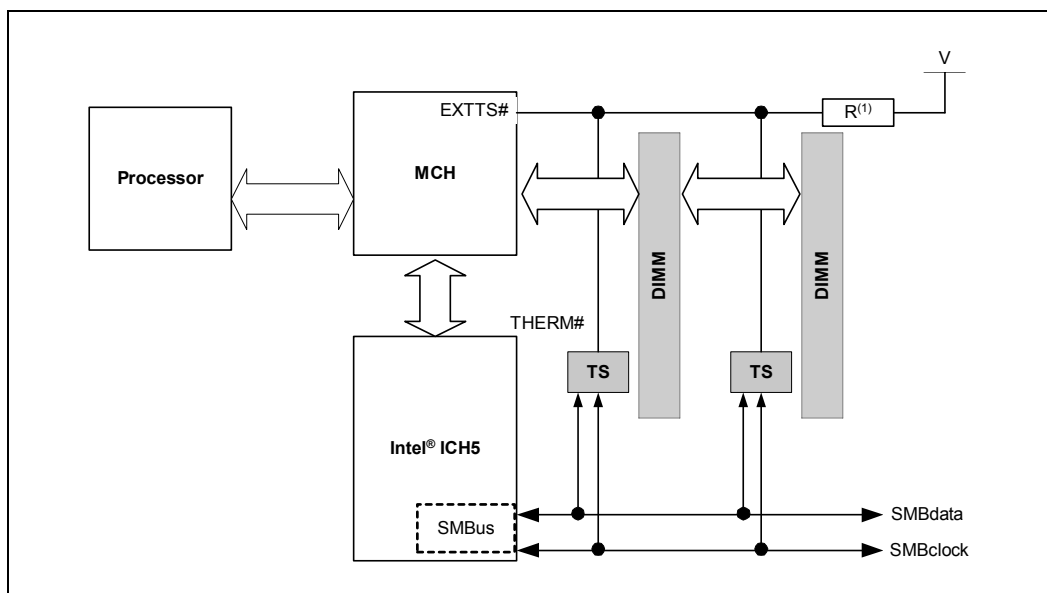
An external thermal sensor with a serial interface (e.g., the National Semiconductor LM77, LM87, or other) may be placed next to DDR DIMM (or any other appropriate platform location), or a remote thermal diode may be placed next to the DIMM (or any other appropriate platform location) and connected to the external thermal sensor.

The external sensor can be connected to the ICH5 via the SMBus interface to allow programming and setup by BIOS software over the serial interface. The external sensor's output should include an active-low open-drain signal indicating an over-temp condition (e.g., LM77 T\_CRIT# or INT# in comparator mode). The sensor's output remains asserted for as long as the over-temp condition exists, and deasserts when the temperature has returned to within normal operating range. This External sensor output will be connected to the MCH input (EXTTS#) and will trigger a preset interrupt and/or read-throttle on a level-sensitive basis.

Additional external thermal sensor's outputs, for multiple sensors, can be wire-OR'd together allow signaling from multiple sensors located physically separately. Software can, if necessary, distinguish which DIMM(s) is the source of the over-temp through the serial interface. However, since the DIMMs will be located on the same memory bus data lines, any MCH-base read throttle will apply equally.

**Note:** The use of external sensors that include an internal pull-up resistor on the open-drain thermal trip output is discouraged; however, it may be possible depending on the size of the pull-up and the voltage of the sensor.

Figure 11. Platform External Sensor

**NOTE:**

1. External pull-up R is associated with the voltage rail of the MCH input.

## 5.5.2 External Thermal Sensor Usage Model

There are several possible usage models for an external thermal sensor:

- External Sensor(s) used for characterization only, not for normal production:
- Sensor on the DIMMS for temperature in OEM platform and use the results to permanently set read throttle values in the BIOS.
- Sensor on the MCH for temperature in OEM platform and use the results to permanently set write throttle values in the BIOS.
- External Sensor(s) used for dynamic temperature feedback control in production releases:
- Sensor on DIMMs, which can be used to dynamically control read throttling
- Sensor on MCH, which can be used to dynamically control write throttling

The advantage of the characterization model is the Bill-of-Materials (BOM) cost, whereas the potential advantage of the dynamic model is that retail customers may be able to experience higher peak performance since the throttle values are not forced to encompass worse case environmental conditions.

Characterization tools (e.g., CTMI and Maxband) can be made to work either with external or internal sensors.

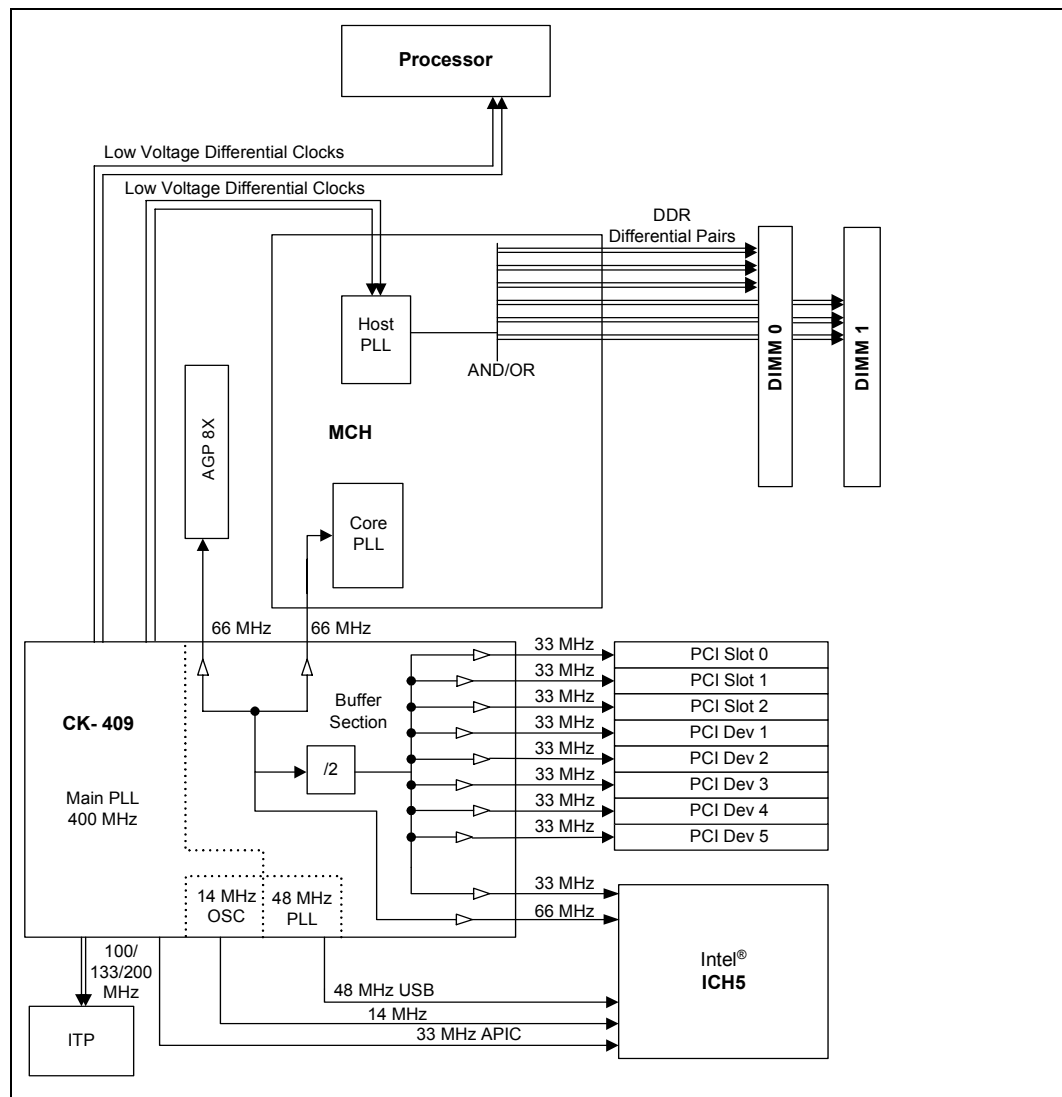
## 5.6 Clocking

The MCH has the following clocks:

- 100/133/200 spread spectrum, Low voltage (0.7 V) Differential HCLKP/HCLKN for FSB
- 66.667 MHz, spread spectrum, 3.3 V GCLKIN for Hub Interface and AGP
- 48 MHz, non-spread spectrum, USB clock
- 12 pairs DRAM output clocks (SCMCLK\_x[5:0] and SCMDCLK\_x[5:0]# for both channels A and B)

The MCH has inputs for a low voltage, differential pair of clocks called HCLKP and HCLKN. These pins receive a host clock from the external clock synthesizer. This clock is used by the host interface and system memory logic (host clock domain). AGP and the hub interface are synchronous to each other and are driven off of the 66 MHz clock.

Figure 12. Intel® 848P Chipset System Clocking Block Diagram



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# Electrical Characteristics

# 6

This chapter contains the maximum ratings, power characteristics, and DC characteristics for the MCH.

## 6.1 Absolute Maximum Ratings

Table 25 lists the MCH's maximum environmental stress ratings. Functional operation at the absolute maximum and minimum is neither implied nor guaranteed. Functional operating parameters are listed in the DC characteristics tables.

**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 25. Absolute Maximum Ratings**

Symbol	Parameter	Min	Max	Unit
VCC	1.5 V Core Supply	-0.3	1.75	V
VCC_AGP	1.5 V AGP Supply (AGP mode)	-0.3	1.75	V
VCCA_AGP	1.5 V Analog AGP Supply	-0.3	1.75	V
VTT	VTT Supply	-0.3	1.75	V
VCC_DDR	2.6 V DDR System Memory Interface Supply	-0.5	3	V
VCCA_DDR	1.5 V Analog Supply for System Memory DLLs	-0.3	1.75	V
VCC_DAC	3.3 V Supply and is required by the MCH.	-0.3	3.6	V
VCCA_DAC	1.5 V DAC Analog Supply	-0.3	1.65	V
VCCA_DPLL	1.5 V Display PLL Analog Supply	-0.3	1.75	V
VCCA_FSB	1.5 V Host PLL Analog Supply	-0.3	1.75	V

## 6.2 Thermal Characteristics

Refer to the *Intel® 848P Chipset Thermal Design Guide* for thermal characteristics.

## 6.3 Power Characteristics

Table 26. Power Characteristics

Symbol	Parameter	Max	Unit	Notes
I <sub>VCC</sub>	1.5 V Core Supply Current	2.88	A	1,2
I <sub>VCC_AGP</sub>	1.5 V AGP Supply Current	0.37	A	2
I <sub>VCCA_AGP</sub>	1.5 V Analog AGP Supply Current	0.01	A	
I <sub>VTT</sub>	VTT Supply Current	1.6	A	
I <sub>VCC_DDR</sub>	2.6 V DDR System Memory Interface Supply Current	2.8	A	
I <sub>VCCA_DDR</sub>	1.5 V Analog Supply Current for System Memory DLLs	1.2	A	
I <sub>VCC_DAC</sub>	3.3 V DAC Signal Supply Current	0.2	A	
I <sub>VCCA_DAC</sub>	1.5 V DAC Signal Analog Supply Current	0.07	A	
I <sub>VCCA_DPLL</sub>	1.5 V Display PLL Analog Supply Current	0.01	A	
I <sub>VCCA_FSB</sub>	1.5 V Host PLL Analog Supply Current	0.05	A	
I <sub>VCC_SUS_2.6</sub>	2.6 V Standby Supply Current	0.25	A	

**NOTES:**

1. The hub interface and CSA interface supply currents are included in the 1.5 V VCC core supply current.
2. VCC and VCC\_AGP current levels may happen simultaneously and can be summed into one 1.5 V supply.

## 6.4 Signal Groups

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

<b>AGTL+</b>	Open Drain AGTL+ interface signal. Refer to the AGTL+ I/O Specification for complete details. The MCH integrates most AGTL+ termination resistors.
<b>AGP</b>	AGP interface signals. These signals are compatible with <i>AGP 2.0 1.5 V and AGP 3.0 0.8 V Signaling Environment DC and AC Specifications</i> . The buffers are not 3.3 V tolerant.
<b>HI15</b>	Hub Interface 1.5 V CMOS buffers.
<b>SSTL_2</b>	Stub Series Terminated Logic 2.6 V compatible signals. DDR System memory 2.6 V CMOS buffers.
<b>Miscellaneous</b>	2.6 V and 3.3 V Miscellaneous buffers.

