National Semiconductor

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Geode™ GX2 Processor Series: GX2-FP-DDR, GX2-FP-SDR, GX2-CRT-DDR, GX2-CRT-SDR

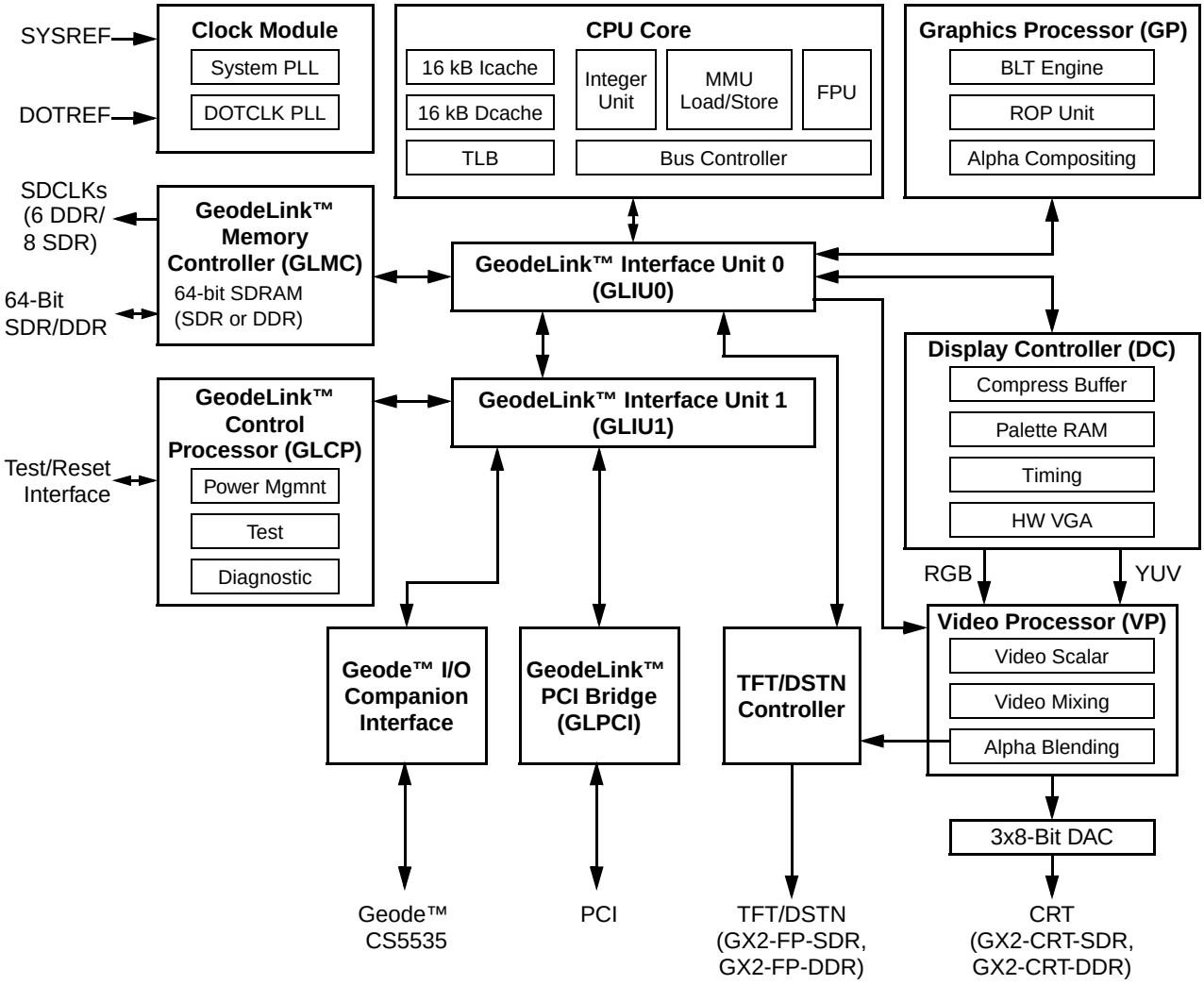
General Description

The National Semiconductor® Geode™ GX2 processor series is a line of integrated processors specifically designed to power information appliances (IA) for entertainment, education, and business. Serving the needs of consumers and business professionals alike, it's the perfect solution for IA applications, such as thin clients, interactive set-top boxes, and personal access devices (PADs).

Available with core voltages of 1.2V to 1.4V, it offers extremely low typical power consumption (1.0W to 2.0W, respectively), leading to longer battery life and enabling small form-factor, fanless designs. Typical power consumption is defined as an average, measured running Microsoft Windows at 80% Active Idle (Suspend-on-Halt) with a display resolution of 800x600x8 BPP at 75 Hz.

While the CPU Core provides maximum compatibility with the vast amount of Internet content available, the intelligent integration of several other functions, including graphics, offers a true system-level multimedia solution.

Internal Block Diagram



Features

General Features

- Functional blocks include:
  - CPU Core
  - GeodeLink™ Control Processor
  - GeodeLink Interface Units
  - GeodeLink Memory Controller
  - Graphics Processor
  - Display Controller
  - TFT/DSTN Controller
  - Video Processor
  - GeodeLink PCI Bridge
  - Geode I/O Companion Chip Interface
- 0.15 micron process
- Packaging:
  - 368-Terminal EBGA (Enhanced Ball Grid Array)
    - GX2-CRT supports CRT displays
  - GX2-FP supports TFT and DSTN displays, digital RGB output

CPU Core

- x86/x87-compatible CPU Core
- Performance:
  - Processor Frequency: 200 to 333 MHz
  - Dhrystone 2.1 MIPs: 150 to 300
  - Fully pipelined FPU (Floating Point Unit), 4x improvement on single precision floating point for AC3 and matrix multiplies compared to Geode GX1 processor
- Single issue/seven stage integer pipeline
- Split I/D cache/TLB (Translation Look-aside Buffer):
  - 16 kB/16 kB caches
  - Efficient Prefetch
- Integrated FPU that supports the Intel MMX and Advanced Micro Devices 3DNow! instruction sets
- Fully pipelined single precision hardware with microcode support for higher precisions
- Branch performance enhanced with Branch Target Buffer (BTB) and Return Stack

GeodeLink Control Processor

- JTAG interface:
  - ATPG, Full Scan, BIST on all arrays
  - 1149.1 Boundary Scan compliant
- ICE interface
- Reset and clock control
- Designed for improved software debug methods and performance analysis
- Power Management:
  - 3.3W max @ 333 MHz
  - Block level clock gating
  - Active hardware power management
  - Software power management
  - Lower power I/O

GeodeLink Interface Units

- High bandwidth packetized uni-directional bus for internal peripherals
- Standardized protocol to allow variants of products to be developed by adding or removing modules

GeodeLink Memory Controller

- Integrated memory controller for low latency to CPU and on-chip peripherals
- 64-Bit wide SDRAM bus operating frequency:
  - 111 MHz, 222 MT/S for DDR (Double Data Rate)
  - 133 MHz for SDR (Single Data Rate)

Note: SDR and DDR are not available on the same part

Graphics Processor

- High performance 2D graphics controller
- Alpha BLT

Display Controller

- Hardware frame buffer compression improves UMA (Unified Memory Architecture) memory efficiency
- Supports up to 1600x1200x16 BPP and 1280x1024x24 BPP running at 85 Hz (CRT)
- Hardware based VGA (Video Graphics Array)
- Hardware video up/down scalar
- Graphics/video alpha blending

Features (Continued)

TFT/DSTN Controller (GX2-FP only)

- DSTN filter
- Integrated Dot Clock PLL (Phase Lock Loop)
- DSTN or TFT outputs

CRT DACs (GX2-CRT only)

- Integrated 3x8-bit DAC

Video Processor

- Hardware video acceleration:
  - X and Y interpolation using three line buffers
  - YUV to RGB color space conversion
  - Horizontal filtering and downscaling
- Graphics/video overlay and blending:
  - Overlay of true color video up to 24 BPP
  - Chroma key and color key for both graphics and video
  - Alpha blending
  - Gamma correction

GeodeLink PCI Bridge

- Industry standard PCI 2.2 specification compliant
- 32-Bit, 66 MHz PCI interface
- Write gathering and write posting of in-bound write requests
- Supports fast back-to-back transactions

Geode I/O Companion Interface

- Designed to work in conjunction with the Geode CS5535 I/O companion

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1.0 Architecture Overview

The CPU Core provides maximum compatibility with the vast amount of Internet content available while the intelligent integration of several other functions, including graphics, makes the Geode GX2 processor a true system-level multimedia solution. GeodeLink is a system architecture for the Information Appliance marketplace.

The GX2 processor can be divided into major functional blocks (as shown in Figure 1-1):

- CPU Core
- GeodeLink™ Control Processor (GLCP)
- GeodeLink™ Interface Units (GLIU0, GLIU1)
- GeodeLink™ Memory Controller (GLMC)
- Graphics Processor (GP)
- Display Controller (DC)
- Video Processor (VP)
- GeodeLink™ PCI Bridge (GLPCI)
- Geode I/O Companion Chip Interface

Note: The Geode GX2 processor series is not pin compatible with previous GX processor generations (i.e., GX1, GXLV, and GXm).

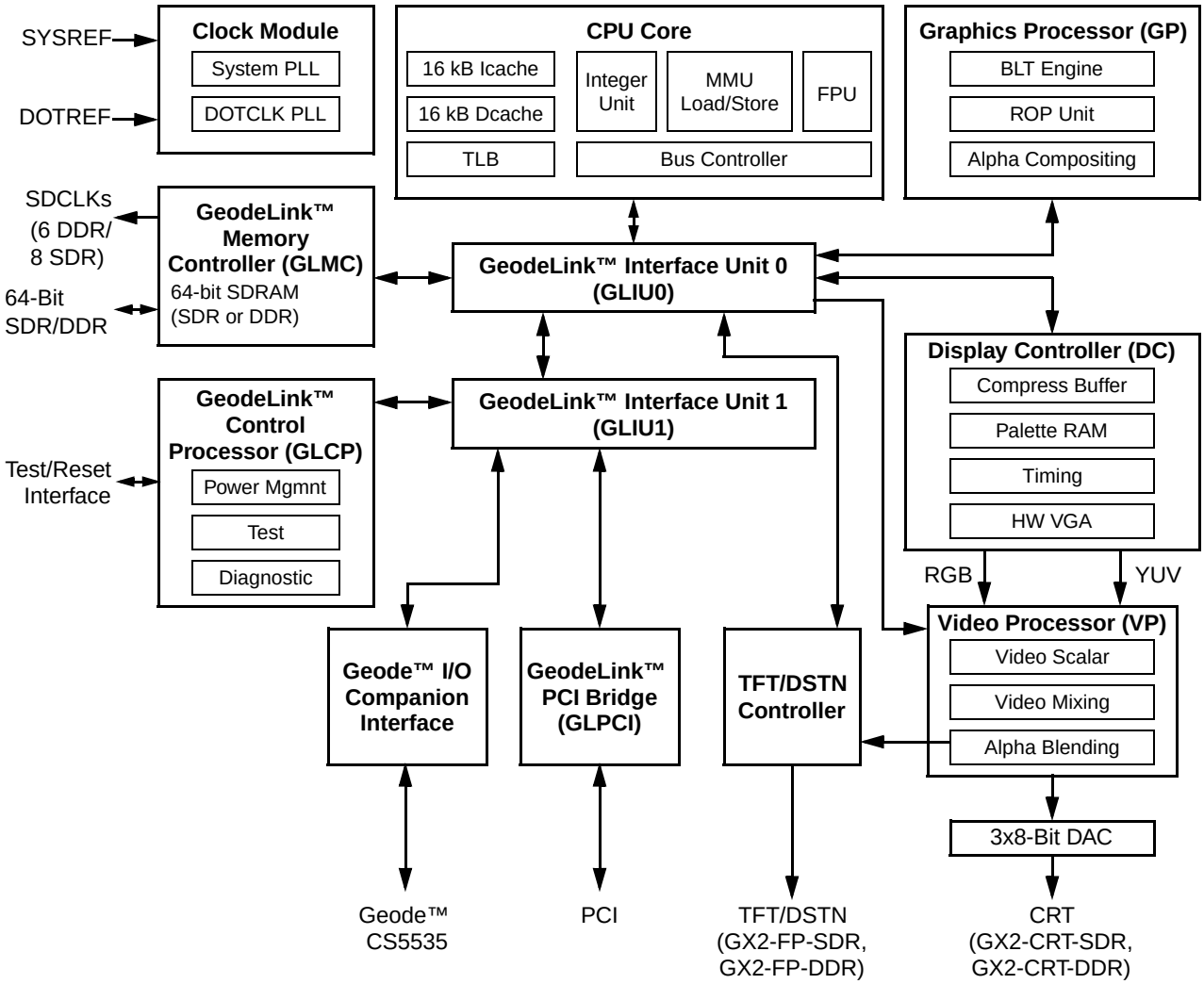


Figure 1-1. GX2 Block Diagram

Architecture Overview (Continued)

1.1 CPU CORE

The x86 core consists of an Integer Unit, cache memory subsystem, and an x87 compatible FPU (Floating Point Unit). The Integer Unit contains the instruction pipeline and associated logic. The memory subsystem contains the instruction and data caches, translation look-aside buffers (TLBs), and the interface to the GeodeLink Interface Units (GLIUs).