Table 27. Signal Groups

Signal Group	Signal Type	Signals	Notes <sup>1</sup>
<b>AGP Interface Signal Groups (only AGP 3.0 naming convention listed)</b>			
(a)	AGP I/O	GADSTBF[1:0], GADSTBS[1:0], GFRAME, GIRDY, GTRDY, GSTOP, GDEVSEL, GAD[31:0], GC#/BE[3:0], GPAR, DBI_HI, DBI_LO	
(b)	AGP Input	GSBA[7:0]#, GRBF, GWBF, GSBSTBF, GSBSTBS, GREQ	
(c)	AGP Output	GST[2:0], GGNT	
(d)	AGP Miscellaneous	GVREF, GRCOMP, GVSWING	
<b>Hub Interface Signal Groups</b>			
(e)	HI15 Hub Interface CMOS I/O	HI[10:0], HISTRS, HISTRF	
(f)	Hub Interface Miscellaneous	HI_SWING, HI_VREF, HI_RCOMP	
<b>CSA Interface Signal Groups</b>			
(e)	HI15 CSA Interface CMOS I/O	CI[10:0], CISTRS, CISTRF	
(f)	CSA Interface Miscellaneous	CI_SWING, CI_VREF, CI_RCOMP	
<b>Host Interface Signal Groups</b>			
(g)	AGTL+ I/O	ADS#, BNR#, DBSY#, DINV[3:0]#, DRDY#, HA[31:3]#, HADSTB[1:0] #, HD[63:0]#, HDSTBP[3:0]#, HDSTBN[3:0]#, HIT#, HITM#, HREQ[4:0]#, PROCHOT#	
(h)	AGTL+ Input	HLOCK#	
(i)	AGTL+ Output	BPRI#, BREQ0#, CPURST#, DEFER#, HTRDY#, RS[2:0]#	
(j)	Host Clock Input	HCLKP, HCLKN	
(k)	Host Miscellaneous	HDVREF[2:0], HDRCOMP, HDSWING	
<b>DDR Interface Signal Groups</b>			
(l)	DDR SSTL_2 I/O	SDQ_A[63:0], SDQS_A[7:0],	
(m)	DDR SSTL_2 Output	SCMDCLK_A[5:0], SCMDCLK_A[5:0]#, SMAA_A[12:0], SMAB_A[5:1], SBA_A[1:0], SRAS_A#, SCAS_A#, SCAS_B#, SWE_A#, SCS_A[3:0]#, SCKE_A[3:0]	
(v)	DDR RCOMP	SMXRCOMP, SMYRCOMP	
(n)	DDR Miscellaneous <sup>2</sup>	SMXRCOMPVOL, SMXRCOMPVOH, SMYRCOMPVOL, SMYRCOMPVOH, SMVREF_A, SMVREF_B	
<b>Reset and Miscellaneous Signal Groups</b>			
(t)	2.6 V Miscellaneous Input (3.3 V tolerant) LVTTTL	RSTIN#, PWROK, EXTTS#	
(w)	FSB Select Input	BSEL[0:1]	
(x)	Clocks LVTTTL	GCLKIN	

**NOTES:**

- For details on BSEL[1:0] pin electrical requirements, see the *Intel® 848P Chipset Platform Design Guide*.
- For additional details on SMXRCOMP, SMYRCOMP, SMXRCOMPVOL, SMYRCOMPVOH, SMYRCOMPVOL, SMYRCOMPVOH pin electrical requirements, see the *Intel® 848P Chipset Platform Design Guide*.

## 6.5 DC Parameters

All DC operating conditions are specified at the pin unless otherwise specified.

**Table 28. DC Operating Characteristics (Sheet 1 of 2)**

Signal Name	Parameter	Min	Nom	Max	Unit
<b>I/O Buffer Supply Voltage</b>					
VCC	Core Voltage	1.425	1.5	1.575	V
VCC_AGP	AGP I/O Voltage	1.425	1.5	1.575	V
VCCA_AGP	AGP Analog Supply Voltage	1.425	1.5	1.575	V
VTT (Intel® Pentium® 4 processor 512-KB L2 cache on 0.13 micron process)	Host AGTL+ Termination Voltage	1.35	1.45	1.55	V
VTT (Intel® Pentium® 4 processor on 90 nm process)	Host AGTL+ Termination Voltage	1.14	1.225	1.31	V
VCC_DDR	DDR I/O Supply Voltage	2.5	2.6	2.7	V
VCCA_DDR	DDR Supply Voltage	1.425	1.5	1.575	V
VCC_DAC	3.3 V DAC Supply Voltage	3.135	3.3	3.465	V
VCCA_DAC	DAC Supply Voltage	1.425	1.5	1.6	V
VCCA_DPLL	Display PLL Analog Voltage	1.425	1.5	1.575	V
VCCA_FSB	Host PLL Analog Voltage	1.425	1.5	1.575	V
<b>Reference Voltages</b>					
GVREF (2.0)	AGP 2.0 Reference Voltage	$1/2 * VCC\_AGP\_min - 2\%$	$1/2 * VCC\_AGP$	$1/2 * VCC\_AGP\_max + 2\%$	V
GVREF (3.0) <sup>4</sup>	AGP 3.0 Reference Voltage	$0.2333 * VCC\_AGP\_min - 0.01$	$0.2333 * VCC\_AGP$	$0.2333 * VCC\_AGP\_max + 0.01$	V
GVSWING (3.0) <sup>5</sup>	AGP 3.0 Swing Voltage	$0.5333 * VCC\_AGP\_min - 0.05$	$0.5333 * VCC\_AGP$	$0.5333 * VCC\_AGP\_max + 0.05$	V
HI_VREF <sup>6,7</sup>	Hub Interface Reference Voltage	0.343	0.35	0.357	V
HI_SWING <sup>6,8</sup>	Hub Interface Compensation Reference Voltage	0.784	0.8	0.816	V
CI_VREF <sup>9,10</sup>	CSA Interface Reference Voltage	0.343	0.35	0.357	V
CI_SWING <sup>9,11</sup>	CSA Interface Compensation Reference Voltage	0.784	0.8	0.816	V
Vsh <sup>1</sup>	MCH VTT/processor Shared Voltage	$(VTT\_min + VccCPU\_min)/2$	$(VTT + VccCPU)/2$	$(VTT\_max + VccCPU\_max)/2$	V
HDVREF <sup>2</sup>	Host Reference Voltage	$0.63 * Vsh\_min - 2\%$	$0.63 * Vsh$	$0.63 * Vsh\_max + 2\%$	V

**Table 28. DC Operating Characteristics (Sheet 2 of 2)**

Signal Name	Parameter	Min	Nom	Max	Unit
HDSWING/ HASWING	Host Compensation Reference Voltage	$1/4 \times V_{TT\_min} - 2\%$	$1/4 \times V_{TT}$	$1/4 \times V_{TT\_max} + 2\%$	V
SMXRCOMPVOL <sup>3</sup> / SMYRCOMPVOL	DDR RCOMP VOL	$V_{CC\_DDR\_min} * (1/4.112) - 2\%$	$V_{CC\_DDR} * (1/4.112)$	$V_{CC\_DDR\_max} * (1/4.112) + 2\%$	V
SMXRCOMPVOH <sup>3</sup> / SMYRCOMPVOH	DDR RCOMP VOH	$V_{CC\_DDR\_min} * (3.112/4.112) - 2\%$	$V_{CC\_DDR} * (3.112/4.112)$	$V_{CC\_DDR\_max} * (3.112/4.112) + 2\%$	V
SMVREF	DDR Reference Voltage	$0.49 \times V_{CC\_DDR\_min}$	$0.5 \times V_{CC\_DDR}$	$0.51 \times V_{CC\_DDR\_max}$	V

**NOTES:**

1. Refer to the *Intel® Pentium® 4 Processor with 512-KB L2 Cache on 0.13 Micron Process Datasheet* processor VCC values used to calculate Vsh. For values pertaining to the Pentium 4 processor on 90 nm process, contact your Intel field representative.
2. HDVREF is generically referred to as GTLREF throughout the rest of this chapter.
3. SMXRCOMPVOL/SMYRCOMPVOL and SMXRCOMPVOH/SMYRCOMPVOH have maximum input leakage current of 1 mA.
4. Measured at receiver pad.
5. Standard 50 Ω load to ground.
6. HI\_REF and HI\_SWING are derived from VCC (nominal VCC = 1.5 V) that is the nominal core voltage for the MCH. Voltage supply tolerance for a particular interface driver voltage must be within a 5% range of nominal.
7. Nominal value of HI\_REF is 0.350 V. The specification is at nominal VCC. Note that HI\_REF varies linearly with VCC; thus, VCC variation (± 5%) must be accounted for in the HI\_REF specification in addition to the 2% variation of HI\_REF in the table.
8. Nominal value of HI\_SWING is 0.800 V. The specification is at nominal VCC. Note that HI\_SWING varies linearly with VCC; thus, VCC variation (± 5%) must be accounted for in the HI\_SWING specification in addition to the 2% variation of HI\_SWING in the table.
9. CI\_REF and CI\_SWING are derived from VCC (nominal VCC = 1.5 V) that is the nominal core voltage for the MCH. Voltage supply tolerance for a particular interface driver voltage must be within a 5% range of nominal.
10. Nominal value of CI\_VREF is 0.350 V. The specification is at nominal VCC. Note that CI\_VREF varies linearly with VCC; thus, VCC variation (± 5%) must be accounted for in the CI\_VREF specification in addition to the 2% variation of CI\_REF in the table.
11. Nominal value of CI\_SWING is 0.800 V. The specification is at nominal VCC. Note that CI\_SWING varies linearly with VCC; thus, VCC variation (± 5%) must be accounted for in the CI\_SWING specification in addition to the 2% variation of CI\_SWING in the table.

Table 29. DC Characteristics (Sheet 1 of 3)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
<b>1.5 V AGP 2.0 (1.5 V signaling) Interface<sup>6</sup></b>							
V <sub>IL_AGP</sub>	(a,b)	AGP Input Low Voltage	-0.5		AGP_VREF - 0.15	V	
V <sub>IH_AGP</sub>	(a,b)	AGP Input High Voltage	AGP_VREF + 0.15		VCC_AGP + 0.5	V	
V <sub>OL_AGP</sub>	(a,c)	AGP Output Low Voltage			0.225	V	
V <sub>OH_AGP</sub>	(a,c)	AGP Output High Voltage	1.275			V	
I <sub>OL_AGP</sub>	(a,c)	AGP Output Low Current			6.65	mA	@ 0.1* VCC_AGP
I <sub>OH_AGP</sub>	(a,c)	AGP Output High Current	-4.7			mA	@0.85* VCC_AGP
I <sub>LEAK_AGP</sub>	(a,b)	AGP Input Leakage Current			±25	µA	0<V <sub>in</sub> < VCC_AGP
C <sub>IN_AGP</sub>	(a,b)	AGP Input Capacitance			4	pF	F <sub>C</sub> =1 MHz
<b>1.5 V AGP 3.0 (0.8 V signaling) Interface<sup>6</sup></b>							
V <sub>IL_AGP</sub>	(a,b)	AGP Input Low Voltage	-0.3		AGP_VREF - 0.10	V	
V <sub>IH_AGP</sub>	(a,b)	AGP Input High Voltage	AGP_VREF + 0.10		VCC_AGP	V	
V <sub>OL_AGP</sub>	(a,c)	AGP Output Low Voltage			0.05	V	I <sub>out</sub> = 1500 µA
V <sub>OH_AGP</sub>	(a,c)	AGP Output High Voltage	0.5333 * VCC_AGP_min - 0.05	0.5333 * VCC_AGP	0.5333 * VCC_AGP_max + 0.05	V	Standard 50 Ω load to ground.
I <sub>OH_AGP</sub>	(a,c)	AGP Output High Current	14.54		17.78	mA	
I <sub>LEAK_AGP</sub>	(a,b)	AGP Input Leakage Current			±25	µA	
C <sub>IN_AGP</sub>	(a,b)	AGP Input Capacitance	1		2.5	pF	F <sub>C</sub> =1 MHz
<b>1.5 V Hub Interface<sup>7</sup></b>							
V <sub>IL_HI</sub>	(e)	Hub Interface Input Low Voltage	-0.3		HI_VREF - 0.1	V	
V <sub>IH_HI</sub>	(e)	Hub Interface Input High Voltage	HI_VREF + 0.1		1.2	V	
V <sub>OL_HI</sub>	(e)	Hub Interface Output Low Voltage			0.05	V	I <sub>OL</sub> = 1 mA
V <sub>OH_HI</sub>	(e)	Hub Interface Output High Voltage	0.6		1.2	V	I <sub>OUT</sub> = 0.8/R <sub>TT</sub> , R <sub>TT</sub> = 60 Ω
I <sub>LEAK_HI</sub>	(e)	Hub Interface Input Leakage Current			± 50	µA	
C <sub>IN_HI</sub>	(e)	Hub Interface Input Capacitance			5	pF	F <sub>C</sub> =1 MHz
<b>1.5 V CSA Interface<sup>8</sup></b>							
V <sub>IL_CI</sub>	(e)	CSA Interface Input Low Voltage	-0.3		CI_VREF - 0.1	V	
V <sub>IH_CI</sub>	(e)	CSA Interface Input High Voltage	CI_VREF + 0.1		1.2	V	
V <sub>OL_CI</sub>	(e)	CSA Interface Output Low Voltage			0.05	V	I <sub>OL</sub> = 1 mA
V <sub>OH_CI</sub>	(e)	CSA Interface Output High Voltage	0.6		1.2	V	I <sub>OUT</sub> = 0.8/R <sub>TT</sub> , R <sub>TT</sub> = 60 Ω
I <sub>LEAK_CI</sub>	(e)	CSA Interface Input Leakage Current			± 50	µA	
C <sub>IN_CI</sub>	(e)	CSA Interface Input Capacitance			5	pF	F <sub>C</sub> =1 MHz

Table 29. DC Characteristics (Sheet 2 of 3)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
<b>VTT DC Characteristics</b>							
$V_{IL\_AGTL+}$	(g,h)	Host AGTL+ Input Low Voltage			HDVREF $-(0.04 \cdot V_{sh})$	V	
$V_{IH\_AGTL+}$	(g,h)	Host AGTL+ Input High Voltage	HDVREF $+ (0.04 \cdot V_{sh})$			V	
$V_{OL\_AGTL+}$	(g,i)	Host AGTL+ Output Low Voltage		$1/4 \cdot V_{sh}$		V	
$V_{OH\_AGTL+}$	(g,i)	Host AGTL+ Output High Voltage	$(V_{sh}-0.1) \cdot 0.95$		$V_{sh}$	V	
$I_{OL\_AGTL+}$	(g,i)	Host AGTL+ Output Low Current			$0.75 \cdot V_{shmax} / R_{ttmin}$	mA	$R_{ttmin}=57 \Omega$
$I_{LEAK\_AGTL+}$	(g,h)	Host AGTL+ Input Leakage Current			$\pm 25$	$\mu A$	$V_{OL} < V_{pad} < V_{TT}$
$C_{PAD\_AGTL+}$	(g,h)	Host AGTL+ Input Capacitance	1		3.3	pF	$F_C=1 \text{ MHz}$
<b>2.6 V DDR System Memory</b>							
$V_{IL\_DDR(DC)}$	(l)	DDR Input Low Voltage	$-0.1 \cdot V_{CC\_DDR}$		SMVREF $- 0.15$	V	
$V_{IH\_DDR(DC)}$	(l)	DDR Input High Voltage	SMVREF $+ 0.15$		$V_{CC\_DDR}$	V	
$V_{IL\_DDR(AC)}$	(l)	DDR Input Low Voltage	$-0.1 \cdot V_{CC\_DDR}$		SMVREF $- 0.31$	V	
$V_{IH\_DDR(AC)}$	(l)	DDR Input High Voltage	SMVREF $+ 0.31$		$V_{CC\_DDR}$	V	
$V_{OL\_DDR}$	(l,m,v)	DDR Output Low Voltage			0.600	V	With 50 $\Omega$ termination to DDR VTT.
$V_{OH\_DDR}$	(l,m,v)	DDR Output High Voltage	$V_{CC\_DDR} - 0.600$			V	With 50 $\Omega$ termination to DDR VTT.
$I_{OL\_DDR}$	(l,m)	DDR Output Low Current			25	mA	With 50 $\Omega$ termination to DDR VTT.
$I_{OH\_DDR}$	(l,m)	DDR Output High Current	-25			mA	With 50 $\Omega$ termination to DDR VTT.
$I_{OL\_DDR\ RCOMP}$	(v)	DDR RCOMP Output Low Current			50	mA	
$I_{OH\_DDR\ RCOMP}$	(v)	DDR RCOMP Output High Current	-50			mA	
$I_{Leak\_DDR}$	(l)	Input Leakage Current			$\pm 15$	$\mu A$	
$C_{IN\_DDR}$	(l)	DDR Input /Output Pin Capacitance			5.5	pF	$F_C=1 \text{ MHz}$
<b>2.6 V Miscellaneous Signals (3.3 V tolerant)</b>							
$V_{IL}$	(t)	2.6 V Input Low Voltage			0.4	V	
$V_{IH}$	(t)	2.6 V Input High Voltage	$V_{CC\_DDR} - 0.4$		$V_{CC\_DAC}$	V	
$I_{LEAK}$	(t)	2.6 V Input Leakage Current			$\pm 50$	$\mu A$	
$C_{IN}$	(t)	2.6 V Input Capacitance			5.5	pF	
<b>FSB Select Signals</b>							
$V_{IL}$	(w)	Input Low Voltage			0.4	V	
$V_{IH}$	(w)	Input High Voltage	0.8			V	

Table 29. DC Characteristics (Sheet 3 of 3)

Symbol	Signal Group	Parameter	Min	Nom	Max	Unit	Notes
<b>Clocks</b>							
V <sub>IL</sub>	(x)	Input Low Voltage			0.4	V	
V <sub>IH</sub>	(x)	Input High Voltage	VCC_DDR – 0.4		VCC_DAC	V	1
I <sub>LEAK</sub>	(x)	Input Leakage Current			100	μA	
C <sub>IN</sub>	(x)	Input Capacitance			5.5	pF	
V <sub>CROSS(abs)</sub>	(j)	Absolute Crossing Voltage	0.250	NA	0.550	V	2,3
V <sub>CROSS(rel)</sub>	(j)	Relative Crossing Voltage	0.250 + 0.5 (V <sub>Havg</sub> – 0.700)		0.550 + 0.5(V <sub>Havg</sub> – 0.700)	V	3,4,5

**NOTES:**

1. Absolute maximum overshoot = 4.5 V
2. Crossing voltage is defined as the instantaneous voltage value when the rising edge of HCLKP equals the falling edge of HCLKN.
3. The crossing point must meet the absolute and relative crossing point specifications simultaneously.
4. V<sub>Havg</sub> is the statistical average of the V<sub>H</sub> measured by the oscilloscope.
5. V<sub>Havg</sub> can be measured directly using “Vtop” on Agilent\* oscilloscopes and “High” on Tektronix\* oscilloscopes.
6. Maximum leakage current specification for GVREF and GVSING pins is 50 uA. Refer to the *Intel® 848P Chipset Platform Design Guide* for the resistor divider circuit details that take this specification into account.
7. Maximum leakage current specification for HI\_VREF and HI\_SWING pins is 50 uA. Refer to *Intel® 848P Chipset Platform Design Guide* for the resistor divider circuit details that take this specification into account.
8. Maximum leakage current specification for CI\_VREF and CI\_SWING pins is 50 uA. Refer to *Intel® 848P Chipset Platform Design Guide* for the resistor divider circuit details that take this specification into account.



# Ballout and Package Information 7

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This chapter provides the MCH ballout and package information.

## 7.1 MCH Ballout

The ballout footprint is shown in [Figure 13](#) and [Figure 14](#). These figures represent the ballout arranged by ball number. [Table 30](#) provides the ballout arranged alphabetically by signal name.

**Note:** The following notes apply to the ballout.

1. For AGP signals, only the AGP 3.0 signal name is listed. For the corresponding AGP 2.0 signal name, refer to [Chapter 2](#).
2. NC = No Connect.
3. RSVD = These reserved balls should not be connected and should be allowed to float.
4. Shaded cells in [Figure 13](#) and [Figure 14](#) do not have a ball.



Figure 13. Intel® 82848P MCH Ballout Diagram (Top View—Left Side)