The instruction set supported by the core is a combination of Intel's Pentium, AMD's K6 and K7 FPU, and National's GX1 specific instructions. Specifically, it supports the Pentium, Pentium Pro, K6 3DNow!, K7 3DNow!, and K7 MMX instructions. It supports a subset of the specialized GX1 instructions including special SMM instructions. The CPU Core does not support the entire KNI instruction set as implemented in the Pentium 3. It does support the AMD K7 MMX instructions, that are a subset of the Pentium 3 KNI instructions.

1.1.1 Integer Unit

The Integer Unit consists of a single issue 8-stage pipeline and all the necessary support hardware to keep the pipeline running efficiently.

The instruction pipeline in the integer unit consists of eight stages:

1) **Instruction Prefetch** - Raw instruction data is fetched from the instruction memory cache.
2) **Instruction Pre-decode** - Prefix bytes are extracted from raw instruction data. This decode looks-ahead to the next instruction and the bubble can be squashed if the pipeline stalls down stream.
3) **Instruction Decode** - Performs full decode of instruction data. Indicates instruction length back to the Prefetch Unit, allowing the Prefetch Unit to shift the appropriate number of bytes to the beginning of the next instruction.
4) **Instruction Queue** - FIFO containing decoded x86 instructions. Allows Instruction Decode to proceed even if the pipeline is stalled downstream. Register reads for data operand address calculations are performed during this stage.
5) **Address Calculation #1** - Computes linear address of operand data (if required) and issues request to the Data Memory Cache. Microcode can take over the pipeline and inject a micro-box here if multi-box instructions require additional data operands.
6) **Address Calculation #2** - Operand data (if required) is returned and set up to the Execution stage with no bubbles if there was a data cache hit. Segment limit checking is performed on the data operand address. The µROM is read for setup to Execution Unit.
7) **Execution Unit** - Register and/or data memory fetch fed through the Arithmetic Logic Unit (ALU) for arithmetic or logical operations. µROM always fires for the first instruction box down the pipeline. Microcode can take over the pipeline and insert additional boxes here if the instruction requires multiple Execution Unit stages to complete.
8) **Writeback** - Results of the Execution Unit stages are written to the register file or to data memory.

1.1.2 Memory Subsystem

The memory subsystem of the CPU Core supplies the integer pipeline with instructions, data, and translated addresses (when necessary). To support the efficient delivery of instructions, the memory subsystem has a single clock access 16 kB 4-way set associative instruction cache and an 8-entry fully associative TLB. The TLB performs necessary address translations when in protected mode. For data, there is a 16 kB 4-way set associative writeback cache, and an 8-entry fully associative TLB. When there is a miss to the instruction or data TLBs, there is a second level unified (instruction and data) 64-entry 2-way set associative TLB that takes an additional clock to access. When there is a miss to the instruction or data caches or the TLB, the access must go to the GeodeLink Memory Controller (GLMC) for processing. Having both an instruction and a data cache and their associated TLBs improves overall efficiency of the integer unit by enabling simultaneous access to both caches.

1.1.3 Floating Point Unit

The Floating Point Unit (FPU) is a pipelined arithmetic unit that performs floating point operations as per the IEEE 754 standard. The instruction sets supported are x87, MMX, and 3DNow!. The FPU is a pipelined machine with dynamic scheduling of instructions to minimize stalls due to data dependencies. It performs out of order execution and register renaming. It is designed to support an instruction issue rate of one per clock from the integer core. The data path is optimized for single precision arithmetic. Extended precision instructions are handled in microcode and require multiple passes through the pipeline. There is an execution pipeline and a load/store pipeline. This allows load/store operations to execute in parallel with arithmetic instructions.

1.2 GEODELINK CONTROL PROCESSOR

The GeodeLink Control Processor (GLCP) is responsible for reset control, macro clock management, and debug support provided in the GX2. It contains the JTAG interface and the scan chain control logic. It supports chip reset, which includes initial PLL control and programming and runtime power management macro clock control.

The JTAG support includes a Tap Controller that is IEEE 1149.1 compliant. CPU control can be obtained through the JTAG interface into the TAP Controller, and all internal registers, including CPU Core registers, can be accessed. In-circuit emulation (ICE) capabilities are supported through this JTAG and Tap Controller interface.

Architecture Overview (Continued)

1.3 GEODELINK INTERFACE UNITS

Together, the two GeodeLink Interface Units (GLIU0 and GLIU1) make up the internal bus derived from the GeodeLink architecture. GLIU0 connects six high speed modules together with a seventh link to GLIU1 that connects to the three lower speed modules. (Refer to Figure 1-1 on page 15 for the internal signal connections.)

1.4 GEODELINK MEMORY CONTROLLER

The GeodeLink Memory Controller (GLMC) is the memory source for all memory needs in a typical GX2 system. The GLMC supports a memory data bus width of 64 bits.

The GLMC supports two types of memory:

- 111 MHz 222 MT/S for DDR (Dual Data Rate)
- 133 MHz for SDR (Single Data Rate)

The GLMC supports up to 1 GB of either type of memory (SDR or DDR).

The modules that need memory are the CPU Core, Graphics Processor, Display Controller, and TFT/DSTN Controller. Because the GLMC supports memory needs for both the CPU Core and the display subsystem, the GLMC is classically called a UMA (Unified Memory Architecture) memory subsystem.

Up to four banks, with eight devices maximum in each bank, of SDRAM are supported with up to 256 MB in each bank. Four banks means that one or two DIMM or SODIMM modules can be used in a GX2 system. Some memory configurations have additional restrictions on maximum device quantity.

1.5 GRAPHICS PROCESSOR

The Graphics Processor (GP) is compatible with the graphics processor used in the Geode GX1 series processor with additional functions and features to improve performance and ease of use. Like its predecessor, the GX2 GP is a BitBLT/vector engine that supports pattern generation, source expansion, pattern/source transparency, and 256 ternary raster operations. New features that have been added to the GP include:

- A 32-bit datapath that can support 32-bit ARGB full color.
- Incorporated BLT FIFOs to replace the cache based BLT buffers used in GX1.
- Improved bus protocols to increase bandwidth to the memory controller.
- The ability to throttle BLTs according to video timing and VGA hardware.

Table 1-1 presents a comparison between the GP features of GX1 and GX2.

Table 1-1. GP Feature Comparison

Feature	GX1	GX2
Color Depth	16	24 plus 8 alpha blending
ROPs	256	256
BLT Buffers	In cache scratch-pad RAM	FIFOs in GP
BLT Splitting	Required for BLT Buffer control	Managed by hardware
Video Synchronized BLT/Vector	No	Throttle by VBLANK
Bresenham Lines	Yes	Yes
Screen to Screen BLT	Yes	Yes
Screen to Screen BLT with mono expansion	No	Yes
Memory to Screen BLT	Yes	Yes (through CPU writes)
Accelerated Text	Yes	No
Pattern Size (Mono)	8x8	8x8
Pattern Size (Color)	8x1	8x1 (32 BPP)
		8x2 (16 BPP)
		8x4 (8 BPP)
Monochrome Pattern	Yes	Yes
Dithered Pattern (4 color)	Yes	No
Color Pattern	8,16 BPP	8, 16, 32 BPP
Transparent Pattern	Monochrome	Monochrome
Solid Fill	Yes	Yes
Pattern Fill	Yes	Yes
Transparent Source	Monochrome	Monochrome
Color Key Source Transparency	Yes	Y with mask
Variable Source Stride	No	Yes
Variable Destination Stride	No	Yes
Destination Write Bursting	No	Yes
Selectable BLT Direction	Vertical	Vertical and Horizontal
VGA Support	None	Decodes VGA registers

Architecture Overview (Continued)

1.6 DISPLAY CONTROLLER

The Display Controller (DC) performs the following functions:

1) Retrieves graphics, video, and overlay streams from the frame buffer.
2) Serializes the streams.
3) Performs any necessary color lookups and output formatting.
4) Interfaces to the display filter for driving the display device(s).

The Display Controller consists of a GUI (Graphical User Interface) and a VGA. The GUI corresponds to the DC function found in the Geode GX1, while the VGA provides full hardware compatibility with the VGA graphics standard. The GUI and the VGA share a single display FIFO and display refresh memory interface to the GeodeLink Memory Controller (GLMC). The VGA passes 8-bit pixels and syncs to the GUI, which expands the pixels to 24 BPP via the color lookup table, and passes the information to the Video Processor (VP). The VP ultimately generates the digital red, green, and blue signals and buffers the sync signals, that are then sent to the DACs or the flat panel interface.

1.7 VIDEO PROCESSOR

The Video Processor (VP) mixes the graphics and video streams, and outputs digital RGB data to the DACs or the flat panel interface, depending upon the part (i.e., GX2-CRT or GX2-FP).

The VP is capable of delivering high-resolution and true-color graphics. It can also overlay or blend a scaled true-color video image on the graphic background.

The VP interfaces with the CPU Core via a GLIU master/slave interface. The VP is a slave only, as it has no memory requirements.

1.7.1 TFT/DSTN Controller

The TFT/DSTN Controller converts the digital RGB output of a Video Mixer block to the digital output suitable for driving a dual-scan color STN (DSTN) flat panel LCD. It connects to the digital RGB output of the Video Processor and drives the graphics data onto a dual-scan flat panel LCD. It can drive all standard dual-scan color STN flat panels up to 1024x768 resolution.

The TFT/DSTN Controller interfaces with the CPU Core via a GLIU master/slave interface. The TFT/DSTN Controller is both a GLIU master and slave.

1.8 GEODELINK PCI BRIDGE

The GeodeLink PCI Bridge (GLPCI) contains all the necessary logic to support an external PCI interface. The PCI interface is PCI 2.2 specification compliant. The logic includes the PCI and GLIU interface control, read and write FIFOs, and a PCI arbiter.

1.9 GEODE I/O COMPANION INTERFACE

The CS5535 Geode I/O companion has several unique signals connected to this module that support GX2 reset, GX2 interrupts, and system power management.

2.0 Signal Definitions

This chapter defines the signals and describes the external interface of the Geode GX2 processor. Figure 2-1 shows the pins organized by their functional groupings. Note that the figure separates out the GX2-CRT and GX2-FP display interface signals and the GX2-DDR and GX2-SDR memory interface signals; all the pins shown are not inclusive (i.e., GX2-CRT-DDR, GX2-CRT-SDR, GX2-FP-DDR, or GX2-FP-SDR).

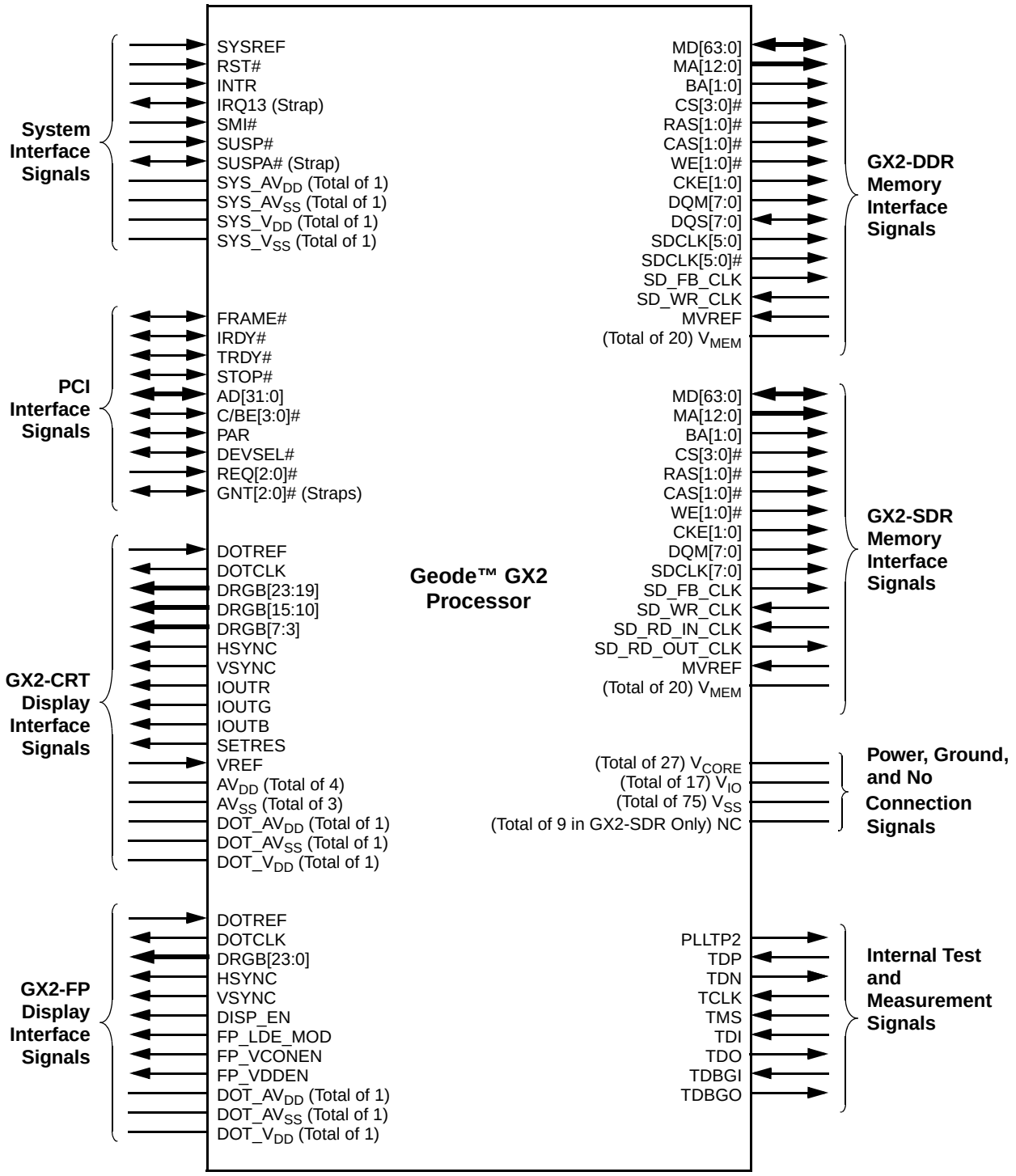


Figure 2-1. Functional Block Diagram

Signal Definitions (Continued)

2.1 BALL ASSIGNMENTS

As illustrated in Figure 2-1 on page 19, the GX2 comes in four flavors, depending upon the display interface chosen (i.e., CRT or FP) and SDRAM type (i.e., DDR or SDR) with the remaining interface signal groups being the same. For quick reference, Table 2-1 summarizes the ball assignment differences between the GX2-CRT and GX2-FP devices. (The memory are too numerous to summarize.)

Table 2-1. Ball Assignment Differences

Ball #	GX2-CRT	GX2-FP
A5	AV_{SS}	DRGB9
A6	AV_{DD}	DRGB2
A7	AV_{DD}	DRGB16
A8	AV_{SS}	FP_VDDEN
B5	VREF	DRGB8
B6	IOUTR	DRGB1
B7	IOUTG	DRGB17
B8	IOUTB	FP_VCONEN
C6	SETRES	DRGB0
C7	AV_{SS}	DRGB18
C8	AV_{DD}	FP_LDE_MOD
C9	AV_{DD}	DISP_EN

The GNT[2:0]# balls are used to select the initial GLIU, GLMC, and CPU Core dividers. These straps are read by software and the dividers are then programmed. Since the straps do not affect hardware directly, their definition can be changed.

IRQ13 and SUSPA# are boot straps for tester features on a board. They must be pulled low to enable tester features.

The tables in this chapter use several common abbreviations. Table 2-2 lists the mnemonics and their meanings.

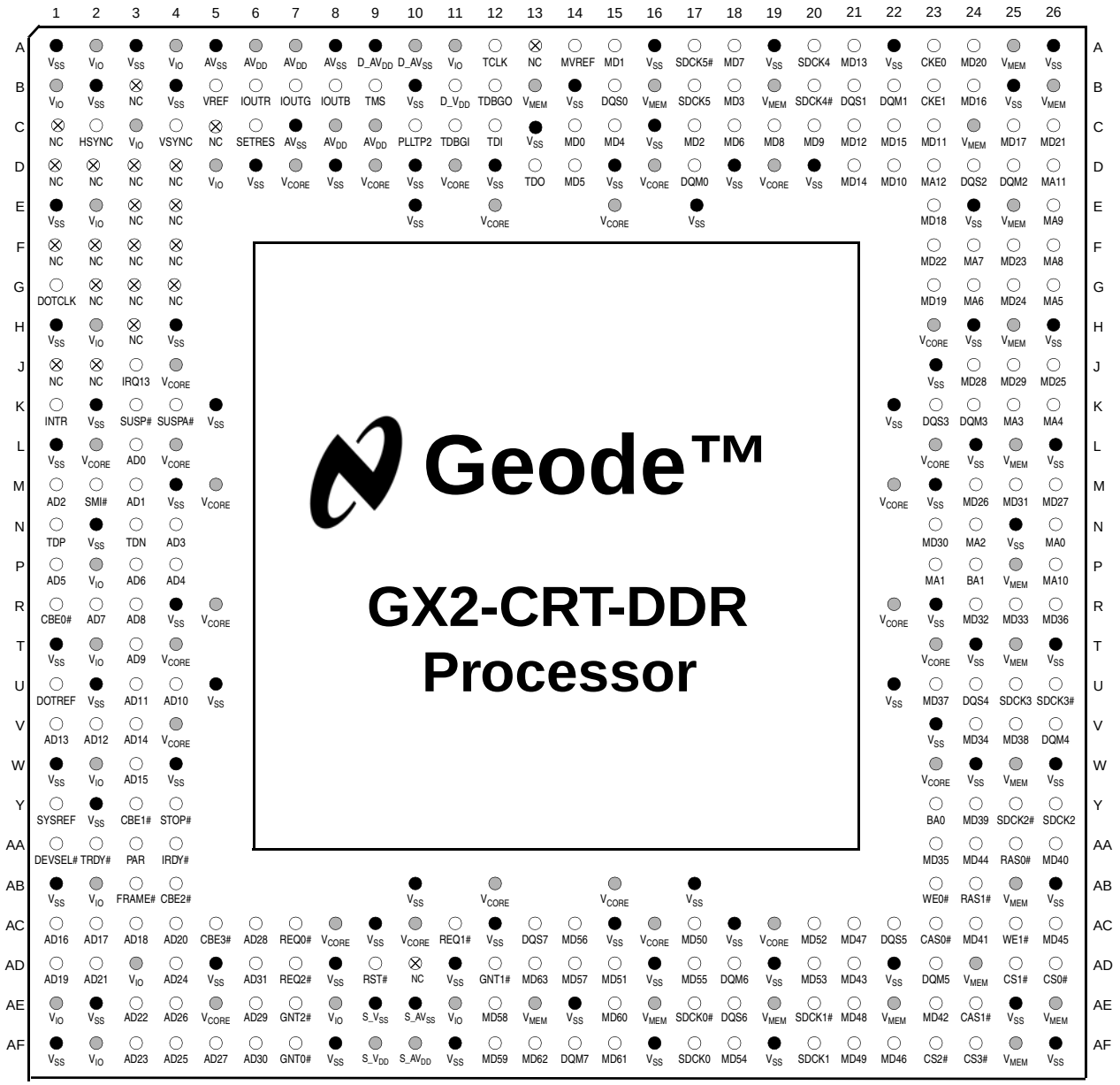
The remaining sub-sections of this chapter provide the ball assignment and signal descriptions for all devices.

Table 2-2. Ball Type Definitions

Mnemonic	Definition
A	Analog
AV_{SS}	Ground ball: Analog
AV_{DD}	Power ball: Analog
I	Input ball
I/O	Bidirectional ball
O	Output ball
V_{CORE}	Power ball: 1.5V
V_{IO}	Power ball: 3.3V
V_{MEM}	Power ball: 2.5V/3.3V GX2-DDR: Signaling is 2.5V GX2-SDR: Signaling is 3.3V
V_{SS}	Ground ball
#	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 a high voltage level.

Signal Definitions (Continued)

2.1.1 GX2-CRT-DDR Ball Assignments



Note: Signal names have been abbreviated in this figure due to space constraints.
● = GND terminal
◎ = PWR terminal
⊗ = No Connection

Figure 2-2. GX2-CRT-DDR Ball Assignment Diagram (Top View)

Signal Definitions (Continued)

Table 2-3. GX2-CRT-DDR Ball Assignment - Sorted by Ball Number

Ball No.	Signal Name	Type (PD)	Buffer Type
A1	V_{SS}	GND	---
A2	V_{IO}	PWR	---
A3	V_{SS}	GND	---
A4	V_{IO}	PWR	---
A5	AV_{SS}	AGND	---
A6	AV_{DD}	APWR	---
A7	AV_{DD}	APWR	---
A8	AV_{SS}	AGND	---
A9	DOT_AV_{DD}	APWR	---
A10	DOT_AV_{SS}	AGND	---
A11	V_{IO}	PWR	---
A12	TCLK	I	24/Q7
A13	NC	---	---
A14	MVREF	AI	Wire
A15	MD1	I/O	SDRAM
A16	V_{SS}	GND	---
A17	SDCLK5#	O	SDCLK
A18	MD7	I/O	SDRAM
A19	V_{SS}	GND	---
A20	SDCLK4	O	SDCLK
A21	MD13	I/O	SDRAM
A22	V_{SS}	GND	---
A23	CKE0	O	SDRAM
A24	MD20	I/O	SDRAM
A25	V_{MEM}	PWR	---
A26	V_{SS}	GND	---
B1	V_{IO}	PWR	---
B2	V_{SS}	GND	---
B3	NC	---	---
B4	V_{SS}	GND	---
B5	VREF	AI	Wire
B6	IOUTR	AO	Wire
B7	IOUTG	AO	Wire
B8	IOUTB	AO	Wire
B9	TMS	I	24/Q7
B10	V_{SS}	GND	---
B11	DOT_V_{DD}	PWR	---
B12	TDBGO	O (PD)	24/Q3
B13	V_{MEM}	PWR	---
B14	V_{SS}	GND	---
B15	DQS0	I/O	SDRAM
B16	V_{MEM}	PWR	---
B17	SDCLK5	O	SDCLK
B18	MD3	I/O	SDRAM
B19	V_{MEM}	PWR	---
B20	SDCLK4#	O	SDCLK
B21	DQS1	I/O	SDRAM
B22	DQM1	O	SDRAM
B23	CKE1	O	SDRAM
B24	MD16	I/O	SDRAM
B25	V_{SS}	GND	---
B26	V_{MEM}	PWR	---
C1	NC	---	---
C2	HSYNC	O (PD)	5V/4
C3	V_{IO}	PWR	---
C4	VSYNC	O (PD)	5V/4
C5	NC	---	---
C6	SETRES	AO	Wire
C7	AV_{SS}	AGND	---
C8	AV_{DD}	APWR	---
C9	AV_{DD}	APWR	---
C10	PLLTP2	AO	Wire
C11	TDBGI	I	24/Q7
C12	TDI	I	24/Q7
C13	V_{SS}	GND	---
C14	MD0	I/O	SDRAM
C15	MD4	I/O	SDRAM
C16	V_{SS}	GND	---
C17	MD2	I/O	SDRAM
C18	MD6	I/O	SDRAM
C19	MD8	I/O	SDRAM
C20	MD9	I/O	SDRAM
C21	MD12	I/O	SDRAM
C22	MD15	I/O	SDRAM
C23	MD11	I/O	SDRAM
C24	V_{MEM}	PWR	---
C25	MD17	I/O	SDRAM
C26	MD21	I/O	SDRAM
D1	NC	---	---
D2	NC	---	---
D3	NC	---	---
D4	NC	---	---
D5	V_{IO}	PWR	---
D6	V_{SS}	GND	---
D7	V_{CORE}	PWR	---
D8	V_{SS}	GND	---
D9	V_{CORE}	PWR	---
D10	V_{SS}	GND	---
D11	V_{CORE}	PWR	---
D12	V_{SS}	GND	---
D13	TDO	O	24/Q5
D14	MD5	I/O	SDRAM
D15	V_{SS}	GND	---
D16	V_{CORE}	PWR	---
D17	DQM0	O	SDRAM
D18	V_{SS}	GND	---
D19	V_{CORE}	PWR	---
D20	V_{SS}	GND	---
D21	MD14	I/O	SDRAM
D22	MD10	I/O	SDRAM
D23	MA12	O	SDRAM
D24	DQS2	I/O	SDRAM
D25	DQM2	O	SDRAM
D26	MA11	O	SDRAM
E1	V_{SS}	GND	---
E2	V_{IO}	PWR	---
E3	NC	---	---
E4	NC	---	---
E10	V_{SS}	GND	---
E12	V_{CORE}	PWR	---
E15	V_{CORE}	PWR	---
E17	V_{SS}	GND	---
E23	MD18	I/O	SDRAM
E24	V_{SS}	GND	---
E25	V_{MEM}	PWR	---
E26	MA9	O	SDRAM
F1	NC	---	---
F2	NC	---	---
F3	NC	---	---
F4	NC	---	---
F23	MD22	I/O	SDRAM
F24	MA7	O	SDRAM
F25	MD23	I/O	SDRAM
F26	MA8	O	SDRAM
G1	DOTCLK	O (PD)	24/Q3
G2	NC	---	---
G3	NC	---	---
G4	NC	---	---
G23	MD19	I/O	SDRAM
G24	MA6	O	SDRAM
G25	MD24	I/O	SDRAM
G26	MA5	O	SDRAM
H1	V_{SS}	GND	---
H2	V_{IO}	PWR	---
H3	NC	---	---
H4	V_{SS}	GND	---
H23	V_{CORE}	PWR	---
H24	V_{SS}	GND	---
H25	V_{MEM}	PWR	---
H26	V_{SS}	GND	---
J1	NC	---	---
J2	NC	---	---
J3	IRQ13 (Strap)	I/O (PD)	24/Q5
J4	V_{CORE}	PWR	---
J23	V_{SS}	GND	---
J24	MD28	I/O	SDRAM
J25	MD29	I/O	SDRAM
J26	MD25	I/O	SDRAM
K1	INTR	I	24/Q7
K2	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-3. GX2-CRT-DDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
K3	SUSP#	I	24/Q7
K4	SUSPA# (Strap)	I/O	24/Q5
K5	V_{SS}	GND	---
K22	V_{SS}	GND	---
K23	DQS3	I/O	SDRAM
K24	DQM3	O	SDRAM
K25	MA3	O	SDRAM
K26	MA4	O	Wire
L1	V_{SS}	GND	---
L2	V_{CORE}	PWR	---
L3	AD0	I/O	PCI
L4	V_{CORE}	PWR	---
L23	V_{CORE}	PWR	---
L24	V_{SS}	GND	---
L25	V_{MEM}	PWR	
L26	V_{SS}	GND	---
M1	AD2	I/O	PCI
M2	SMI#	I	24/Q7
M3	AD1	I/O	PCI
M4	V_{SS}	GND	---
M5	V_{CORE}	PWR	---
M22	V_{CORE}	PWR	---
M23	V_{SS}	GND	---
M24	MD26	I/O	SDRAM
M25	MD31	I/O	SDRAM
M26	MD27	I/O	SDRAM
N1	TDP	AI	Wire
N2	V_{SS}	GND	---
N3	TDN	AO	Wire
N4	AD3	I/O	PCI
N23	MD30	I/O	SDRAM
N24	MA2	O	SDRAM
N25	V_{SS}	GND	---
N26	MA0	O	SDRAM
P1	AD5	I/O	PCI
P2	V_{IO}	PWR	---
P3	AD6	I/O	PCI
P4	AD4	I/O	PCI
P23	MA1	O	SDRAM
P24	BA1	O	SDRAM
P25	V_{MEM}	PWR	---
P26	MA10	O	SDRAM
R1	C/BE0#	I/O	PCI
R2	AD7	I/O	PCI
R3	AD8	I/O	PCI
R4	V_{SS}	GND	---
R5	V_{CORE}	PWR	---
R22	V_{CORE}	PWR	---
R23	V_{SS}	GND	---
R24	MD32	I/O	SDRAM
R25	MD33	I/O	SDRAM
R26	MD36	I/O	SDRAM
T1	V_{SS}	GND	---
T2	V_{IO}	PWR	---
T3	AD9	I/O	PCI
T4	V_{CORE}	PWR	---
T23	V_{CORE}	PWR	---
T24	V_{SS}	GND	---
T25	V_{MEM}	PWR	---
T26	V_{SS}	GND	---
U1	DOTREF	I	24/Q3
U2	V_{SS}	GND	---
U3	AD11	I/O	PCI
U4	AD10	I/O	PCI
U5	V_{SS}	GND	---
U22	V_{SS}	GND	---
U23	MD37	I/O	SDRAM
U24	DQS4	I/O	SDRAM
U25	SDCLK3	O	SDCLK
U26	SDCLK3#	O	SDCLK
V1	AD13	I/O	PCI
V2	AD12	I/O	PCI
V3	AD14	I/O	PCI
V4	V_{CORE}	PWR	---
V23	V_{SS}	GND	---
V24	MD34	I/O	SDRAM
V25	MD38	I/O	SDRAM
V26	DQM4	O	SDRAM
W1	V_{SS}	GND	---
W2	V_{IO}	PWR	---
W3	AD15	I/O	PCI
W4	V_{SS}	GND	---
W23	V_{CORE}	PWR	---
W24	V_{SS}	GND	---
W25	V_{MEM}	PWR	---
W26	V_{SS}	GND	---
Y1	SYSREF	I	24/Q3
Y2	V_{SS}	GND	---
Y3	C/BE1#	I/O	PCI
Y4	STOP#	I/O	PCI
Y23	BA0	O	SDRAM
Y24	MD39	I/O	SDRAM
Y25	SDCLK2#	O	SDCLK
Y26	SDCLK2	O	SDCLK
AA1	DEVSEL#	I/O	PCI
AA2	TRDY#	I/O	PCI
AA3	PAR	I/O	PCI
AA4	IRDY#	I/O	PCI
AA23	MD35	I/O	SDRAM
AA24	MD44	I/O	SDRAM
AA25	RAS0#	O	SDRAM
AA26	MD40	I/O	SDRAM
AB1	V_{SS}	GND	---
AB2	V_{IO}	PWR	---
AB3	FRAME#	I/O	PCI
AB4	C/BE2#	I/O	PCI
AB10	V_{SS}	GND	---
AB12	V_{CORE}	PWR	---
AB15	V_{CORE}	PWR	---
AB17	V_{SS}	GND	---
AB23	WE0#	O	SDRAM
AB24	RAS1#	O	SDRAM
AB25	V_{MEM}	PWR	---
AB26	V_{SS}	GND	---
AC1	AD16	I/O	PCI
AC2	AD17	I/O	PCI
AC3	AD18	I/O	PCI
AC4	AD20	I/O	PCI
AC5	C/BE3#	I/O	PCI
AC6	AD28	I/O	PCI
AC7	REQ0#	I	PCI
AC8	V_{CORE}	PWR	---
AC9	V_{SS}	GND	---
AC10	V_{CORE}	PWR	---
AC11	REQ1#	I	PCI
AC12	V_{SS}	GND	---
AC13	DQS7	I/O	SDRAM
AC14	MD56	I/O	SDRAM
AC15	V_{SS}	GND	---
AC16	V_{CORE}	PWR	---
AC17	MD50	I/O	SDRAM
AC18	V_{SS}	GND	---
AC19	V_{CORE}	PWR	---
AC20	MD52	I/O	SDRAM
AC21	MD47	I/O	SDRAM
AC22	DQS5	I/O	SDRAM
AC23	CAS0#	O	SDRAM
AC24	MD41	I/O	SDRAM
AC25	WE1#	O	SDRAM
AC26	MD45	I/O	SDRAM
AD1	AD19	I/O	SDRAM
AD2	AD21	I/O	PCI
AD3	V_{IO}	PWR	---
AD4	AD24	I/O	PCI
AD5	V_{SS}	GND	---
AD6	AD31	I/O	PCI
AD7	REQ2#	I	PCI
AD8	V_{SS}	GND	---
AD9	RST#	I	RST
AD10	NC	---	---