	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18			
AR	NC		NC	VSS	VCC_DDR		VSS		VSS		VSS		VSS		VCC_DDR	VSS					
AP		RSVD	SDQ_A26	TESTP27	TESTP28	TESTP20	SDQ_A25	SDQ_A24	SDQ_A23	SMAA_A8	SDQ_A22	SMAA_A9	SDQS_A2	SDQ_A16	SDQ_A20	SCKE_A3	SDQ_A11	SDQ_A14			
AN	RSVD	SDQ_A31		VSS	SMAA_A3	VSS	SDQ_A29	VSS	SDQ_A19	VSS	SMAA_A7	VSS	SMAA_A11	VSS	SMAA_A12	VSS	SCKE_A1	VSS			
AM	VSS	TESTP26	SDQ_A27		SDQ_A30	SDQS_A3	VSS	SDQ_A28	VSS	TESTP29	VSS	TESTP19	VSS	SDQ_A17	VSS	SCKE_A2	VSS	SDQ_A15			
AL	VCCA_DDR	TESTP25	SMAA_A1	VSS		SMAA_A4	TESTP14	SMAA_A6	TESTP15	SMAA_A5	TESTP52	SDQ_A18	TESTP54	SDQ_A21	TESTP57	SCKE_A0	TESTP84	SDQ_A10			
AK		SCMD_CLK_A3#	SCMD_CLK_A3	SCMD_CLK_A0	SCMD_CLK_A0#		SMAA_A2	VSS	TESTP50	VSS	TESTP88	VSS	TESTP83	VSS	TESTP85	VSS	TESTP136	VSS			
AJ	VSS	SMAA_A0	SMAA_A10	VSS	TESTP47	TESTP33		TESTP7	TESTP93	TESTP92		TESTP86		TESTP55		TESTP58		TESTP79			
AH		SBA_A1	VSS	SDQ_A32	SDQ_A36	VSS	TESTP39		TEST_P131	TESTP89		VSS		VSS		VSS		VSS			
AG	VSS	SDQ_A33	SDQ_A37	VSS	TESTP46	TESTP36	TESTP30	VSS	TESTP90	VSS	TESTP51	VSS	TESTP82	VSS	TESTP130	VSS	TESTP138	VSS			
AF		SDQS_A4	VSS	SDQ_A34	TESTP21	VSS	TESTP56	TESTP95	TESTP91		VSS	VSS	NC	VSS	TESTP53	VSS	TESTP137	VSS			
AE	VSS	SDQ_A38	SBA_A0	VSS	TESTP100	TESTP96			TESTP12	VSS	VSS	TESTP49	TESTP16	TESTP87	TESTP6	TESTP81	TESTP80	TESTP139			
AD		SDQ_A39	VSS	SDQ_A35	SDQ_A44	VSS	TESTP132	VSS	TESTP48	TESTP13	TESTP94										
AC	VSS	SDQ_A40	SRAS_A#	VSS	TESTP8	TESTP98			TESTP97	VCCA_DDR	VCCA_DDR										
AB		SWE_A#	VSS	SDQ_A45	SDQ_A41	VSS	TESTP101	VSS	VSS	VSS	VCCA_DDR										
AA	VCC_DDR	SCS_A0#	SMY_RCOMP	VSS	TESTP108	TESTP104			TESTP103	TESTP102	TESTP60										
Y	VSS	SCAS_A#	VSS	SCS_A2#	SCS_A1#	VSS	TESTP99	VSS	VSS	VSS	TESTP59								VCC	VCC	VCC
W		SCS_A3#	TESTP22	VSS	TESTP62	TESTP105			TESTP63	TESTP61	TESTP45								VCC	VCC	VSS
V		SDQS_A5	VSS	SDQ_A42	SDQ_A43	VSS	TESTP109	VSS	VSS	VSS	TESTP44								VCC	VSS	VCC
U		SDQ_A46	SDQ_A47	VSS	TESTP9	TESTP133			TESTP106	TESTP42	TESTP110								VCC	VSS	VSS
T	VSS	SDQ_A48	VSS	SDQ_A49	SDQ_A52	VSS	TESTP43	VSS	VSS	VSS	TESTP107								VCC	VCC	VCC
R	VCC_DDR	SMYRCO_MPVOH	SMYRCO_MPVOL	VSS	TESTP116	TESTP113			TESTP111	TESTP117	NC										
P		SDQ_A53	VSS	SCMD_CLK_A5#	SCMD_CLK_A5	VSS	TESTP112	VSS	VSS	VSS	TESTP118										
N	VSS	SCMD_CLK_A2#	SCMD_CLK_A2	VSS	TESTP35	TESTP41			TESTP32	TESTP38	TESTP125										
M		TESTP23	VSS	SDQS_A6	NC	VSS	TESTP10	VSS	VSS	VSS	SDQ_B61										
L	VSS	SDQ_A54	SDQ_A55	TESTP119	VSS	TESTP115			TESTP134	VSS	VSS	VSS	HA5#	HREQ2#	DEFER#	PRO_CHOT#	HDSTB_P1#	HD21#			
K		SDQ_A50	VSS	SDQ_A51	SDQ_A60	TESTP120	VSS	TESTP114	VSS		VSS	HA26#	HA8#	VSS	HIT#	VSS	HDSTB_N1#	VSS			
J	VSS	SDQ_A61	SDQ_A56	VSS	TESTP11	TESTP135	TESTP126	VSS	HA21#	HA30#	HA11#	HA15#	HREQ1#	VSS	HREQ4#	VSS	HD28#	VSS			
H		SDQ_A57	VSS	TESTP24	SDQS_A7	VSS	TESTP121		HA25#	VSS		VSS		VSS		VSS		VSS			
G	VSS	SDQ_A62	TESTP123	TESTP127	VSS	HA29#		VSS	HA22#	HA31#		DRDY#		RS0#		HD16#		HD23#			
F		SDQ_A63	SDQ_A59	TESTP122	HA28#		HA23#	HA19#	ADS#	VSS	HA16#	VSS	HDVREF	VSS	HD24#	VSS	HD19#	VSS			
E	VCC_DDR	SMV_REF_A	SDQ_A58	HA27#		HA13#	HA6#	HA24#	DBSY#	NC	HLOCK#	HD_RCOMP	HITM#	HD1#	HD27#	HD9#	HD18#	HD8#			
D	VSS	HA17#	VSS		VSS	HA4#	VSS	HADST_B1#	VSS	HA3#	VSS	HTRDY#	VSS	HD5#	VSS	HD3#	VSS	HD15#			
C	NC	HA20#		HA18#	HA10#	HA9#	HREQ3#	VSS	RS1#	VSS	HD_SWING	VSS	NC	VSS	HD7#	VSS	HDSTB_NO#	VSS			
B		NC	HA14#	HA7#	HA12#	HADST_B0#	HREQ0#	BNR#	RS2#	BPRI#	NC	BREQ0#	HD0#	HD4#	HD2#	HD6#	HDSTB_P0#	HD12#			
A	NC		NC	VSS	VCCA_FSB		VSS		VSS		VSS		VSS		VTT	VSS					
	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18			

Figure 14. Intel® 82848P MCH Ballout Diagram (Top View—Right Side)

	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	VSS	VCC_DDR		VSS		VSS		VSS		VCC_DDR		VCC_DDR	VCC_DDR	VCC_DDR	NC		RSVD	AR
SCMD CLK_A1	TESTP18	SDQS_A1	SDQ_A8	SDQ_A7	TESTP17	SDQ_A1	SDQ_A0	SMV REF_B	EXTTS#	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR	NC		AP
SCMD CLK_A1#	VSS	SDQ_A13	VSS	SDQ_A3	VSS	SDQS_A0	VSS	SMXRCOMP PVOH	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR		VCC_DDR	NC		AN
VSS	SCMD CLK_A4	VSS	SDQ_A9	VSS	SDQ_A2	VSS	SDQ_A4	VSS	VCC_DDR	VCC_DDR	VCC_DDR	VCC_DDR		VCC_DDR	VCC_DDR	VCC_DDR		AM
TESTP75	SCMD CLK_A4#	TESTP40	SDQ_A12	TESTP73	SDQ_A6	TESTP66	SDQ_A5	SMXRCOMP PVOL	TESTP68	VCC_DDR	VCC_DDR			HI7	HI5	HI6	VSS	AL
TESTP74	VSS	TESTP34	VSS	TESTP76	VSS	TESTP70	VSS	SMXRCOMP	VSS	CI0			HI4	RSTIN#	VSS	HI2		AK
	TESTP78		TESTP77		NC		TESTP64	VSS	ICH SYNC#	\		CISTRF	CISTRS	VSS	HI10	HI8	VSS	AJ
	VSS		VSS		VSS		VSS	CI9		CI1	VSS	HISTRF	HISTRS	VSS	HI9			AH
TESTP37	VSS	TESTP5	VSS	TESTP129	TESTP71	TESTP4	RSVD	RSVD	VSS	CI7	CI10	HI3	VSS	HI1	CI_RCOMP	VCCA_AGP		AG
TESTP31	VSS	TESTP128	VSS	NC	TESTP69	VSS		VSS	CI6	CI3	VSS	HI0	CI_VREF	VSS	CI_SWING			AF
TESTP72	TESTP67	TESTP65	PWROK	VSS	VSS	VSS	VSS	CI8			GAD0	GAD3	VSS	HI_SWING	HI_VREF	VSS		AE
							CI2	VSS	VSS	VSS	CI4	VSS	GAD2	HI_RCOMP	VSS	GVREF		AD
							GAD1	CI5	GAD5			GADSTBF0	GADSTBS0	VSS	GVSWING	GRCOMP	VSS	AC
							GAD6	VSS	VSS	VSS	GAD7	VSS	GTRDY	GDEVSEL	VSS	GPAR		AB
							GAD12	GAD4	GAD8			GAD9	GAD10	VSS	GCBE2	GAD16	VSS	AA
VCC	VCC						VCCA_AGP	VSS	VSS	VSS	GCBE0	VSS	GAD20	GAD17	VSS	GAD18	VCCA_AGP	Y
VSS	VCC						GSTOP	GAD11	GAD14			GAD13	GCBE1	VSS	GAD22	GAD19		W
VSS	VCC						GIRDY	VSS	VSS	VSS	GAD15	VSS	GADSTBS1	GADSTBF1	VSS	GAD21		V
VCC	VCC						GSBSTBF	GSBA5#	GSBA4#			GFRAME	GSBA6#	VSS	GAD23	GCBE3		U
VCC	VCC						GSBSTBS	VSS	VSS	VSS	GSBA7#	VSS	GAD26	GAD25	VSS	GAD24	VSS	T
							VCC	GRBF	GWBF			GSBA0#	GSBA3#	VSS	GSBA2#	GAD27	VSS	R
							VCC	VCC	VSS	VSS	GSBA1#	VSS	GAD29	GAD30	VSS	GAD28		P
							VCC	VCC	VCC			GREQ	GST1	VSS	GST0	GST2	VSS	N
							VCC	VCC	VCC	VCC	GGNT	VSS	DBI_LO	DBI_HI	VSS	GAD31		M
DINV1#	HD33#	HD41#	DINV2#	BSEL0	BSEL1	VCC	VCC	VCC		VCC	VCC	VCC	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	L
HD31#	VSS	HD38#	VSS	HD43#	VSS	VSS	VSS	VCC	VCC	VCC	VCC	VCC	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	K
HD20#	VSS	HD32#	VSS	HD34#	VSS	HD44#	VSS	VCC	VCC	VCC	VCC	VCC	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	VCC_AGP	J
	VSS		VSS		VSS		HD45#	VSS	VSS	RSVD	RSVD	VSS	GCLKIN	TESTP3	VSS			H
	HD22#		HD29#		HD39#		HD40#	HDSTBP2#	HD46#		RSVD	RSVD	RSVD	TESTP1	VCC_DAC	VCC_DAC		G
HD17#	VSS	HD25#	VSS	HD35#	VSS	HD36#	VSS	HDSTBN2#	VSS	VTT		VSS	RSVD	VSS	TESTP2	VSS		F
HD30#	HD14#	HD26#	HD49#	HD37#	HDSTBN3#	HD42#	HD58#	HD47#	CPURST#	VTT	VTT		RSVD	VSS	TESTP0	VSS		E
VSS	HD11#	VSS	HD53#	VSS	HDSTBP3#	VSS	HD56#	VSS	HD62#	VTT	VTT	VTT		VSSA_DAC	RSVD	VSS		D
DINV0#	VSS	DINV3#	VSS	HD54#	VSS	HD57#	VSS	HD60#	VSS	HCLKN	VTT	VTT	VSS		VCCA_DAC	NC		C
HD13#	HD10#	HD52#	HD50#	HD48#	HD51#	HD55#	HD59#	HD61#	HD63#	HCLKP	VTT	VTT	VCCA_FSB	VCCA_DPLL	NC			B
	VSS	VTT		VSS		VSS		VSS		VSS	VTT	VTT	VTT	NC				A

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
ADS#	F27
BNR#	B28
BPRI#	B26
BREQ0#	B24
BSEL0	L13
BSEL1	L12
CI_RCOMP	AG2
CI_SWING	AF2
CI_VREF	AF4
CI0	AK7
CI1	AH7
CI2	AD11
CI3	AF7
CI4	AD7
CI5	AC10
CI6	AF8
CI7	AG7
CI8	AE9
CI9	AH9
CI10	AG6
CISTRF	AJ6
CISTRS	AJ5
CPURST#	E8
DBI_HI	M4
DBI_LO	M5
DBSY#	E27
DEFER#	L21
DINV0#	C17
DINV1#	L17
DINV2#	L14
DINV3#	C15
DRDY#	G24
EXTTS#	AP8
GAD0	AE6
GAD1	AC11
GAD2	AD5
GAD3	AE5
GAD4	AA10
GAD5	AC9
GAD6	AB11
GAD7	AB7

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
GAD8	AA9
GAD9	AA6
GAD10	AA5
GAD11	W10
GAD12	AA11
GAD13	W6
GAD14	W9
GAD15	V7
GAD16	AA2
GAD17	Y4
GAD18	Y2
GAD19	W2
GAD20	Y5
GAD21	V2
GAD22	W3
GAD23	U3
GAD24	T2
GAD25	T4
GAD26	T5
GAD27	R2
GAD28	P2
GAD29	P5
GAD30	P4
GAD31	M2
GADSTBF0	AC6
GADSTBF1	V4
GADSTBS0	AC5
GADSTBS1	V5
GC#/BE0	Y7
GC#/BE1	W5
GC#/BE2	AA3
GC#/BE3	U2
GCLKIN	H4
GDEVSEL	AB4
GFRAME	U6
GGNT	M7
GIRDY	V11
GPARG	AB2
GRBF	R10
GRCOMP	AC2
GREQ	N6

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
GSBA0#	R6
GSBA1#	P7
GSBA2#	R3
GSBA3#	R5
GSBA4#	U9
GSBA5#	U10
GSBA6#	U5
GSBA7#	T7
GSBSTBF	U11
GSBSTBS	T11
GST0	N3
GST1	N5
GST2	N2
GSTOP	W11
GTRDY	AB5
GVREF	AD2
GVSWING	AC3
GWBF	R9
HA3#	D26
HA4#	D30
HA5#	L23
HA6#	E29
HA7#	B32
HA8#	K23
HA9#	C30
HA10#	C31
HA11#	J25
HA12#	B31
HA13#	E30
HA14#	B33
HA15#	J24
HA16#	F25
HA17#	D34
HA18#	C32
HA19#	F28
HA20#	C34
HA21#	J27
HA22#	G27
HA23#	F29
HA24#	E28
HA25#	H27