Signal Definitions (Continued)

Table 2-3. GX2-CRT-DDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
AD11	V_{SS}	GND	---
AD12	GNT1# (Strap)	I/O	PCI
AD13	MD63	I/O	SDRAM
AD14	MD57	I/O	SDRAM
AD15	MD51	I/O	SDRAM
AD16	V_{SS}	GND	---
AD17	MD55	I/O	SDRAM
AD18	DQM6	O	SDRAM
AD19	V_{SS}	GND	---
AD20	MD53	I/O	SDRAM
AD21	MD43	I/O	SDRAM
AD22	V_{SS}	GND	---
AD23	DQM5	O	SDRAM
AD24	V_{MEM}	PWR	---
AD25	CS1#	O	SDRAM
AD26	CS0#	O	SDRAM
AE1	V_{IO}	PWR	---
AE2	V_{SS}	GND	---
AE3	AD22	I/O	PCI
AE4	AD26	I/O	PCI
AE5	V_{CORE}	PWR	---
AE6	AD29	I/O	PCI
AE7	GNT2# (Strap)	I/O	PCI
AE8	V_{IO}	PWR	---
AE9	SYS_V_{SS}	GND	---
AE10	SYS_AV_{SS}	AGND	---
AE11	V_{IO}	PWR	---
AE12	MD58	I/O	SDRAM
AE13	V_{MEM}	PWR	---
AE14	V_{SS}	GND	---
AE15	MD60	I/O	SDRAM
AE16	V_{MEM}	PWR	---
AE17	SDCLK0#	O	SDCLK
AE18	DQS6	I/O	SDRAM
AE19	V_{MEM}	PWR	---
AE20	SDCLK1#	O	SDCLK
AE21	MD48	I/O	SDRAM
AE22	V_{MEM}	PWR	---
AE23	MD42	I/O	SDRAM
AE24	CAS1#	O	SDRAM
AE25	V_{SS}	GND	---
AE26	V_{MEM}	PWR	---
AF1	V_{SS}	GND	---
AF2	V_{IO}	PWR	---
AF3	AD23	I/O	PCI
AF4	AD25	I/O	PCI
AF5	AD27	I/O	PCI
AF6	AD30	I/O	PCI
AF7	GNT0# (Strap)	I/O	PCI
AF8	V_{SS}	GND	---
AF9	SYS_V_{DD}	PWR	---
AF10	SYS_AV_{DD}	APWR	---
AF11	V_{SS}	GND	---
AF12	MD59	I/O	SDRAM
AF13	MD62	I/O	SDRAM
AF14	DQM7	O	SDRAM
AF15	MD61	I/O	SDRAM
AF16	V_{SS}	GND	---
AF17	SDCLK0	O	SDCLK
AF18	MD54	I/O	SDRAM
AF19	V_{SS}	GND	---
AF20	SDCLK1	O	SDCLK
AF21	MD49	I/O	Wire
AF22	MD46	I/O	SDRAM
AF23	CS2#	O	SDRAM
AF24	CS3#	O	SDRAM
AF25	V_{MEM}	PWR	---
AF26	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-4. GX2-CRT-DDR Ball Assignment - Sorted Alphabetically by Signal Name

Signal Name	Ball No.
AD0	L3
AD1	M3
AD2	M1
AD3	N4
AD4	P4
AD5	P1
AD6	P3
AD7	R2
AD8	R3
AD9	T3
AD10	U4
AD11	U3
AD12	V2
AD13	V1
AD14	V3
AD15	W3
AD16	AC1
AD17	AC2
AD18	AC3
AD19	AD1
AD20	AC4
AD21	AD2
AD22	AE3
AD23	AF3
AD24	AD4
AD25	AF4
AD26	AE4
AD27	AF5
AD28	AC6
AD29	AE6
AD30	AF6
AD31	AD6
AV_{DD}	A6
AV_{DD}	A7
AV_{DD}	C8
AV_{DD}	C9
AV_{SS}	A5
AV_{SS}	A8
AV_{SS}	C7
BA0	Y23
BA1	P24
C/BE0#	R1
C/BE1#	Y3
C/BE2#	AB4
C/BE3#	AC5
CAS0#	AC23
CAS1#	AE24
CKE0	A23
CKE1	B23
CS0#	AD26
CS1#	AD25
CS2#	AF23
CS3#	AF24
DEVSEL#	AA1
DOT_AV_{DD}	A9
DOT_AV_{SS}	A10
DOT_V_{DD}	B11
DOTCLK	G1
DOTREF	U1
DQM0	D17
DQM1	B22
DQM2	D25
DQM3	K24
DQM4	V26
DQM5	AD23
DQM6	AD18
DQM7	AF14
DQS0	B15
DQS1	B21
DQS2	D24
DQS3	K23
DQS4	U24
DQS5	AC22
DQS6	AE18
DQS7	AC13
FRAME#	AB3
GNT0# (Strap)	AF7
GNT1# (Strap)	AD12
GNT2# (Strap)	AE7
HSYNC	C2
INTR	K1
IOUTB	B8
IOUTG	B7
IOUTR	B6
IRDY#	AA4
IRQ13 (Strap)	J3
MA0	N26
MA1	P23
MA2	N24
MA3	K25
MA4	K26
MA5	G26
MA6	G24
MA7	F24
MA8	F26
MA9	E26
MA10	P26
MA11	D26
MA12	D23
MD0	C14
MD1	A15
MD2	C17
MD3	B18
MD4	C15
MD5	D14
MD6	C18
MD7	A18
MD8	C19
MD9	C20
MD10	D22
MD11	C23
MD12	C21
MD13	A21
MD14	D21
MD15	C22
MD16	B24
MD17	C25
MD18	E23
MD19	G23
MD20	A24
MD21	C26
MD22	F23
MD23	F25
MD24	G25
MD25	J26
MD26	M24
MD27	M26
MD28	J24
MD29	J25
MD30	N23
MD31	M25
MD32	R24
MD33	R25
MD34	V24
MD35	AA23
MD36	R26
MD37	U23
MD38	V25
MD39	Y24
MD40	AA26
MD41	AC24
MD42	AE23
MD43	AD21
MD44	AA24
MD45	AC26
MD46	AF22
MD47	AC21
MD48	AE21
MD49	AF21
MD50	AC17
MD51	AD15
MD52	AC20
MD53	AD20
MD54	AF18
MD55	AD17
MD56	AC14
MD57	AD14
MD58	AE12
MD59	AF12
MD60	AE15
MD61	AF15
MD62	AF13
MD63	AD13
MVREF	A14
NC	A13
NC	B3
NC	C1
NC	C5
NC	D1
NC	D2
NC	D3
NC	D4
NC	E3
NC	E4
NC	F1
NC	F2
NC	F3
NC	F4
NC	G2
NC	G3
NC	G4
NC	H3
NC	J1
NC	J2
NC	AD10
PAR	AA3
PLLTP2	C10
RAS0#	AA25
RAS1#	AB24
REQ0#	AC7
REQ1#	AC11
REQ2#	AD7
RST#	AD9
SDCLK0	AF17
SDCLK0#	AE17
SDCLK1	AF20
SDCLK1#	AE20
SDCLK2	Y26
SDCLK2#	Y25
SDCLK3	U25
SDCLK3#	U26
SDCLK4	A20
SDCLK4#	B20
SDCLK5	B17
SDCLK5#	A17
SETRES	C6
SMI#	M2
STOP#	Y4
SUSP#	K3
SUSPA# (Strap)	K4
SYS_AV_{DD}	AF10
SYS_AV_{SS}	AE10
SYS_V_{DD}	AF9
SYS_V_{SS}	AE9
SYSREF	Y1
TCLK	A12
TDBGI	C11
TDBGO	B12
TDI	C12
TDN	N3
TDO	D13
TDP	N1
TMS	B9
TRDY#	AA2
V_{CORE}	D7
V_{CORE}	D9
V_{CORE}	D11
V_{CORE}	D16
V_{CORE}	D19
V_{CORE}	E12
V_{CORE}	E15
V_{CORE}	H23
V_{CORE}	J4
V_{CORE}	L2
V_{CORE}	L4
V_{CORE}	L23
V_{CORE}	M5
V_{CORE}	M22

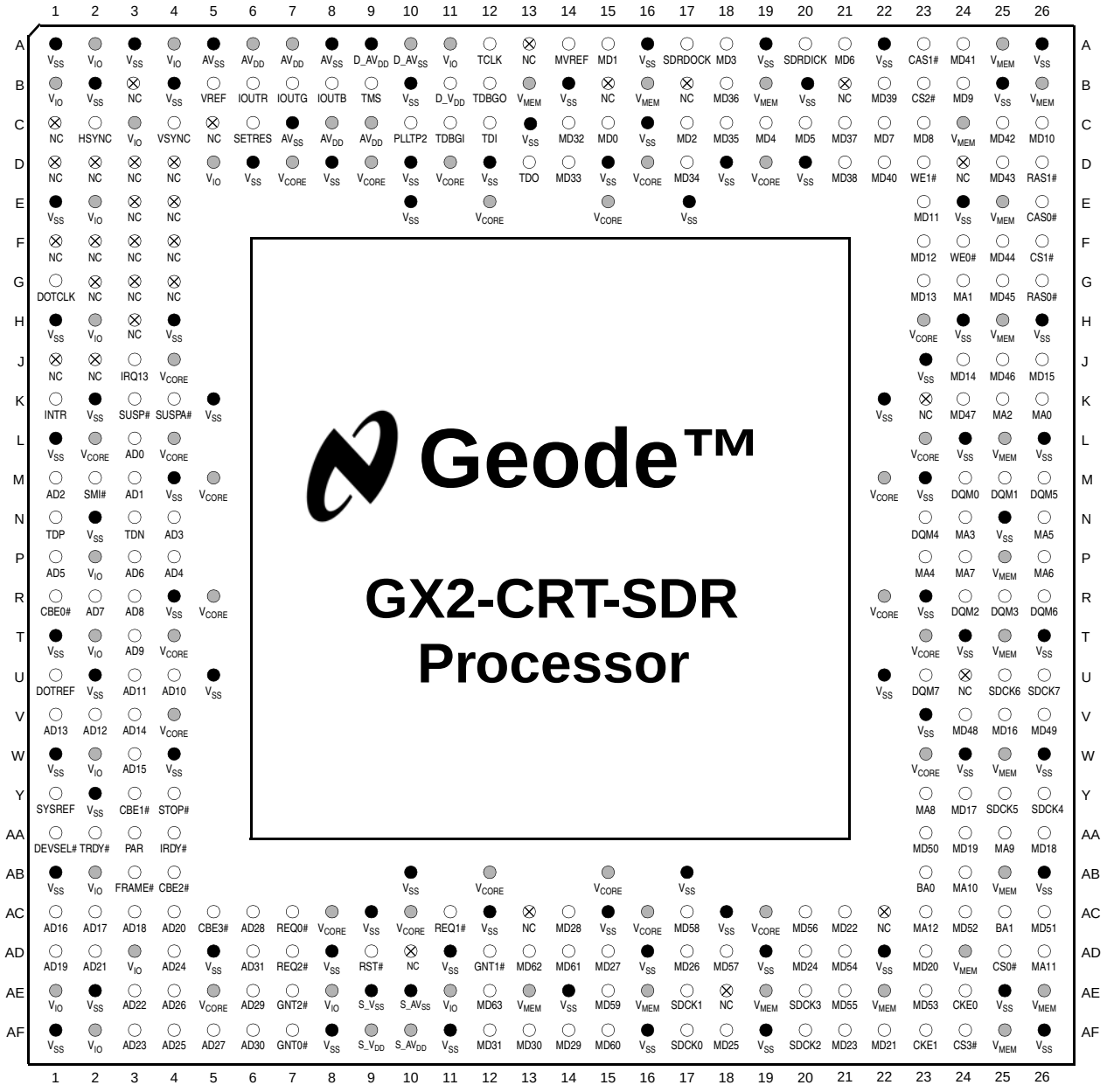
Signal Definitions (Continued)

Table 2-4. GX2-CRT-DDR Ball Assignment - Sorted Alphabetically by Signal Name (Continued)

Signal Name	Ball No.
V_{CORE}	R5
V_{CORE}	R22
V_{CORE}	T4
V_{CORE}	T23
V_{CORE}	V4
V_{CORE}	W23
V_{CORE}	AB12
V_{CORE}	AB15
V_{CORE}	AC8
V_{CORE}	AC10
V_{CORE}	AC16
V_{CORE}	AC19
V_{CORE}	AE5
V_{IO}	A2
V_{IO}	A4
V_{IO}	A11
V_{IO}	B1
V_{IO}	C3
V_{IO}	D5
V_{IO}	E2
V_{IO}	H2
V_{IO}	P2
V_{IO}	T2
V_{IO}	W2
V_{IO}	AB2
V_{IO}	AD3
V_{IO}	AE1
V_{IO}	AE8
V_{IO}	AE11
V_{IO}	AF2
V_{MEM}	A25
V_{MEM}	B13
V_{MEM}	B16
V_{MEM}	B19
V_{MEM}	B26
V_{MEM}	C24
V_{MEM}	E25
V_{MEM}	H25
V_{MEM}	L25
V_{MEM}	P25
V_{MEM}	T25
V_{MEM}	W25
V_{MEM}	AB25
V_{MEM}	AD24
V_{MEM}	AE13
V_{MEM}	AE16
V_{MEM}	AE19
V_{MEM}	AE22
V_{MEM}	AE26
V_{MEM}	AF25
VREF	B5
V_{SS}	A1
V_{SS}	A3
V_{SS}	A16
V_{SS}	A19
V_{SS}	A22
V_{SS}	A26
V_{SS}	B2
V_{SS}	B4
V_{SS}	B10
V_{SS}	B14
V_{SS}	B25
V_{SS}	C13
V_{SS}	C16
V_{SS}	D6
V_{SS}	D8
V_{SS}	D10
V_{SS}	D12
V_{SS}	D15
V_{SS}	D18
V_{SS}	D20
V_{SS}	E1
V_{SS}	E10
V_{SS}	E17
V_{SS}	E24
V_{SS}	H1
V_{SS}	H4
V_{SS}	H24
V_{SS}	H26
V_{SS}	J23
V_{SS}	K2
V_{SS}	K5
V_{SS}	K22
V_{SS}	L1
V_{SS}	L24
V_{SS}	L26
V_{SS}	M4
V_{SS}	M23
V_{SS}	N2
V_{SS}	N25
V_{SS}	R4
V_{SS}	R23
V_{SS}	T1
V_{SS}	T24
V_{SS}	T26
V_{SS}	U2
V_{SS}	U5
V_{SS}	U22
V_{SS}	V23
V_{SS}	W1
V_{SS}	W4
V_{SS}	W24
V_{SS}	W26
V_{SS}	Y2
V_{SS}	AB1
V_{SS}	AB10
V_{SS}	AB17
V_{SS}	AB26
V_{SS}	AC9
V_{SS}	AC12
V_{SS}	AC15
V_{SS}	AC18
V_{SS}	AD5
V_{SS}	AD8
V_{SS}	AD11
V_{SS}	AD16
V_{SS}	AD19
V_{SS}	AD22
V_{SS}	AE2
V_{SS}	AE14
V_{SS}	AE25
V_{SS}	AF1
V_{SS}	AF8
V_{SS}	AF11
V_{SS}	AF16
V_{SS}	AF19
V_{SS}	AF26
VSYNC	C4
WE0#	AB23
WE1#	AC25

Signal Definitions (Continued)

2.1.2 GX2-CRT-SDR Ball Assignments



Note: Signal names have been abbreviated in this figure due to space constraints.
- ● = GND terminal
- ◎ = PWR terminal
- ⊗ = No Connection

Figure 2-3. GX2-CRT-SDR Ball Assignment Diagram (Top View)

Signal Definitions (Continued)

Table 2-5. GX2-CRT-SDR Ball Assignment - Sorted by Ball Number

Ball No.	Signal Name	Type (PD)	Buffer Type
A1	V_{SS}	GND	---
A2	V_{IO}	PWR	---
A3	V_{SS}	GND	---
A4	V_{IO}	PWR	---
A5	AV_{SS}	AGND	---
A6	AV_{DD}	APWR	---
A7	AV_{DD}	APWR	---
A8	AV_{SS}	AGND	---
A9	DOT_AV_{DD}	APWR	---
A10	DOT_AV_{SS}	AGND	---
A11	V_{IO}	PWR	---
A12	TCLK	I	24/Q7
A13	NC	---	---
A14	MVREF	AI	Wire
A15	MD1	I/O	SDRAM
A16	V_{SS}	GND	---
A17	SD_RD_OUT_CLK	O	SDCLK
A18	MD3	I/O	SDRAM
A19	V_{SS}	GND	---
A20	SD_RD_IN_CLK	I	SDCLK
A21	MD6	I/O	SDRAM
A22	V_{SS}	GND	---
A23	CAS1#	O	SDRAM
A24	MD41	I/O	SDRAM
A25	V_{MEM}	PWR	---
A26	V_{SS}	GND	---
B1	V_{IO}	PWR	---
B2	V_{SS}	GND	---
B3	NC	---	---
B4	V_{SS}	GND	---
B5	VREF	AI	Wire
B6	IOUTR	AO	Wire
B7	IOUTG	AO	Wire
B8	IOUTB	AO	Wire
B9	TMS	I	24/Q7
B10	V_{SS}	GND	---
B11	DOT_V_{DD}	PWR	---
B12	TDBGO	O (PD)	24/Q3
B13	V_{MEM}	PWR	---
B14	V_{SS}	GND	---
B15	NC	---	---
B16	V_{MEM}	PWR	---
B17	NC	---	---
B18	MD36	I/O	SDRAM
B19	V_{MEM}	PWR	---
B20	V_{SS}	GND	---
B21	NC	---	---
B22	MD39	I/O	SDRAM
B23	CS2#	O	SDRAM
B24	MD9	I/O	SDRAM
B25	V_{SS}	GND	---
B26	V_{MEM}	PWR	---
C1	NC	---	---
C2	HSYNC	O (PD)	5V/4
C3	V_{IO}	PWR	---
C4	VSYNC	O (PD)	5V/4
C5	NC	---	---
C6	SETRES	AO	Wire
C7	AV_{SS}	AGND	---
C8	AV_{DD}	APWR	---
C9	AV_{DD}	APWR	---
C10	PLLTP2	AO	Wire
C11	TDBGI	I	24/Q7
C12	TDI	I	24/Q7
C13	V_{SS}	GND	---
C14	MD32	I/O	SDRAM
C15	MD0	I/O	SDRAM
C16	V_{SS}	GND	---
C17	MD2	I/O	SDRAM
C18	MD35	I/O	SDRAM
C19	MD4	I/O	SDRAM
C20	MD5	I/O	SDRAM
C21	MD37	I/O	SDRAM
C22	MD7	I/O	SDRAM
C23	MD8	I/O	SDRAM
C24	V_{MEM}	PWR	---
C25	MD42	I/O	SDRAM
C26	MD10	I/O	SDRAM
D1	NC	---	---
D2	NC	---	---
D3	NC	---	---
D4	NC	---	---
D5	V_{IO}	PWR	---
D6	V_{SS}	GND	---
D7	V_{CORE}	PWR	---
D8	V_{SS}	GND	---
D9	V_{CORE}	PWR	---
D10	V_{SS}	GND	---
D11	V_{CORE}	PWR	---
D12	V_{SS}	GND	---
D13	TDO	O	24/Q5
D14	MD33	I/O	SDRAM
D15	V_{SS}	GND	---
D16	V_{CORE}	PWR	---
D17	MD34	I/O	SDRAM
D18	V_{SS}	GND	---
D19	V_{CORE}	PWR	---
D20	V_{SS}	GND	---
D21	MD38	I/O	SDRAM
D22	MD40	I/O	SDRAM
D23	WE1#	O	SDRAM
D24	NC	---	---
D25	MD43	I/O	SDRAM
D26	RAS1#	O	SDRAM
E1	V_{SS}	GND	---
E2	V_{IO}	PWR	---
E3	NC	---	---
E4	NC	---	---
E10	V_{SS}	GND	---
E12	V_{CORE}	PWR	---
E15	V_{CORE}	PWR	---
E17	V_{SS}	GND	---
E23	MD11	I/O	SDRAM
E24	V_{SS}	GND	---
E25	V_{MEM}	PWR	---
E26	CAS0#	O	SDRAM
F1	NC	---	---
F2	NC	---	---
F3	NC	---	---
F4	NC	---	---
F23	MD12	I/O	SDRAM
F24	WE0#	O	SDRAM
F25	MD44	I/O	SDRAM
F26	CS1#	O	SDRAM
G1	DOTCLK	O (PD)	24/Q3
G2	NC	---	---
G3	NC	---	---
G4	NC	---	---
G23	MD13	I/O	SDRAM
G24	MA1	O	SDRAM
G25	MD45	I/O	SDRAM
G26	RAS0#	O	SDRAM
H1	V_{SS}	GND	---
H2	V_{IO}	PWR	---
H3	NC	---	---
H4	V_{SS}	GND	---
H23	V_{CORE}	PWR	---
H24	V_{SS}	GND	---
H25	V_{MEM}	PWR	---
H26	V_{SS}	GND	---
J1	NC	---	---
J2	NC	---	---
J3	IRQ13 (Strap)	I/O (PD)	24/Q5
J4	V_{CORE}	PWR	---
J23	V_{SS}	GND	---
J24	MD14	I/O	SDRAM
J25	MD46	I/O	SDRAM
J26	MD15	I/O	SDRAM
K1	INTR	I	24/Q7
K2	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-5. GX2-CRT-SDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
K3	SUSP#	I	24/Q7
K4	SUSPA# (Strap)	I/O	24/Q3
K5	V_{SS}	GND	---
K22	V_{SS}	GND	---
K23	NC	---	---
K24	MD47	I/O	SDRAM
K25	MA2	O	SDRAM
K26	MA0	O	Wire
L1	V_{SS}	GND	---
L2	V_{CORE}	PWR	---
L3	AD0	I/O	PCI
L4	V_{CORE}	PWR	---
L23	V_{CORE}	PWR	---
L24	V_{SS}	GND	---
L25	V_{MEM}	PWR	
L26	V_{SS}	GND	---
M1	AD2	I/O	PCI
M2	SMI#	I	24/Q7
M3	AD1	I/O	PCI
M4	V_{SS}	GND	---
M5	V_{CORE}	PWR	---
M22	V_{CORE}	PWR	---
M23	V_{SS}	GND	---
M24	DQM0	O	SDRAM
M25	DQM1	O	SDRAM
M26	DQM5	O	SDRAM
N1	TDP	AI	Wire
N2	V_{SS}	GND	---
N3	TDN	AO	Wire
N4	AD3	I/O	PCI
N23	DQM4	O	SDRAM
N24	MA3	O	SDRAM
N25	V_{SS}	GND	---
N26	MA5	O	SDRAM
P1	AD5	I/O	PCI
P2	V_{IO}	PWR	---
P3	AD6	I/O	PCI
P4	AD4	I/O	PCI
P23	MA4	O	SDRAM
P24	MA7	O	SDRAM
P25	V_{MEM}	PWR	---
P26	MA6	O	SDRAM
R1	C/BE0#	I/O	PCI
R2	AD7	I/O	PCI
R3	AD8	I/O	PCI
R4	V_{SS}	GND	---
R5	V_{CORE}	PWR	---
R22	V_{CORE}	PWR	---
R23	V_{SS}	GND	---
R24	DQM2	O	SDRAM
R25	DQM3	O	SDRAM
R26	DQM6	O	SDRAM
T1	V_{SS}	GND	---
T2	V_{IO}	PWR	---
T3	AD9	I/O	PCI
T4	V_{CORE}	PWR	---
T23	V_{CORE}	PWR	---
T24	V_{SS}	GND	---
T25	V_{MEM}	PWR	---
T26	V_{SS}	GND	---
U1	DOTREF	I	24/Q3
U2	V_{SS}	GND	---
U3	AD11	I/O	PCI
U4	AD10	I/O	PCI
U5	V_{SS}	GND	---
U22	V_{SS}	GND	---
U23	DQM7	O	SDRAM
U24	NC	---	---
U25	SDCLK6	O	SDCLK
U26	SDCLK7	O	SDCLK
V1	AD13	I/O	PCI
V2	AD12	I/O	PCI
V3	AD14	I/O	PCI
V4	V_{CORE}	PWR	---
V23	V_{SS}	GND	---
V24	MD48	I/O	SDRAM
V25	MD16	I/O	SDRAM
V26	MD49	I/O	SDRAM
W1	V_{SS}	GND	---
W2	V_{IO}	PWR	---
W3	AD15	I/O	PCI
W4	V_{SS}	GND	---
W23	V_{CORE}	PWR	---
W24	V_{SS}	GND	---
W25	V_{MEM}	PWR	---
W26	V_{SS}	GND	---
Y1	SYSREF	I	24/Q3
Y2	V_{SS}	GND	---
Y3	C/BE1#	I/O	PCI
Y4	STOP#	I/O	PCI
Y23	MA8	O	SDRAM
Y24	MD17	I/O	SDRAM
Y25	SDCLK5	O	SDCLK
Y26	SDCLK4	O	SDCLK
AA1	DEVSEL#	I/O	PCI
AA2	TRDY#	I/O	PCI
AA3	PAR	I/O	PCI
AA4	IRDY#	I/O	PCI
AA23	MD50	I/O	SDRAM
AA24	MD19	I/O	SDRAM
AA25	MA9	O	SDRAM
AA26	MD18	I/O	SDRAM
AB1	V_{SS}	GND	---
AB2	V_{IO}	PWR	---
AB3	FRAME#	I/O	PCI
AB4	C/BE2#	I/O	PCI
AB10	V_{SS}	GND	---
AB12	V_{CORE}	PWR	---
AB15	V_{CORE}	PWR	---
AB17	V_{SS}	GND	---
AB23	BA0	O	SDRAM
AB24	MA10	O	SDRAM
AB25	V_{MEM}	PWR	---
AB26	V_{SS}	GND	---
AC1	AD16	I/O	PCI
AC2	AD17	I/O	PCI
AC3	AD18	I/O	PCI
AC4	AD20	I/O	PCI
AC5	C/BE3#	I/O	PCI
AC6	AD28	I/O	PCI
AC7	REQ0#	I	PCI
AC8	V_{CORE}	PWR	---
AC9	V_{SS}	GND	---
AC10	V_{CORE}	PWR	---
AC11	REQ1#	I	PCI
AC12	V_{SS}	GND	---
AC13	NC	---	---
AC14	MD28	I/O	SDRAM
AC15	V_{SS}	GND	---
AC16	V_{CORE}	PWR	---
AC17	MD58	I/O	SDRAM
AC18	V_{SS}	GND	---
AC19	V_{CORE}	PWR	---
AC20	MD56	I/O	SDRAM
AC21	MD22	I/O	SDRAM
AC22	NC	---	---
AC23	MA12	O	SDRAM
AC24	MD52	I/O	SDRAM
AC25	BA1	O	SDRAM
AC26	MD51	I/O	SDRAM
AD1	AD19	I/O	SDRAM
AD2	AD21	I/O	PCI
AD3	V_{IO}	PWR	---
AD4	AD24	I/O	PCI
AD5	V_{SS}	GND	---
AD6	AD31	I/O	PCI
AD7	REQ2#	I	PCI
AD8	V_{SS}	GND	---
AD9	RST#	I	RST
AD10	NC	---	---