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
HA26#	K24
HA27#	E32
HA28#	F31
HA29#	G30
HA30#	J26
HA31#	G26
HADSTB0#	B30
HADSTB1#	D28
HCLKN	C7
HCLKP	B7
HD0#	B23
HD1#	E22
HD2#	B21
HD3#	D20
HD4 #	B22
HD5#	D22
HD6#	B20
HD7#	C21
HD8#	E18
HD9#	E20
HD10#	B16
HD11#	D16
HD12#	B18
HD13#	B17
HD14#	E16
HD15#	D18
HD16#	G20
HD17#	F17
HD18#	E19
HD19#	F19
HD20#	J17
HD21#	L18
HD22#	G16
HD23#	G18
HD24#	F21
HD25#	F15
HD26#	E15
HD27#	E21
HD28#	J19
HD29#	G14
HD30#	E17

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
HD31#	K17
HD32#	J15
HD33#	L16
HD34#	J13
HD35#	F13
HD36#	F11
HD37#	E13
HD38#	K15
HD39#	G12
HD40#	G10
HD41#	L15
HD42#	E11
HD43#	K13
HD44#	J11
HD45#	H10
HD46#	G8
HD47#	E9
HD48#	B13
HD49#	E14
HD50#	B14
HD51#	B12
HD52#	B15
HD53#	D14
HD54#	C13
HD55#	B11
HD56#	D10
HD57#	C11
HD58#	E10
HD59#	B10
HD60#	C9
HD61#	B9
HD62#	D8
HD63#	B8
HDRCOMP	E24
HDSTBN0#	C19
HDSTBN1#	K19
HDSTBN2#	F9
HDSTBN3#	E12
HDSTBP0#	B19
HDSTBP1#	L19
HDSTBP2#	G9

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
HDSTBP3#	D12
HDSWING	C25
HDVREF	F23
HI_RCOMP	AD4
HI_SWING	AE3
HI_VREF	AE2
HI0	AF5
HI1	AG3
HI2	AK2
HI3	AG5
HI4	AK5
HI5	AL3
HI6	AL2
HI7	AL4
HI8	AJ2
HI9	AH2
HI10	AJ3
HISTRF	AH5
HISTRS	AH4
HIT#	K21
HITM#	E23
HLOCK#	E25
HREQ0#	B29
HREQ1#	J23
HREQ2#	L22
HREQ3#	C29
HREQ4#	J21
HTRDY#	D24
NC	A3
NC	A33
NC	A35
NC	AF13
NC	AF23
NC	AJ12
NC	AN1
NC	AP2
NC	AR3
NC	AR33
NC	AR35
NC	B2
NC	B25



**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
NC	B34
NC	C1
NC	C23
NC	C35
NC	E26
NC	M31
NC	R25
PROCHOT#	L20
PWROK	AE14
RS0#	G22
RS1#	C27
RS2#	B27
RSTIN#	AK4
RSVD	AJ8
RSVD	H7
RSVD	G6
RSVD	G4
RSVD	H6
RSVD	G5
RSVD	F4
RSVD	E4
RSVD	D2
RSVD	AR1
RSVD	AP34
RSVD	AG9
RSVD	AN35
RSVD	AG10
SBA_A0	AE33
SBA_A1	AH34
SCAS_A#	Y34
SCKE_A0	AL20
SCKE_A1	AN19
SCKE_A2	AM20
SCKE_A3	AP20
SCMDCLK_A0	AK32
SCMDCLK_A0#	AK31
SCMDCLK_A1	AP17
SCMDCLK_A1#	AN17
SCMDCLK_A2	N33
SCMDCLK_A2#	N34
SCMDCLK_A3	AK33

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
SCMDCLK_A3#	AK34
SCMDCLK_A4	AM16
SCMDCLK_A4#	AL16
SCMDCLK_A5	P31
SCMDCLK_A5#	P32
SCS_A0#	AA34
SCS_A1#	Y31
SCS_A2#	Y32
SCS_A3#	W34
SDQ_A0	AP10
SDQ_A1	AP11
SDQ_A2	AM12
SDQ_A3	AN13
SDQ_A4	AM10
SDQ_A5	AL10
SDQ_A6	AL12
SDQ_A7	AP13
SDQ_A8	AP14
SDQ_A9	AM14
SDQ_A10	AL18
SDQ_A11	AP19
SDQ_A12	AL14
SDQ_A13	AN15
SDQ_A14	AP18
SDQ_A15	AM18
SDQ_A16	AP22
SDQ_A17	AM22
SDQ_A18	AL24
SDQ_A19	AN27
SDQ_A20	AP21
SDQ_A21	AL22
SDQ_A22	AP25
SDQ_A23	AP27
SDQ_A24	AP28
SDQ_A25	AP29
SDQ_A26	AP33
SDQ_A27	AM33
SDQ_A28	AM28
SDQ_A29	AN29
SDQ_A30	AM31
SDQ_A31	AN34

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
SDQ_A32	AH32
SDQ_A33	AG34
SDQ_A34	AF32
SDQ_A35	AD32
SDQ_A36	AH31
SDQ_A37	AG33
SDQ_A38	AE34
SDQ_A39	AD34
SDQ_A40	AC34
SDQ_A41	AB31
SDQ_A42	V32
SDQ_A43	V31
SDQ_A44	AD31
SDQ_A45	AB32
SDQ_A46	U34
SDQ_A47	U33
SDQ_A48	T34
SDQ_A49	T32
SDQ_A50	K34
SDQ_A51	K32
SDQ_A52	T31
SDQ_A53	P34
SDQ_A54	L34
SDQ_A55	L33
SDQ_A56	J33
SDQ_A57	H34
SDQ_A58	E33
SDQ_A59	F33
SDQ_A60	K31
SDQ_A61	J34
SDQ_A62	G34
SDQ_A63	F34
SMAA_A0	AJ34
SMAA_A1	AL33
SMAA_A2	AK29
SMAA_A3	AN31
SMAA_A4	AL30
SMAA_A5	AL26
SMAA_A6	AL28
SMAA_A7	AN25
SMAA_A8	AP26

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
SMAA_A9	AP24
SMAA_A10	AJ33
SMAA_A11	AN23
SMAA_A12	AN21
SMVREF_A	E34
SMVREF_B	AP9
SMXRCOMP	AK9
SMXRCOMPVOH	AN9
SMXRCOMPVOL	AL9
SMYRCOMP	AA33
SMYRCOMPVOH	R34
SMYRCOMPVOL	R33
SRAS_A#	AC33
SWE_A#	AB34
TESTP0	E2
TESTP1	G3
TESTP2	F2
TESTP3	H3
TESTP4	AG11
TESTP5	AG15
TESTP6	AE21
TESTP7	AJ28
TESTP8	AC31
TESTP9	U31
TESTP10	M29
TESTP11	J31
TESTP12	AE27
TESTP13	AD26
TESTP14	AL29
TESTP15	AL27
TESTP16	AE23
TESTP17	AP12
TESTP18	AP16
TESTP19	AM24
TESTP20	AP30
TESTP21	AF31
TESTP22	W33
TESTP23	M34
TESTP24	H32
TESTP25	AL34
TESTP26	AM34

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
TESTP27	AP32
TESTP28	AP31
TESTP29	AM26
TESTP30	AG29
TESTP31	AF17
TESTP32	N27
TESTP33	AJ30
TESTP34	AK15
TESTP35	N31
TESTP36	AG30
TESTP37	AG17
TESTP38	N26
TESTP39	AH29
TESTP40	AL15
TESTP41	N30
TESTP42	U26
TESTP43	T29
TESTP44	V25
TESTP45	W25
TESTP46	AG31
TESTP47	AJ31
TESTP48	AD27
TESTP49	AE24
TESTP50	AK27
TESTP51	AG25
TESTP52	AL25
TESTP53	AF21
TESTP54	AL23
TESTP55	AJ22
TESTP56	AF29
TESTP57	AL21
TESTP58	AJ20
TESTP59	Y25
TESTP60	AA25
TESTP61	W26
TESTP62	W31
TESTP63	W27
TESTP64	AJ10
TESTP65	AE15
TESTP66	AL11
TESTP67	AE16

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
TESTP68	AL8
TESTP69	AF12
TESTP70	AK11
TESTP71	AG12
TESTP72	AE17
TESTP73	AL13
TESTP74	AK17
TESTP75	AL17
TESTP76	AK13
TESTP77	AJ14
TESTP78	AJ16
TESTP79	AJ18
TESTP80	AE19
TESTP81	AE20
TESTP82	AG23
TESTP83	AK23
TESTP84	AL19
TESTP85	AK21
TESTP86	AJ24
TESTP87	AE22
TESTP88	AK25
TESTP89	AH26
TESTP90	AG27
TESTP91	AF27
TESTP92	AJ26
TESTP93	AJ27
TESTP94	AD25
TESTP95	AF28
TESTP96	AE30
TESTP97	AC27
TESTP98	AC30
TESTP99	Y29
TESTP100	AE31
TESTP101	AB29
TESTP102	AA26
TESTP103	AA27
TESTP104	AA30
TESTP105	W30
TESTP106	U27
TESTP107	T25
TESTP108	AA31

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
TESTP109	V29
TESTP110	U25
TESTP111	R27
TESTP112	P29
TESTP113	R30
TESTP114	K28
TESTP115	L30
TESTP116	R31
TESTP117	R26
TESTP118	P25
TESTP119	L32
TESTP120	K30
TESTP121	H29
TESTP122	F32
TESTP123	G33
TESTP124	N25
TESTP125	M25
TESTP126	J29
TESTP127	G32
TESTP128	AF15
TESTP129	AG13
TESTP130	AG21
TESTP131	AH27
TESTP132	AD29
TESTP133	U30
TESTP134	L27
TESTP135	J30
TESTP136	AK19
TESTP137	AF19
TESTP138	AG19
TESTP139	AE18
SDQS_A0	AN11
SDQS_A1	AP15
SDQS_A2	AP23
SDQS_A3	AM30
SDQS_A4	AF34
SDQS_A5	V34
SDQS_A6	M32
SDQS_A7	H31
VCC	J6
VCC	J7

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VCC	J8
VCC	J9
VCC	K6
VCC	K7
VCC	K8
VCC	K9
VCC	L10
VCC	L11
VCC	L6
VCC	L7
VCC	L9
VCC	M10
VCC	M11
VCC	M8
VCC	M9
VCC	N10
VCC	N11
VCC	N9
VCC	P10
VCC	P11
VCC	R11
VCC	T16
VCC	T17
VCC	T18
VCC	T19
VCC	T20
VCC	U16
VCC	U17
VCC	U20
VCC	V16
VCC	V18
VCC	V20
VCC	W16
VCC	W19
VCC	W20
VCC	Y16
VCC	Y17
VCC	Y18
VCC	Y19
VCC	Y20
VCC_AGP	J1

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VCC_AGP	J2
VCC_AGP	J3
VCC_AGP	J4
VCC_AGP	J5
VCC_AGP	K2
VCC_AGP	K3
VCC_AGP	K4
VCC_AGP	K5
VCC_AGP	L1
VCC_AGP	L2
VCC_AGP	L3
VCC_AGP	L4
VCC_AGP	L5
VCC_AGP	Y1
VCC_DAC	G1
VCC_DAC	G2
VCC_DDR	AA35
VCC_DDR	AL6
VCC_DDR	AL7
VCC_DDR	AM1
VCC_DDR	AM2
VCC_DDR	AM3
VCC_DDR	AM5
VCC_DDR	AM6
VCC_DDR	AM7
VCC_DDR	AM8
VCC_DDR	AN2
VCC_DDR	AN4
VCC_DDR	AN5
VCC_DDR	AN6
VCC_DDR	AN7
VCC_DDR	AN8
VCC_DDR	AP3
VCC_DDR	AP4
VCC_DDR	AP5
VCC_DDR	AP6
VCC_DDR	AP7
VCC_DDR	AR15
VCC_DDR	AR21
VCC_DDR	AR31
VCC_DDR	AR4