Signal Definitions (Continued)

Table 2-5. GX2-CRT-SDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
AD11	V_{SS}	GND	---
AD12	GNT1# (Strap)	I/O	PCI
AD13	MD62	I/O	SDRAM
AD14	MD61	I/O	SDRAM
AD15	MD27	I/O	SDRAM
AD16	V_{SS}	GND	---
AD17	MD26	I/O	SDRAM
AD18	MD57	I/O	SDRAM
AD19	V_{SS}	GND	---
AD20	MD24	I/O	SDRAM
AD21	MD54	I/O	SDRAM
AD22	V_{SS}	GND	---
AD23	MD20	I/O	SDRAM
AD24	V_{MEM}	PWR	---
AD25	CS0#	O	SDRAM
AD26	MA11	O	SDRAM
AE1	V_{IO}	PWR	---
AE2	V_{SS}	GND	---
AE3	AD22	I/O	PCI
AE4	AD26	I/O	PCI
AE5	V_{CORE}	PWR	---
AE6	AD29	I/O	PCI
AE7	GNT2# (Strap)	I/O	PCI
AE8	V_{IO}	PWR	---
AE9	SYS_V_{SS}	GND	---
AE10	SYS_AV_{SS}	AGND	---
AE11	V_{IO}	PWR	---
AE12	MD63	I/O	SDRAM
AE13	V_{MEM}	PWR	---
AE14	V_{SS}	GND	---
AE15	MD59	I/O	SDRAM
AE16	V_{MEM}	PWR	---
AE17	SDCLK1	O	SDCLK
AE18	NC	---	---
AE19	V_{MEM}	PWR	---
AE20	SDCLK3	O	SDCLK
AE21	MD55	I/O	SDRAM
AE22	V_{MEM}	PWR	---
AE23	MD53	I/O	SDRAM
AE24	CKE0	O	SDRAM
AE25	V_{SS}	GND	---
AE26	V_{MEM}	PWR	---
AF1	V_{SS}	GND	---
AF2	V_{IO}	PWR	---
AF3	AD23	I/O	PCI
AF4	AD25	I/O	PCI
AF5	AD27	I/O	PCI
AF6	AD30	I/O	PCI
AF7	GNT0# (Strap)	I/O	PCI
AF8	V_{SS}	GND	---
AF9	SYS_V_{DD}	PWR	---
AF10	SYS_AV_{DD}	APWR	---
AF11	V_{SS}	GND	---
AF12	MD31	I/O	SDRAM
AF13	MD30	I/O	SDRAM
AF14	MD29	I/O	SDRAM
AF15	MD60	I/O	SDRAM
AF16	V_{SS}	GND	---
AF17	SDCLK0	O	SDCLK
AF18	MD25	I/O	SDRAM
AF19	V_{SS}	GND	---
AF20	SDCLK2	O	SDCLK
AF21	MD23	I/O	SDRAM
AF22	MD21	I/O	SDRAM
AF23	CKE1	O	SDRAM
AF24	CS3#	O	SDRAM
AF25	V_{MEM}	PWR	---
AF26	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-6. GX2-CRT-SDR Ball Assignment - Sorted Alphabetically by Signal Name

Signal Name	Ball No.
AD0	L3
AD1	M3
AD2	M1
AD3	N4
AD4	P4
AD5	P1
AD6	P3
AD7	R2
AD8	R3
AD9	T3
AD10	U4
AD11	U3
AD12	V2
AD13	V1
AD14	V3
AD15	W3
AD16	AC1
AD17	AC2
AD18	AC3
AD19	AD1
AD20	AC4
AD21	AD2
AD22	AE3
AD23	AF3
AD24	AD4
AD25	AF4
AD26	AE4
AD27	AF5
AD28	AC6
AD29	AE6
AD30	AF6
AD31	AD6
AV_{DD}	A6
AV_{DD}	A7
AV_{DD}	C8
AV_{DD}	C9
AV_{SS}	A5
AV_{SS}	A8
AV_{SS}	C7
BA0	AB23
BA1	AC25
C/BE0#	R1
C/BE1#	Y3
C/BE2#	AB4
C/BE3#	AC5
CAS0#	E26
CAS1#	A23
CKE0	AE24
CKE1	AF23
CS0#	AD25
CS1#	F26
CS2#	B23
CS3#	AF24
DEVSEL#	AA1
DOT_AV_{DD}	A9
DOT_AV_{SS}	A10
DOT_V_{DD}	B11
DOTCLK	G1
DOTREF	U1
DQM0	M24
DQM1	M25
DQM2	R24
DQM3	R25
DQM4	N23
DQM5	M26
DQM6	R26
DQM7	U23
FRAME#	AB3
GNT0# (Strap)	AF7
GNT1# (Strap)	AD12
GNT2# (Strap)	AE7
HSYNC	C2
INTR	K1
IOUTB	B8
IOUTG	B7
IOUTR	B6
IRDY#	AA4
IRQ13 (Strap)	J3
MA0	K26
MA1	G24
MA2	K25
MA3	N24
MA4	P23
MA5	N26
MA6	P26
MA7	P24
MA8	Y23
MA9	AA25
MA10	AB24
MA11	AD26
MA12	AC23
MD0	C15
MD1	A15
MD2	C17
MD3	A18
MD4	C19
MD5	C20
MD6	A21
MD7	C22
MD8	C23
MD9	B24
MD10	C26
MD11	E23
MD12	F23
MD13	G23
MD14	J24
MD15	J26
MD16	V25
MD17	Y24
MD18	AA26
MD19	AA24
MD20	AD23
MD21	AF22
MD22	AC21
MD23	AF21
MD24	AD20
MD25	AF18
MD26	AD17
MD27	AD15
MD28	AC14
MD29	AF14
MD30	AF13
MD31	AF12
MD32	C14
MD33	D14
MD34	D17
MD35	C18
MD36	B18
MD37	C21
MD38	D21
MD39	B22
MD40	D22
MD41	A24
MD42	C25
MD43	D25
MD44	F25
MD45	G25
MD46	J25
MD47	K24
MD48	V24
MD49	V26
MD50	AA23
MD51	AC26
MD52	AC24
MD53	AE23
MD54	AD21
MD55	AE21
MD56	AC20
MD57	AD18
MD58	AC17
MD59	AE15
MD60	AF15
MD61	AD14
MD62	AD13
MD63	AE12
MVREF	A14
NC	A13
NC	B3
NC	B15
NC	B17
NC	B21
NC	C1
NC	C5
NC	D1
NC	D2
NC	D3
NC	D4
NC	D24
NC	E3
NC	E4
NC	F1
NC	F2
NC	F3
NC	F4
NC	G2
NC	G3
NC	G4
NC	H3
NC	J1
NC	J2
NC	K23
NC	U24
NC	AC13
NC	AC22
NC	AD10
NC	AE18
PAR	AA3
PLLTP2	C10
RAS0#	G26
RAS1#	D26
REQ0#	AC7
REQ1#	AC11
REQ2#	AD7
RST#	AD9
SD_RD_IN_CLK	A20
SD_RD_OUT_CLK	A17
SDCLK0	AF17
SDCLK1	AE17
SDCLK2	AF20
SDCLK3	AE20
SDCLK4	Y26
SDCLK5	Y25
SDCLK6	U25
SDCLK7	U26
SETRES	C6
SMI#	M2
STOP#	Y4
SUSP#	K3
SUSPA# (Strap)	K4
SYS_AV_{DD}	AF10
SYS_AV_{SS}	AE10
SYS_V_{DD}	AF9
SYS_V_{SS}	AE9
SYSREF	Y1
TCLK	A12
TDBGI	C11
TDBGO	B12
TDI	C12
TDN	N3
TDO	D13
TDP	N1
TMS	B9
TRDY#	AA2
V_{CORE}	D7
V_{CORE}	D9
V_{CORE}	D11
V_{CORE}	D16
V_{CORE}	D19
V_{CORE}	E12
V_{CORE}	E15
V_{CORE}	H23
V_{CORE}	J4
V_{CORE}	L2
V_{CORE}	L4
V_{CORE}	L23
V_{CORE}	M5

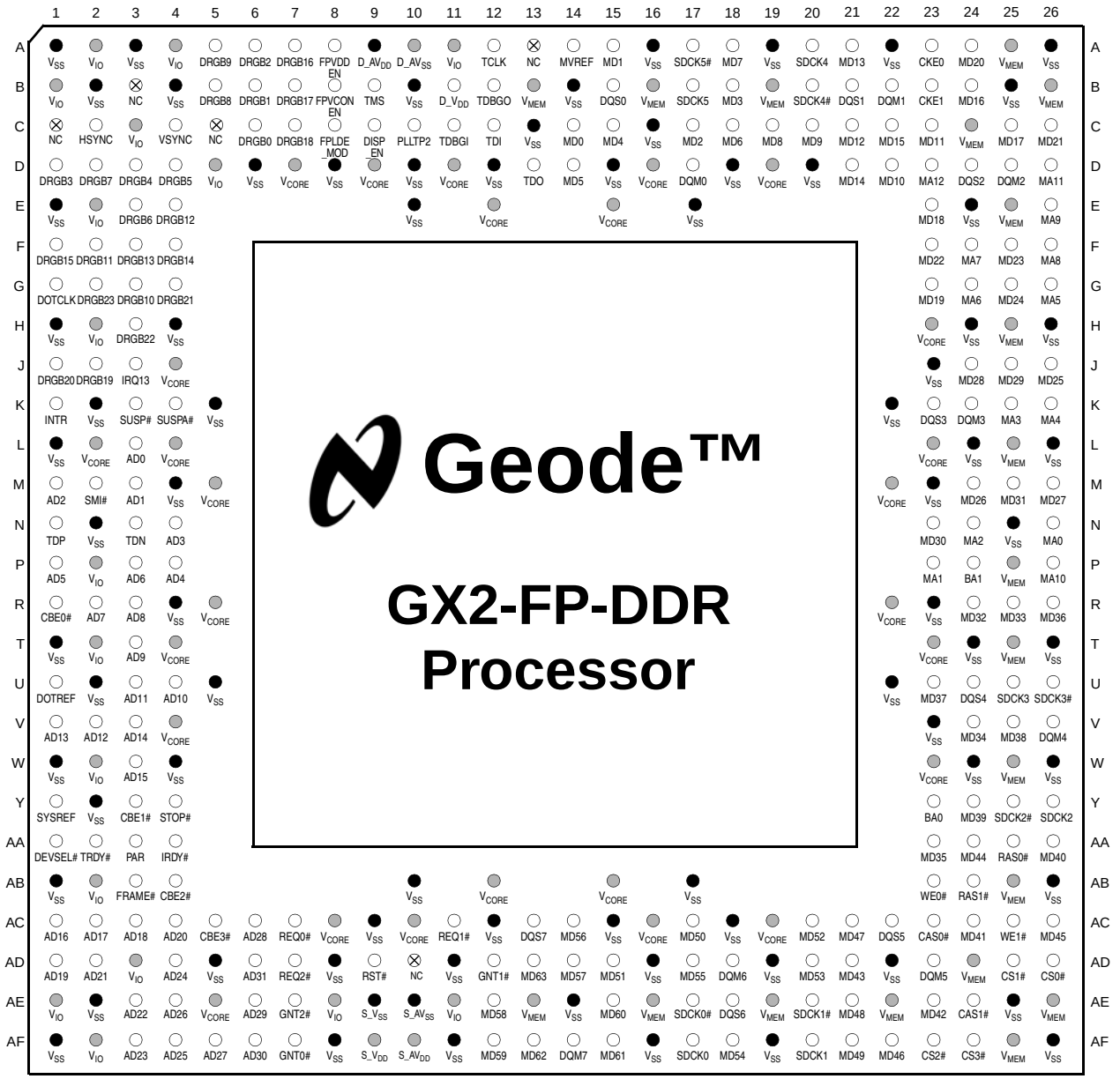
Signal Definitions (Continued)

Table 2-6. GX2-CRT-SDR Ball Assignment - Sorted Alphabetically by Signal Name (Continued)

Signal Name	Ball No.	Signal Name	Ball No.	Signal Name	Ball No.	Signal Name	Ball No.	Signal Name	Ball No.
V_{CORE}	M22	V_{IO}	AE1	V_{SS}	A16	V_{SS}	J23	V_{SS}	AB17
V_{CORE}	R5	V_{IO}	AE8	V_{SS}	A19	V_{SS}	K2	V_{SS}	AB26
V_{CORE}	R22	V_{IO}	AE11	V_{SS}	A22	V_{SS}	K5	V_{SS}	AC9
V_{CORE}	T4	V_{IO}	AF2	V_{SS}	A26	V_{SS}	K22	V_{SS}	AC12
V_{CORE}	T23	V_{MEM}	A25	V_{SS}	B2	V_{SS}	L1	V_{SS}	AC15
V_{CORE}	V4	V_{MEM}	B13	V_{SS}	B4	V_{SS}	L24	V_{SS}	AC18
V_{CORE}	W23	V_{MEM}	B16	V_{SS}	B10	V_{SS}	L26	V_{SS}	AD5
V_{CORE}	AB12	V_{MEM}	B19	V_{SS}	B14	V_{SS}	M4	V_{SS}	AD8
V_{CORE}	AB15	V_{MEM}	B26	V_{SS}	B20	V_{SS}	M23	V_{SS}	AD11
V_{CORE}	AC8	V_{MEM}	C24	V_{SS}	B25	V_{SS}	N2	V_{SS}	AD16
V_{CORE}	AC10	V_{MEM}	E25	V_{SS}	C13	V_{SS}	N25	V_{SS}	AD19
V_{CORE}	AC16	V_{MEM}	H25	V_{SS}	C16	V_{SS}	R4	V_{SS}	AD22
V_{CORE}	AC19	V_{MEM}	L25	V_{SS}	D6	V_{SS}	R23	V_{SS}	AE2
V_{CORE}	AE5	V_{MEM}	P25	V_{SS}	D8	V_{SS}	T1	V_{SS}	AE14
V_{IO}	A2	V_{MEM}	T25	V_{SS}	D10	V_{SS}	T24	V_{SS}	AE25
V_{IO}	A4	V_{MEM}	W25	V_{SS}	D12	V_{SS}	T26	V_{SS}	AF1
V_{IO}	A11	V_{MEM}	AB25	V_{SS}	D15	V_{SS}	U2	V_{SS}	AF8
V_{IO}	B1	V_{MEM}	AD24	V_{SS}	D18	V_{SS}	U5	V_{SS}	AF11
V_{IO}	C3	V_{MEM}	AE13	V_{SS}	D20	V_{SS}	U22	V_{SS}	AF16
V_{IO}	D5	V_{MEM}	AE16	V_{SS}	E1	V_{SS}	V23	V_{SS}	AF19
V_{IO}	E2	V_{MEM}	AE19	V_{SS}	E10	V_{SS}	W1	V_{SS}	AF26
V_{IO}	H2	V_{MEM}	AE22	V_{SS}	E17	V_{SS}	W4	VSYNC	C4
V_{IO}	P2	V_{MEM}	AE26	V_{SS}	E24	V_{SS}	W24	WE0#	F24
V_{IO}	T2	V_{MEM}	AF25	V_{SS}	H1	V_{SS}	W26	WE1#	D23
V_{IO}	W2	VREF	B5	V_{SS}	H4	V_{SS}	Y2		
V_{IO}	AB2	V_{SS}	A1	V_{SS}	H24	V_{SS}	AB1		
V_{IO}	AD3	V_{SS}	A3	V_{SS}	H26	V_{SS}	AB10		

Signal Definitions (Continued)

2.1.3 GX2-FP-DDR Ball Assignments



Note: Signal names have been abbreviated in this figure due to space constraints.
- ● = GND terminal
- ◎ = PWR terminal
- ⊗ = No Connection

Figure 2-4. GX2-FP-DDR Ball Assignment Diagram (Top View)

Signal Definitions (Continued)