**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VCC_DDR	AR5
VCC_DDR	AR7
VCC_DDR	E35
VCC_DDR	R35
VCCA_AGP	AG1
VCCA_AGP	Y11
VCCA_DAC	C2
VCCA_DDR	AC26
VCCA_DDR	AL35
VCCA_DDR	AB25
VCCA_DDR	AC25
VCCA_DPLL	B3
VCCA_FSB	A31
VCCA_FSB	B4
VSS	AF24
VSS	AF25
VSS	AF3
VSS	AF30
VSS	AF33
VSS	AF6
VSS	AF9
VSS	AG14
VSS	AG16
VSS	AG18
VSS	AG20
VSS	AG22
VSS	AG24
VSS	AG26
VSS	AG28
VSS	AG32
VSS	AG35
VSS	AG4
VSS	AG8
VSS	AH10
VSS	AH12
VSS	AH14
VSS	AH16
VSS	AH18
VSS	AN30
VSS	AN32
VSS	AR11

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VSS	AR13
VSS	AR16
VSS	AR20
VSS	AR23
VSS	AR25
VSS	AR27
VSS	AR29
VSS	AR32
VSS	AR9
VSS	C10
VSS	C12
VSS	C14
VSS	C16
VSS	C18
VSS	C20
VSS	C22
VSS	C24
VSS	C26
VSS	C28
VSS	C4
VSS	C8
VSS	D1
VSS	D11
VSS	D13
VSS	D15
VSS	D17
VSS	D19
VSS	D19
VSS	K29
VSS	K33
VSS	L24
VSS	L25
VSS	L26
VSS	L31
VSS	L35
VSS	M26
VSS	M27
VSS	M28
VSS	M3
VSS	M30
VSS	M33
VSS	M6

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VSS	N1
VSS	N32
VSS	N35
VSS	N4
VSS	P26
VSS	P27
VSS	P28
VSS	P3
VSS	P30
VSS	P33
VSS	P6
VSS	P8
VSS	P9
VSS	R1
VSS	R32
VSS	R4
VSS	T1
VSS	T10
VSS	A11
VSS	A13
VSS	A16
VSS	A20
VSS	A23
VSS	A25
VSS	A27
VSS	A29
VSS	A32
VSS	A7
VSS	A9
VSS	AA1
VSS	AA32
VSS	AA4
VSS	AB10
VSS	AB26
VSS	AB27
VSS	AB28
VSS	AB3
VSS	AB30
VSS	AB33
VSS	AB6
VSS	AB8

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
VSS	AB9
VSS	AH20
VSS	AH22
VSS	AH24
VSS	AH3
VSS	AH30
VSS	AH33
VSS	AH6
VSS	AJ1
VSS	AJ32
VSS	AJ35
VSS	AJ4
VSS	AJ9
VSS	AK10
VSS	AK12
VSS	AK14
VSS	AK16
VSS	AK18
VSS	AK20
VSS	AK22
VSS	AK24
VSS	AK26
VSS	AK28
VSS	AK3
VSS	AK8
VSS	D21
VSS	D23
VSS	D25
VSS	D27
VSS	D29
VSS	D31
VSS	D33
VSS	D35
VSS	D9
VSS	E1
VSS	E3
VSS	F1
VSS	F10
VSS	F12
VSS	F14
VSS	F16

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
VSS	F18
VSS	F20
VSS	F22
VSS	F24
VSS	F26
VSS	F3
VSS	F5
VSS	F8
VSS	G28
VSS	G31
VSS	G35
VSS	H12
VSS	H14
VSS	H16
VSS	T26
VSS	T27
VSS	T28
VSS	T3
VSS	T30
VSS	T33
VSS	T35
VSS	T6
VSS	T8
VSS	T9
VSS	U18
VSS	U19
VSS	U32
VSS	U4
VSS	V10
VSS	V17
VSS	V19
VSS	V26
VSS	V27
VSS	V28
VSS	V3
VSS	V30
VSS	V33
VSS	V6
VSS	V8
VSS	V9
VSS	W17

Table 30. MCH Ballout by Signal Name

Signal Name	Ball #
VSS	W18
VSS	W32
VSS	W4
VSS	Y10
VSS	Y26
VSS	AC1
VSS	AC32
VSS	AC35
VSS	AC4
VSS	AD10
VSS	AD28
VSS	AD3
VSS	AD30
VSS	AD33
VSS	AD6
VSS	AD8
VSS	AD9
VSS	AE1
VSS	AE10
VSS	AE11
VSS	AE12
VSS	AE13
VSS	AE25
VSS	AE26
VSS	AE32
VSS	AE35
VSS	AE4
VSS	AF11
VSS	AF14
VSS	AF16
VSS	AF18
VSS	AF20
VSS	AF22
VSS	AL1
VSS	AL32
VSS	AM11
VSS	AM13
VSS	AM15
VSS	AM17
VSS	AM19
VSS	AM21

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VSS	AM23
VSS	AM25
VSS	AM27
VSS	AM29
VSS	AM35
VSS	AM9
VSS	AN10
VSS	AN12
VSS	AN14
VSS	AN16
VSS	AN18
VSS	AN20
VSS	AN22
VSS	AN24
VSS	AN26
VSS	AN28
VSS	H18
VSS	H2
VSS	H20
VSS	H22
VSS	H24
VSS	H26
VSS	H30
VSS	H33

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VSS	H5
VSS	H8
VSS	H9
VSS	J10
VSS	J12
VSS	J14
VSS	J16
VSS	J18
VSS	J20
VSS	J22
VSS	J28
VSS	J32
VSS	J35
VSS	K11
VSS	K12
VSS	K14
VSS	K16
VSS	K18
VSS	K20
VSS	K22
VSS	K25
VSS	K27
VSS	Y27
VSS	Y28

**Table 30. MCH Ballout by Signal Name**

Signal Name	Ball #
VSS	Y3
VSS	Y30
VSS	Y33
VSS	Y35
VSS	Y6
VSS	Y8
VSS	Y9
VSSA_DAC	D3
VTT	A15
VTT	A21
VTT	A4
VTT	A5
VTT	A6
VTT	B5
VTT	B6
VTT	C5
VTT	C6
VTT	D5
VTT	D6
VTT	D7
VTT	E6
VTT	E7
VTT	F7

## 7.2 MCH Package Information

The MCH is in a 37.5 mm x 37.5 mm Flip Chip Ball Grid Array (FC-BGA) package with 932 solder balls. Figure 15 and Figure 16 show the package dimensions.

Figure 15. Intel® 82848P MCH Package Dimensions (Top and Side Views)

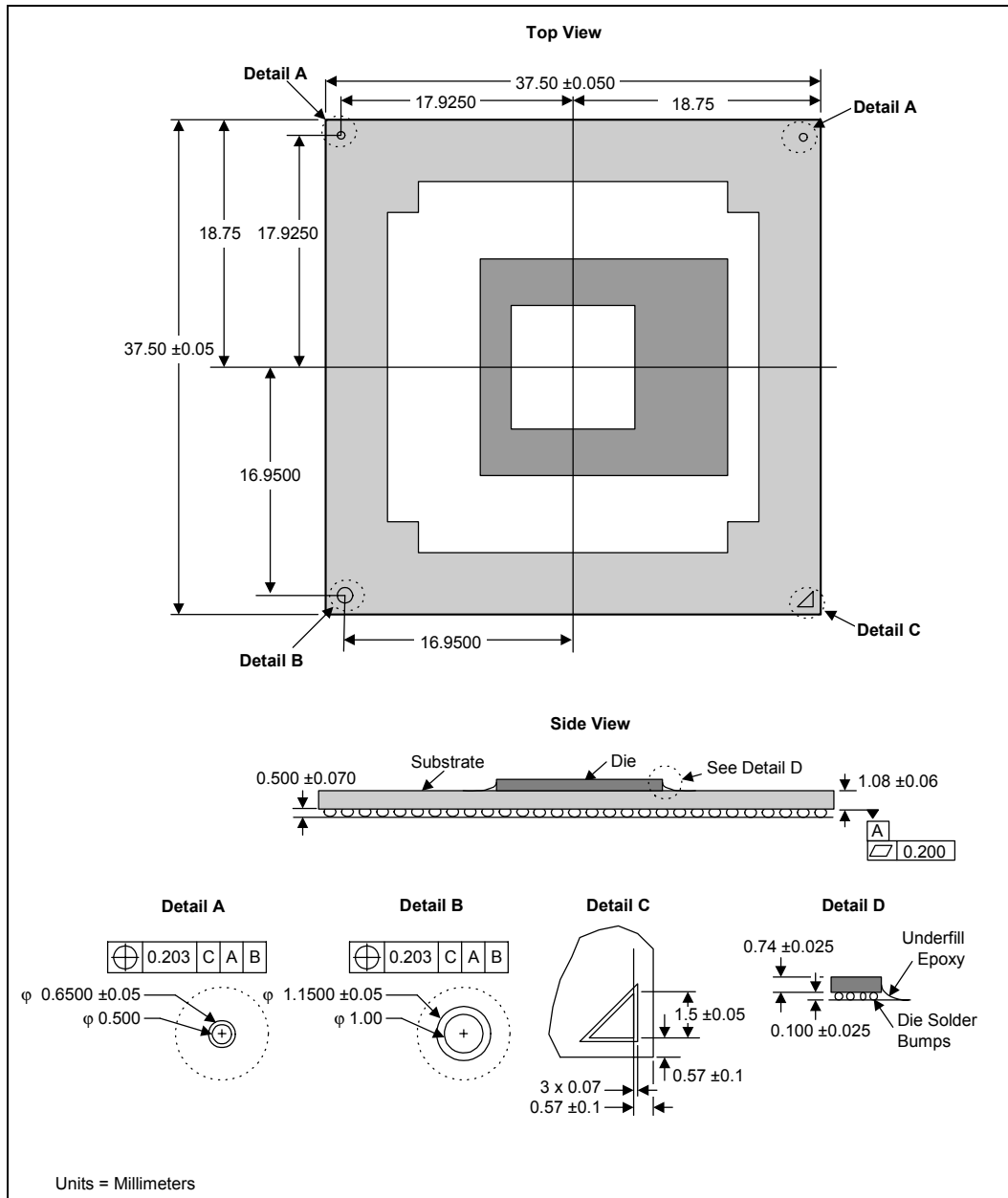
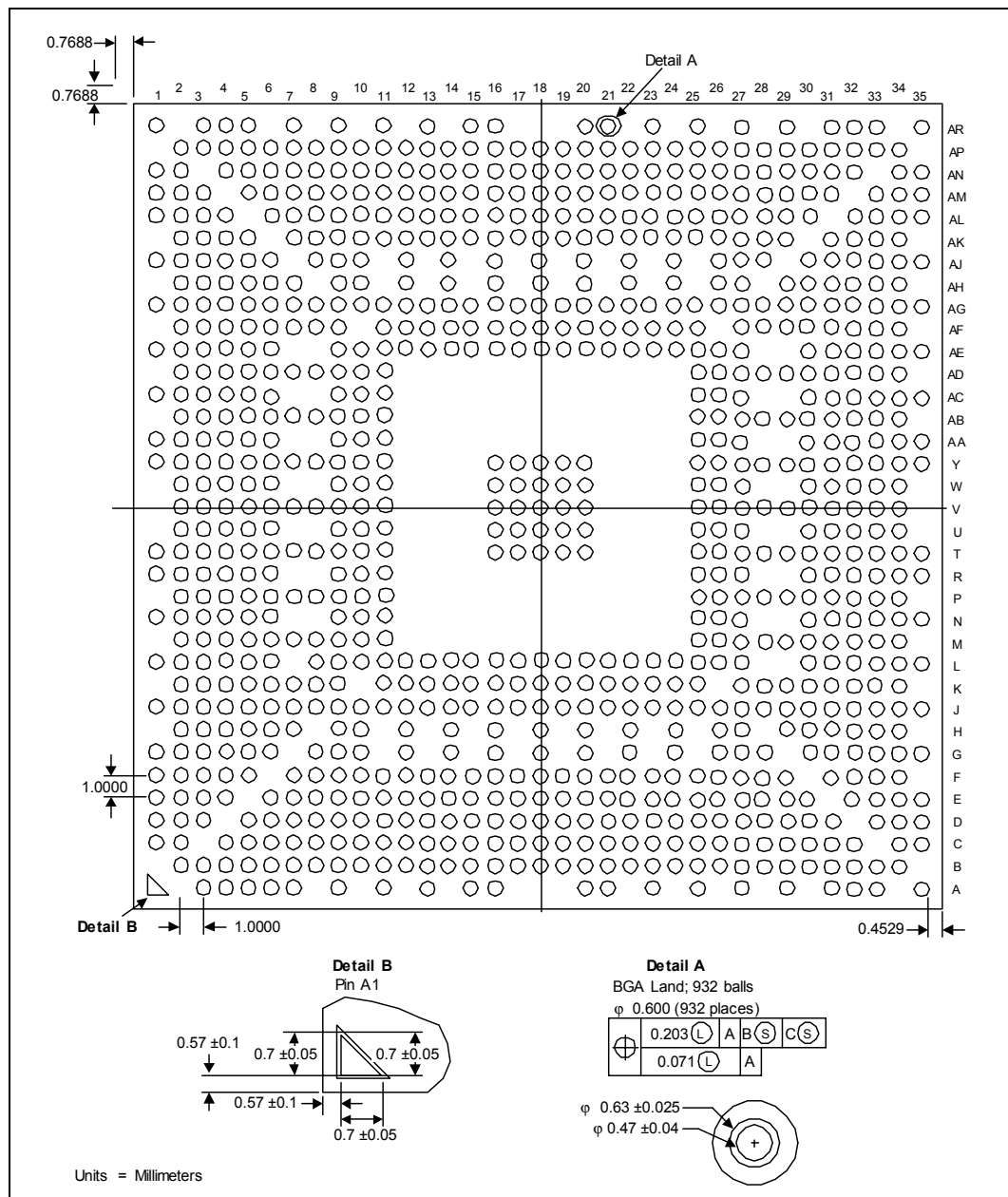


Figure 16. Intel® 82848P MCH Package Dimensions (Bottom View)



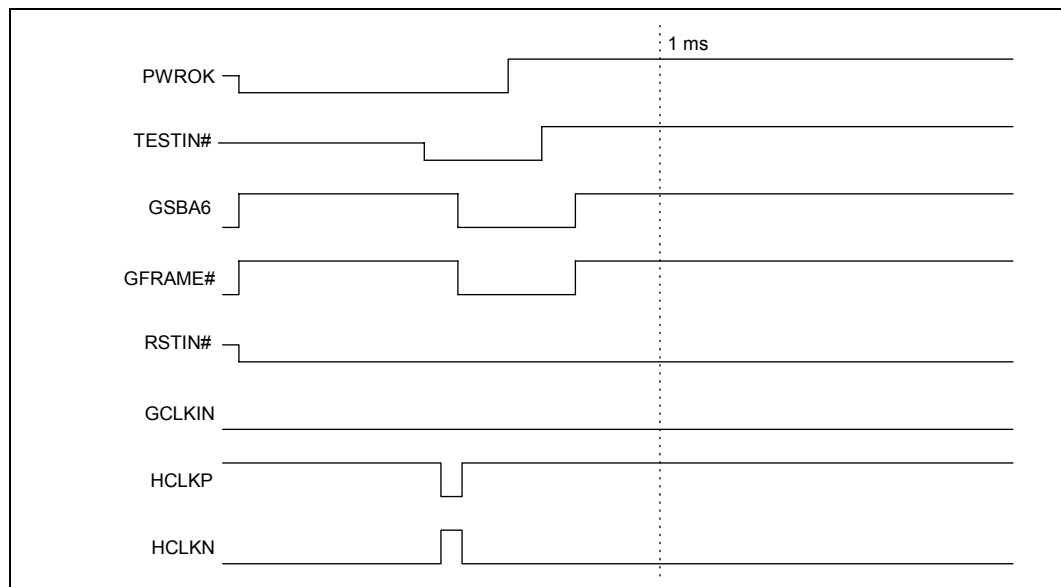
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In the MCH, testability for Automated Test Equipment (ATE) board level testing has been implemented as an XOR chain. An XOR-tree is a chain of XOR gates, each with one input pin connected to it.

### 8.1 XOR Test Mode Initialization

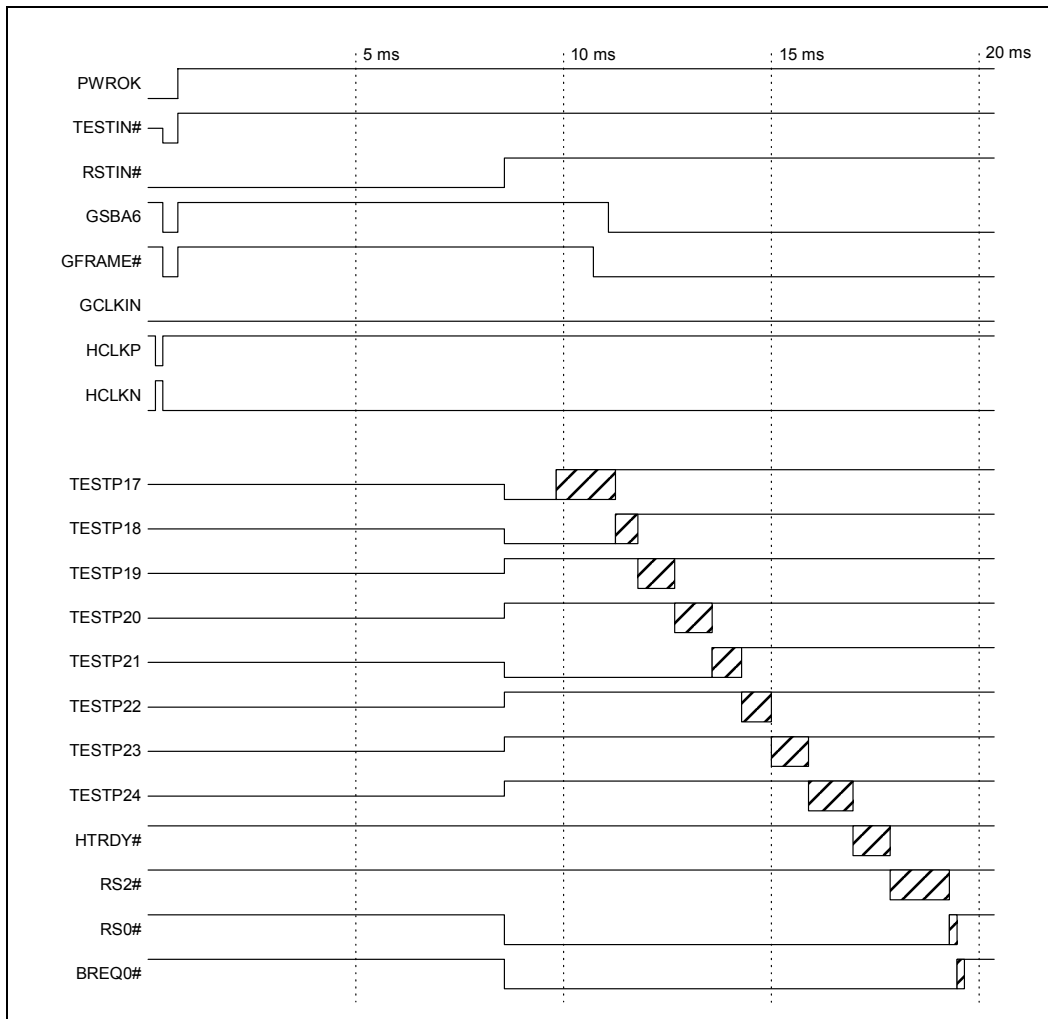
XOR test mode can be entered by driving GSBA6#, GSBA7#, TESTIN#, PWROK low, and RSTIN# low, then driving PWROK high, then RSTIN# high. XOR test mode via TESTIN# does not require a clock. But toggling of HCLKP and HCLKN as shown below is required for deterministic XOR operation. This applies to AGP 2.0 mode. If the component is in AGP 3.0 mode, GSBA6#, GSBA7#, and GC#/BE1 must be driven high.

Figure 17. XOR Toggling of HCLKP and HCLKN



Pin testing will not start until RSTIN# is de-asserted. Figure 18 shows chains are tested sequentially. Note that for the MCH, sequential testing is not required. All chains can be tested in parallel for test time reduction.

**Figure 18. XOR Testing Chains Tested Sequentially**





## 8.2 XOR Chain Definition

The MCH has 10 XOR chains. The XOR chain outputs are driven out on the following output pins. During full-width testing, XOR chain outputs will be visible on both pins. (For example, xor\_out0 is visible on TESTP17 and TESTP4.) During channel shared mode on the tester, outputs are visible on their respective channels. (For example, in channel A mode, xor\_out0 is visible on TESTP17 and the same is visible on TESTP4 in channel B mode.)

**Table 31. XOR Chain Outputs**

XOR Chain	DDR Output Pin Channel A	DDR Output Pin Channel B
xor_out0	TESTP17	TESTP4
xor_out1	TESTP18	TESTP5
xor_out2	TESTP19	TESTP6
xor_out3	TESTP20	TESTP7
xor_out4	TESTP21	TESTP8
xor_out5	TESTP22	TESTP9
xor_out6	TESTP23	TESTP10
xor_out7	TESTP24	TESTP11
xor_out8	HTRDY#	BPRI#
xor_out9	RS2#	DEFER#
xor_out10	RS0#	RS1#
xor_out11	BREQ0#	CPURST#

The following tables show the XOR chain pin mappings and their monitors for the MCH.

**Note:** Notes for [Table 32](#) through [Table 42](#).

1. Only AGP differential strobes are on different chains but in the same channel group. Other interface strobes are on the same chain since they do not require to be in opposite polarity all the time. All XOR chains can be run in parallel except chains with AGP strobes (chains 0 and 1, chains 0 and 2, and chains 2 and 4).
2. The channel A and channel B output pins for each chain show the same output:
3. For AGP signals, only the AGP 3.0 signal name is listed. For the corresponding AGP 2.0 signal name, refer to [Chapter 2](#).

Table 32. XOR Chain 0 (60 Inputs) Output Pins: TESTP17, TESTP4

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
CI7	AG7	GAD3	AE5	GST0	N3
CI1	AH7	GC#/BE0	Y7	GIRDY	V11
CI2	AD11	GADSTB0	AC6	GC#/BE2	AA3
CI8	AE9	GAD12	AA11	GC#/BE3	U2
CI9	AH9	GAD7	AB7	GST2	N2
CI0	AK7	GSTOP	W11	DBI_HI	M4
CISTRF	AJ6	GAD11	W10	GREQ	N6
CISTR5	AJ5	GAD10	AA5	GSBA2#	R3
CI6	AF8	GAD9	AA6	GSBSTBF	U11
CI3	AF7	GAD15	V7	GSBA7#	T7
CI4	AD7	GAD13	W6	GSBA0#	R6
CI5	AC10	GAD14	W9	GSBA5#	U10
CI10	AG6	GTRDY	AB5	GSBA3#	R5
GAD1	AC11	GPAR	AB2	GSBA4#	U9
GAD5	AC9	GC#/BE1	W5	GSBA1#	P7
GAD0	AE6	GFRAME	U6	GSBA6#	U5
GAD6	AB11	DBI_LO	M5	TESTP2	F2
GAD2	AD5	GDEVSEL	AB4	TESTP3	H3
GAD4	AA10	GRBF	R10	TESTP0	E2
GAD8	AA9	GWBF	R9	RSVD	AJ8
<b>Output Pins</b>					
TESTP17	AP12				
TESTP4	AG11				

**Table 33. XOR Chain 1 (33 Inputs) Output Pins: TESTP18, TESTP5**

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
HI7	AL4	HI8	AJ2	GAD23	U3
HI4	AK5	HI9	AH2	GAD25	T4
HI3	AG5	GST1	N5	GAD27	R2
HI5	AL3	GAD20	Y5	GAD24	T2
HISTRF	AH5	GAD16	AA2	GAD21	V2
HI10	AJ3	GAD17	Y4	GAD28	P2
HISTRS	AH4	GAD19	W2	GAD30	P4
HI2	AK2	GAD18	Y2	GAD31	M2
HI0	AF5	GADSTBF1	V5	GAD29	P5
HI6	AL2	GAD22	W3	GGNT	M7
HI1	AG3	GAD26	T5	EXTTS#	AP8
<b>Output Pins</b>					
TESTP18	AP16				
TESTP5	AG15				

**Table 34. XOR Chain 2 (44 Inputs) Output Pins: TESTP19, TESTP6**

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
GADSTBF0	AC5	HD19#	F19	HDSTBN0#	C19
GSBSTBS	T11	HD27#	E21	HD6#	B20
HD29#	G14	HD24#	F21	HD9#	E20
HD25#	F15	HD21#	L18	HD12#	B18
HD26#	E15	HD28#	J19	HD3#	D20
HD31#	K17	HD16#	G20	HD2#	B21
HD22#	G16	HD18#	E19	HD0#	B23
HD17#	F17	DINV0#	C17	HD4#	B22
HD30#	E17	HD8#	E18	HD5#	D22
HD20#	J17	HD11#	D16	HD7#	C21
DINVB_1	L17	HD14#	E16	HD1#	E22
HD23#	G18	HD10#	B16	PROCHOT#	L20
HDSTBP1#	L19	HD15#	D18	HITM#	E23
HDSTBN1#	K19	HD13#	B17	BSEL0	L13
		HDSTBP0#	B19	HLOCK#	E25
<b>Output Pins</b>					
TESTP19	AM24				
TESTP6	AE21				

Table 35. XOR Chain 3 (41 Inputs) Output Pins: TESTP20, TESTP7

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
BNR#	B28	HA12#	B31	HA19#	F28
BSEL1	L12	HA9#	C30	HA18#	C32
HIT#	K21	HA4#	D30	HA22#	G27
DRDY#	G24	HA10#	C31	HA24#	E28
DBSY#	E27	HA15#	J24	HA23#	F29
ADS#	F27	HA8#	K23	HADSTB1#	D28
HREQ4#	J21	HA13#	E30	HA17#	D34
HA16#	F25	HA6#	E29	HA25#	H27
HREQ3#	C29	HA5#	L23	HA20#	C34
HREQ0#	B29	HA11#	J25	HA30#	J26
HA3#	D26	HREQ2#	L22	HA21#	J27
HREQ1#	J23	HA31#	G26	HA27#	E32
HA7#	B32	HA26#	K24	HA29#	G30
HA14#	B33			HA28#	F31
<b>Output Pins</b>					
TESTP20	AP30				
TESTP7	AJ28				

Table 36. XOR Chain 4 (40 Inputs) Output Pins: TESTP21, TESTP8

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
HD45#	H10	HD43#	K13	HD57#	C11
HD46#	G8	HD33#	L16	HDSTBP3#	D12
HD40#	G10	HD41#	L15	HDSTBN3#	E12
HD47#	E9	HD35#	F13	HD51#	B12
HD39#	G12	HD32#	J15	HD49#	E14
HD36#	F11	HD37#	E13	HD55#	B11
HD44#	J11	HD58#	E10	HD54#	C13
HD42#	E11	HD56#	D10	HD53#	D14
DINV2#	L14	HD62#	D8	HD50#	B14
HDSTBP2#	G9	HD61#	B9	HD48#	B13
HDSTBN2#	F9	HD63#	B8	HD52#	B15
HD34#	J13	HD59#	B10	DINV3#	C15
HD38#	K15	HD60#	C9	GADSTBF1	V4
<b>Output Pins</b>				TESTP1	G3
TESTP21	AF31				
TESTP8	AC31				

**Table 37. XOR Chain 5 (44 Inputs) Output Pins: TESTP22, TESTP9**

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
SDQ_A58	E33	SDQ_A53	P34	SDQ_A41	AB31
SDQ_A59	F33	SDQ_A48	T34	SDQ_A44	AD31
SDQ_A62	G34	SDQ_A52	T31	SDQS_A4	AF34
SDQ_A63	F34	SDQ_A49	T32	SDQ_A35	AD32
SDQS_A7	H31	SCMDCLK_A5#	P32	SDQ_A38	AE34
SDQ_A61	J34	SCMDCLK_A5	P31	SDQ_A39	AD34
SDQ_A57	H34	SCMDCLK_A2#	N34	SDQ_A34	AF32
SDQ_A56	J33	SCMDCLK_A2	N33	SDQ_A33	AG34
SDQ_A60	K31	SDQS_A5	V34	SDQ_A37	AG33
SDQ_A51	K32	SDQ_A42	V32	SDQ_A36	AH31
SDQ_A50	K34	SDQ_A46	U34	SDQ_A32	AH32
SDQ_A55	L33	SDQ_A47	U33	SCMDCLK_A0	AK32
SDQS_A6	M32	SDQ_A43	V31	SCMDCLK_A0#	AK31
SDQ_A54	L34	SDQ_A40	AC34	SCMDCLK_A3#	AK34
		SDQ_A45	AB32	SCMDCLK_A3	AK33
<b>Output Pins</b>					
TESTP22	W33				
TESTP9	U31				

**Table 38. XOR Chain 6 (40 Inputs) Output Pins: TESTP23, TESTP10**

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
SDQ_A30	AM31	SDQ_A19	AN27	SDQ_A8	AP14
SDQS_A3	AM30	SDQ_A23	AP27	SDQ_A6	AL12
SDQ_A27	AM33	SDQ_A22	AP25	SDQ_A2	AM12
SDQ_A31	AN34	SDQ_A16	AP22	SDQ_A3	AN13
SDQ_A29	AN29	SDQ_A20	AP21	SDQS_A0	AN11
SDQ_A26	AP33	SDQ_A10	AL18	SDQ_A5	AL10
SDQ_A25	AP29	SDQ_A15	AM18	SDQ_A7	AP13
SDQ_A24	AP28	SDQ_A14	AP18	SDQ_A4	AM10
SDQ_A28	AM28	SDQS_A1	AP15	SCMDCLK_A1	AP17
SDQS_A2	AP23	SDQ_A11	AP19	SCMDCLK_A1#	AN17
SDQ_A21	AL22	SDQ_A13	AN15	SDQ_A1	AP11
SDQ_A17	AM22	SDQ_A9	AM14	SCMDCLK_A4#	AL16
SDQ_A18	AL24	SDQ_A12	AL14	SCMDCLK_A4	AM16
				SDQ_A0	AP10
<b>Output Pins</b>					
TESTP23	M34				
TESTP10	M29				

Table 39. XOR Chain 7 (45 Inputs) Output Pins: TESTP24, TESTP11

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
HADSTB1#	D28	TESTP134	L27	TESTP105	W30
TESTP121	H29	TESTP112	P29	TESTP133	U30
SDQ_B61	M25	TESTP113	R30	TESTP101	AB29
TESTP122	F32	TESTP116	R31	TESTP100	AE31
TESTP127	G32	TESTP35	N31	TESTP99	Y29
TESTP125	N25	TESTP41	N30	TESTP96	AE30
TESTP135	J30	TESTP38	N26	TESTP98	AC30
TESTP126	J29	TESTP32	N27	TESTP102	AA26
TESTP132	G33	TESTP107	T25	TESTP97	AC27
TESTP120	K30	TESTP110	U25	TESTP103	AA27
TESTP115	L30	TESTP106	U27	TESTP132	AD29
TESTP118	P25	TESTP111	R27	TESTP30	AG29
TESTP119	L32	TESTP109	V29	TESTP36	AG30
TESTP117	R26	TESTP104	AA30	TESTP33	AJ30
TESTP114	K28	TESTP108	AA31	TESTP39	AH29
<b>Output Pins</b>					
TESTP24	H32				
TESTP11	J31				

Table 40. XOR Chain 8 (40 Inputs) Output Pins: HTRDY#, BPRI#

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
TESTP94	AD25	TESTP85	AK21	TESTP72	AE17
TESTP90	AG27	TESTP81	AE20	TESTP40	AL15
TESTP93	AJ27	TESTP130	AG21	TESTP34	AK15
TESTP91	AF27	TESTP80	AE19	TESTP37	AG17
TESTP95	AF28	TESTP84	AL19	TESTP31	AF17
TESTP89	AH26	TESTP74	AK17	TESTP65	AE15
TESTP131	AH27	TESTP78	AJ16	TESTP67	AE16
TESTP92	AJ26	TESTP79	AJ18	TESTP71	AG12
TESTP88	AK25	TESTP75	AL17	TESTP66	AL11
TESTP87	AE22	TESTP77	AJ14	TESTP70	AK11
TESTP82	AG23	TESTP76	AK13	TESTP69	AF12
TESTP83	AK23	TESTP73	AL13	TESTP64	AJ10
TESTP86	AJ24	TESTP129	AG13	TESTP68	AL8
				TESTP128	AF15
<b>Output Pins</b>					
HTRDY#	D24				
BPRI#	B26				

**Table 41. XOR Chain 9 (62 Inputs) Output Pins: RS2#, DEFER#**

Signal Name	Ball Number	Signal Name	Ball Number	Signal Name	Ball Number
SCAS_A#	Y34	TESTP46	AG31	TESTP53	AF21
SWE_A#	AB34	TESTP25	AL34	TESTP55	AJ22
TESTP45	W25	SMAA_A6	AL28	TESTP57	AL21
TESTP60	AA25	TESTP52	AL25	TESTP50	AK27
SBA_A1	AH34	TESTP27	AP32	TESTP51	AG25
SCS_A1#	Y31	TESTP26	AM34	SCKE_A3	AP20
SCS_A2#	Y32	SMAA_A3	AN31	SCKE_A0	AL20
SCS_A3#	W34	TESTP49	AE24	SMAA_A11	AN23
SRAS_A#	AC33	TESTP47	AJ31	SMAA_A12	AN21
SBA_A0	AE33	TESTP14	AL29	SCKE_A2	AM20
SCS_A0#	AA34	SMAA_A4	AL30	SCKE_A1	AN19
TESTP48	AD27	TESTP15	AL27	TESTP136	AK19
TESTP61	W26	TESTP13	AD26	TESTP139	AE18
TESTP56	AF29	TESTP28	AP31	TESTP138	AG19
TESTP59	Y25	TESTP29	AM26	TESTP58	AJ20
SMAA_A10	AJ33	SMAA_A9	AP24	TESTP137	AF19
TESTP12	AE27	TESTP16	AE23	TESTP43	T29
SMAA_A0	AJ34	SMAA_A8	AP26	TESTP42	U26
SMAA_A1	AL33	SMAA_A5	AL26	TESTP44	V25
SMAA_A2	AK29	SMAA_A7	AN25	TESTP63	W27
		TESTP54	AL23	TESTP62	W31
<b>Output Pins</b>					
RS2#	B27				
DEFER#	L21				

Table 42. XOR Excluded Pins

Signal Name	Ball Number	Signal Name	Ball Number
Reserved	H7	TESTP17	AP12
Reserved	G6	TESTP18	AP16
BPRI#	B26	TESTP19	AM24
BREQ0#	B24	TESTP20	AP30
CPURST#	E8	TESTP21	AF31
DEFER#	L21	TESTP22	W33
RESERVED	G4	TESTP23	M34
GCLKIN	H4	TESTP24	H32
GRCOMP	AC2	TESTP4	AG11
RESERVED	H6	TESTP5	AG15
RESERVED	G5	TESTP6	AE21
GVREF	AD2	TESTP7	AJ28
GVSWING	AC3	TESTP8	AC31
HCLKN	C7	TESTP9	U31
HCLKP	B7	TESTP10	M29
HDRCOMP	E24	TESTP11	J31
HDSWING	C25	SMVREF_A0	E34
HDVREF	F23	SMVREF_B0	AP9
HTRDY#	D24	SMXRCOMP	AK9
HI_COMP	AD4	SMXRCOMPVOH	AN9
HI_VREF	AE2	SMXRCOMPVOL	AL9
HI_SWING	AE3	SMYRCOMP	AA33
PWROK	AE14	SMYRCOMPVOH	R34
RESERVED	F4	SMYRCOMPVOL	R33
RESERVED	E4	RESERVED	AG9
RESERVED	D2	RESERVED	AG10
RS0#	G22	CI_RCOMP	AG2
RS1#	C27	CI_VREF	AF4
RS2#	B27	CI_VSWING	AF2
RSTIN#	AK4		