Table 2-7. GX2-FP-DDR Ball Assignment - Sorted by Ball Number

Ball No.	Signal Name	Type (PD)	Buffer Type
A1	V_{SS}	GND	---
A2	V_{IO}	PWR	---
A3	V_{SS}	GND	---
A4	V_{IO}	PWR	---
A5	DRGB9	O (PD)	24/Q5
A6	DRGB2	O (PD)	24/Q5
A7	DRGB16	O (PD)	24/Q5
A8	FP_VDDEN	O (PD)	24/Q5
A9	DOT_AV_{DD}	APWR	---
A10	DOT_AV_{SS}	AGND	---
A11	V_{IO}	PWR	---
A12	TCLK	I	24/Q7
A13	NC	---	---
A14	MVREF	AI	Wire
A15	MD1	I/O	SDRAM
A16	V_{SS}	GND	---
A17	SDCLK5#	O	SDCLK
A18	MD7	I/O	SDRAM
A19	V_{SS}	GND	---
A20	SDCLK4	O	SDCLK
A21	MD13	I/O	SDRAM
A22	V_{SS}	GND	---
A23	CKE0	O	SDRAM
A24	MD20	I/O	SDRAM
A25	V_{MEM}	PWR	---
A26	V_{SS}	GND	---
B1	V_{IO}	PWR	---
B2	V_{SS}	GND	---
B3	NC	---	---
B4	V_{SS}	GND	---
B5	DRGB8	O (PD)	24/Q5
B6	DRGB1	O (PD)	24/Q5
B7	DRGB17	O (PD)	24/Q5
B8	FP_VCONEN	O (PD)	24/Q5
B9	TMS	I	24/Q7
B10	V_{SS}	GND	---
B11	DOT_V_{DD}	PWR	---
B12	TDBGO	O (PD)	24/Q3
B13	V_{MEM}	PWR	---
B14	V_{SS}	GND	---
B15	DQS0	I/O	SDRAM
B16	V_{MEM}	PWR	---
B17	SDCLK5	O	SDCLK
B18	MD3	I/O	SDRAM
B19	V_{MEM}	PWR	---
B20	SDCLK4#	O	SDCLK
B21	DQS1	I/O	SDRAM
B22	DQM1	O	SDRAM
B23	CKE1	O	SDRAM
B24	MD16	I/O	SDRAM
B25	V_{SS}	GND	---
B26	V_{MEM}	PWR	---
C1	NC	---	---
C2	HSYNC	O (PD)	5V/4
C3	V_{IO}	PWR	---
C4	VSYNC	O (PD)	5V/4
C5	NC	---	---
C6	DRGB0	O (PD)	24/Q5
C7	DRGB18	O (PD)	24/Q5
C8	FP_LDE_MOD	O (PD)	24/Q5
C9	DISP_EN	O (PD)	24/Q5
C10	PLLTP2	AO	Wire
C11	TDBGI	I	24/Q7
C12	TDI	I	24/Q7
C13	V_{SS}	GND	---
C14	MD0	I/O	SDRAM
C15	MD4	I/O	SDRAM
C16	V_{SS}	GND	---
C17	MD2	I/O	SDRAM
C18	MD6	I/O	SDRAM
C19	MD8	I/O	SDRAM
C20	MD9	I/O	SDRAM
C21	MD12	I/O	SDRAM
C22	MD15	I/O	SDRAM
C23	MD11	I/O	SDRAM
C24	V_{MEM}	PWR	---
C25	MD17	I/O	SDRAM
C26	MD21	I/O	SDRAM
D1	DRGB3	O (PD)	24/Q5
D2	DRGB7	O (PD)	24/Q5
D3	DRGB4	O (PD)	24/Q5
D4	DRGB5	O (PD)	24/Q5
D5	V_{IO}	PWR	---
D6	V_{SS}	GND	---
D7	V_{CORE}	PWR	---
D8	V_{SS}	GND	---
D9	V_{CORE}	PWR	---
D10	V_{SS}	GND	---
D11	V_{CORE}	PWR	---
D12	V_{SS}	GND	---
D13	TDO	O	24/Q5
D14	MD5	I/O	SDRAM
D15	V_{SS}	GND	---
D16	V_{CORE}	PWR	---
D17	DQM0	O	SDRAM
D18	V_{SS}	GND	---
D19	V_{CORE}	PWR	---
D20	V_{SS}	GND	---
D21	MD14	I/O	SDRAM
D22	MD10	I/O	SDRAM
D23	MA12	O	SDRAM
D24	DQS2	I/O	SDRAM
D25	DQM2	O	SDRAM
D26	MA11	O	SDRAM
E1	V_{SS}	GND	---
E2	V_{IO}	PWR	---
E3	DRGB6	O (PD)	24/Q5
E4	DRGB12	O (PD)	24/Q5
E10	V_{SS}	GND	---
E12	V_{CORE}	PWR	---
E15	V_{CORE}	PWR	---
E17	V_{SS}	GND	---
E23	MD18	I/O	SDRAM
E24	V_{SS}	GND	---
E25	V_{MEM}	PWR	---
E26	MA9	O	SDRAM
F1	DRGB15	O (PD)	24/Q5
F2	DRGB11	O (PD)	24/Q5
F3	DRGB13	O (PD)	24/Q5
F4	DRGB14	O (PD)	24/Q5
F23	MD22	I/O	SDRAM
F24	MA7	O	SDRAM
F25	MD23	I/O	SDRAM
F26	MA8	O	SDRAM
G1	DOTCLK	O (PD)	24/Q3
G2	DRGB23	O (PD)	24/Q5
G3	DRGB10	O (PD)	24/Q5
G4	DRGB21	O (PD)	24/Q5
G23	MD19	I/O	SDRAM
G24	MA6	O	SDRAM
G25	MD24	I/O	SDRAM
G26	MA5	O	SDRAM
H1	V_{SS}	GND	---
H2	V_{IO}	PWR	---
H3	DRGB22	O (PD)	24/Q5
H4	V_{SS}	GND	---
H23	V_{CORE}	PWR	---
H24	V_{SS}	GND	---
H25	V_{MEM}	PWR	---
H26	V_{SS}	GND	---
J1	DRGB20	O (PD)	24/Q5
J2	DRGB19	O (PD)	24/Q5
J3	IRQ13 (Strap)	I/O (PD)	24/Q5
J4	V_{CORE}	PWR	---
J23	V_{SS}	GND	---
J24	MD28	I/O	SDRAM
J25	MD29	I/O	SDRAM
J26	MD25	I/O	SDRAM
K1	INTR	I	24/Q7
K2	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-7. GX2-FP-DDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
K3	SUSP#	I	24/Q7
K4	SUSPA# (Strap)	I/O	24/Q5
K5	V_{SS}	GND	---
K22	V_{SS}	GND	---
K23	DQS3	I/O	SDRAM
K24	DQM3	O	SDRAM
K25	MA3	O	SDRAM
K26	MA4	O	SDRAM
L1	V_{SS}	GND	---
L2	V_{CORE}	PWR	---
L3	AD0	I/O	PCI
L4	V_{CORE}	PWR	---
L23	V_{CORE}	PWR	---
L24	V_{SS}	GND	---
L25	V_{MEM}	PWR	
L26	V_{SS}	GND	---
M1	AD2	I/O	PCI
M2	SMI#	I	24/Q7
M3	AD1	I/O	PCI
M4	V_{SS}	GND	---
M5	V_{CORE}	PWR	---
M22	V_{CORE}	PWR	---
M23	V_{SS}	GND	---
M24	MD26	I/O	SDRAM
M25	MD31	I/O	SDRAM
M26	MD27	I/O	SDRAM
N1	TDP	AI	Wire
N2	V_{SS}	GND	---
N3	TDN	AO	Wire
N4	AD3	I/O	PCI
N23	MD30	I/O	SDRAM
N24	MA2	O	SDRAM
N25	V_{SS}	GND	---
N26	MA0	O	SDRAM
P1	AD5	I/O	PCI
P2	V_{IO}	PWR	---
P3	AD6	I/O	PCI
P4	AD4	I/O	PCI
P23	MA	O	SDRAM
P24	BA1	O	SDRAM
P25	V_{MEM}	PWR	---
P26	MA10	O	SDRAM
R1	C/BE0#	I/O	PCI
R2	AD7	I/O	PCI
R3	AD8	I/O	PCI
R4	V_{SS}	GND	---
R5	V_{CORE}	PWR	---
R22	V_{CORE}	PWR	---
R23	V_{SS}	GND	---
R24	MD32	I/O	SDRAM
R25	MD33	I/O	SDRAM
R26	MD36	I/O	SDRAM
T1	V_{SS}	GND	---
T2	V_{IO}	PWR	---
T3	AD9	I/O	PCI
T4	V_{CORE}	PWR	---
T23	V_{CORE}	PWR	---
T24	V_{SS}	GND	---
T25	V_{MEM}	PWR	---
T26	V_{SS}	GND	---
U1	DOTREF	I	24/Q3
U2	V_{SS}	GND	---
U3	AD11	I/O	PCI
U4	AD10	I/O	PCI
U5	V_{SS}	GND	---
U22	V_{SS}	GND	---
U23	MD37	I/O	SDRAM
U24	DQS4	I/O	SDRAM
U25	SDCLK3	O	SDCLK
U26	SDCLK3#	O	SDCLK
V1	AD13	I/O	PCI
V2	AD12	I/O	PCI
V3	AD14	I/O	PCI
V4	V_{CORE}	PWR	---
V23	V_{SS}	GND	---
V24	MD34	I/O	SDRAM
V25	MD38	I/O	SDRAM
V26	DQM4	O	SDRAM
W1	V_{SS}	GND	---
W2	V_{IO}	PWR	---
W3	AD15	I/O	PCI
W4	V_{SS}	GND	---
W23	V_{CORE}	PWR	---
W24	V_{SS}	GND	---
W25	V_{MEM}	PWR	---
W26	V_{SS}	GND	---
Y1	SYSREF	I	24/Q3
Y2	V_{SS}	GND	---
Y3	C/BE1#	I/O	PCI
Y4	STOP#	I/O	PCI
Y23	BA0	O	SDRAM
Y24	MD39	I/O	SDRAM
Y25	SDCLK2#	O	SDCLK
Y26	SDCLK2	O	SDCLK
AA1	DEVSEL#	I/O	PCI
AA2	TRDY#	I/O	PCI
AA3	PAR	I/O	PCI
AA4	IRDY#	I/O	PCI
AA23	MD35	I/O	SDRAM
AA24	MD44	I/O	SDRAM
AA25	RAS0#	O	SDRAM
AA26	MD40	I/O	SDRAM
AB1	V_{SS}	GND	---
AB2	V_{IO}	PWR	---
AB3	FRAME#	I/O	PCI
AB4	C/BE2#	I/O	PCI
AB10	V_{SS}	GND	---
AB12	V_{CORE}	PWR	---
AB15	V_{CORE}	PWR	---
AB17	V_{SS}	GND	---
AB23	WE0#	O	SDRAM
AB24	RAS1#	O	SDRAM
AB25	V_{MEM}	PWR	---
AB26	V_{SS}	GND	---
AC1	AD16	I/O	PCI
AC2	AD17	I/O	PCI
AC3	AD18	I/O	PCI
AC4	AD20	I/O	PCI
AC5	C/BE3#	I/O	PCI
AC6	AD28	I/O	PCI
AC7	REQ0#	I	PCI
AC8	V_{CORE}	PWR	---
AC9	V_{SS}	GND	---
AC10	V_{CORE}	PWR	---
AC11	REQ1#	I	PCI
AC12	V_{SS}	GND	---
AC13	DQS7	I/O	SDRAM
AC14	MD56	I/O	SDRAM
AC15	V_{SS}	GND	---
AC16	V_{CORE}	PWR	---
AC17	MD50	I/O	SDRAM
AC18	V_{SS}	GND	---
AC19	V_{CORE}	PWR	---
AC20	MD52	I/O	SDRAM
AC21	MD47	I/O	SDRAM
AC22	DQS5	I/O	SDRAM
AC23	CAS0#	O	SDRAM
AC24	MD41	I/O	SDRAM
AC25	WE1#	O	SDRAM
AC26	MD45	I/O	SDRAM
AD1	AD19	I/O	PCI
AD2	AD21	I/O	PCI
AD3	V_{IO}	PWR	---
AD4	AD24	I/O	PCI
AD5	V_{SS}	GND	---
AD6	AD31	I/O	PCI
AD7	REQ2#	I	PCI
AD8	V_{SS}	GND	---
AD9	RST#	I	RST
AD10	NC	---	---

Signal Definitions (Continued)

Table 2-7. GX2-FP-DDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
AD11	V_{SS}	GND	---
AD12	GNT1# (Strap)	I/O	PCI
AD13	MD63	I/O	SDRAM
AD14	MD57	I/O	SDRAM
AD15	MD51	I/O	SDRAM
AD16	V_{SS}	GND	---
AD17	MD55	I/O	SDRAM
AD18	DQM6	O	SDRAM
AD19	V_{SS}	GND	---
AD20	MD53	I/O	SDRAM
AD21	MD43	I/O	SDRAM
AD22	V_{SS}	GND	---
AD23	DQM5	O	SDRAM
AD24	V_{MEM}	PWR	---
AD25	CS1#	O	SDRAM
AD26	CS0#	O	SDRAM
AE1	V_{IO}	PWR	---
AE2	V_{SS}	GND	---
AE3	AD22	I/O	PCI
AE4	AD26	I/O	PCI
AE5	V_{CORE}	PWR	---
AE6	AD29	I/O	PCI
AE7	GNT2# (Strap)	I/O	PCI
AE8	V_{IO}	PWR	---
AE9	SYS_V_{SS}	GND	---
AE10	SYS_AV_{SS}	AGND	---
AE11	V_{IO}	PWR	---
AE12	MD58	I/O	SDRAM
AE13	V_{MEM}	PWR	---
AE14	V_{SS}	GND	---
AE15	MD60	I/O	SDRAM
AE16	V_{MEM}	PWR	---
AE17	SDCLK0#	O	SDCLK
AE18	DQS6	I/O	SDRAM
AE19	V_{MEM}	PWR	---
AE20	SDCLK1#	O	SDCLK
AE21	MD48	I/O	SDRAM
AE22	V_{MEM}	PWR	---
AE23	MD42	I/O	SDRAM
AE24	CAS1#	O	SDRAM
AE25	V_{SS}	GND	---
AE26	V_{MEM}	PWR	---
AF1	V_{SS}	GND	---
AF2	V_{IO}	PWR	---
AF3	AD23	I/O	PCI
AF4	AD25	I/O	PCI
AF5	AD27	I/O	PCI
AF6	AD30	I/O	PCI
AF7	GNT0# (Strap)	I/O	PCI
AF8	V_{SS}	GND	---
AF9	SYS_V_{DD}	PWR	---
AF10	SYS_AV_{DD}	APWR	---
AF11	V_{SS}	GND	---
AF12	MD59	I/O	SDRAM
AF13	MD62	I/O	SDRAM
AF14	DQM7	O	SDRAM
AF15	MD61	I/O	SDRAM
AF16	V_{SS}	GND	---
AF17	SDCLK0	O	SDCLK
AF18	MD54	I/O	SDRAM
AF19	V_{SS}	GND	---
AF20	SDCLK1	O	SDCLK
AF21	MD49	I/O	SDRAM
AF22	MD46	I/O	SDRAM
AF23	CS2#	O	SDRAM
AF24	CS3#	O	SDRAM
AF25	V_{MEM}	PWR	---
AF26	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-8. GX2-FP-DDR Ball Assignment - Sorted Alphabetically by Signal Name

Signal Name	Ball No.
AD0	L3
AD1	M3
AD2	M1
AD3	N4
AD4	P4
AD5	P1
AD6	P3
AD7	R2
AD8	R3
AD9	T3
AD10	U4
AD11	U3
AD12	V2
AD13	V1
AD14	V3
AD15	W3
AD16	AC1
AD17	AC2
AD18	AC3
AD19	AD1
AD20	AC4
AD21	AD2
AD22	AE3
AD23	AF3
AD24	AD4
AD25	AF4
AD26	AE4
AD27	AF5
AD28	AC6
AD29	AE6
AD30	AF6
AD31	AD6
BA0	Y23
BA1	P24
C/BE0#	R1
C/BE1#	Y3
C/BE2#	AB4
C/BE3#	AC5
CAS0#	AC23
CAS1#	AE24
CKE0	A23
CKE1	B23
CS0#	AD26
CS1#	AD25
CS2#	AF23
CS3#	AF24
DEVSEL#	AA1
DISP_EN	C9
DOT_AV_{DD}	A9
DOT_AV_{SS}	A10
DOT_VDD	B11
DOTCLK	G1
DOTREF	U1
DQM0	D17
DQM1	B22
DQM2	D25
DQM3	K24
DQM4	V26
DQM5	AD23
DQM6	AD18
DQM7	AF14
DQS0	B15
DQS1	B21
DQS2	D24
DQS3	K23
DQS4	U24
DQS5	AC22
DQS6	AE18
DQS7	AC13
DRGB0	C6
DRGB1	B6
DRGB2	A6
DRGB3	D1
DRGB4	D3
DRGB5	D4
DRGB6	E3
DRGB7	D2
DRGB8	B5
DRGB9	A5
DRGB10	G3
DRGB11	F2
DRGB12	E4
DRGB13	F3
DRGB14	F4
DRGB15	F1
DRGB16	A7
DRGB17	B7
DRGB18	C7
DRGB19	J2
DRGB20	J1
DRGB21	G4
DRGB22	H3
DRGB23	G2
FP_LDE_MOD	C8
FP_VCONEN	B8
FP_VDDEN	A8
FRAME#	AB3
GNT0# (Strap)	AF7
GNT1# (Strap)	AD12
GNT2# (Strap)	AE7
HSYNC	C2
INTR	K1
IRDY#	AA4
IRQ13 (Strap)	J3
MA0	N26
MA1	P23
MA2	N24
MA3	K25
MA4	K26
MA5	G26
MA6	G24
MA7	F24
MA8	F26
MA9	E26
MA10	P26
MA11	D26
MA12	D23
MD0	C14
MD1	A15
MD2	C17
MD3	B18
MD4	C15
MD5	D14
MD6	C18
MD7	A18
MD8	C19
MD9	C20
MD10	D22
MD11	C23
MD12	C21
MD13	A21
MD14	D21
MD15	C22
MD16	B24
MD17	C25
MD18	E23
MD19	G23
MD20	A24
MD21	C26
MD22	F23
MD23	F25
MD24	G25
MD25	J26
MD26	M24
MD27	M26
MD28	J24
MD29	J25
MD30	N23
MD31	M25
MD32	R24
MD33	R25
MD34	V24
MD35	AA23
MD36	R26
MD37	U23
MD38	V25
MD39	Y24
MD40	AA26
MD41	AC24
MD42	AE23
MD43	AD21
MD44	AA24
MD45	AC26
MD46	AF22
MD47	AC21
MD48	AE21
MD49	AF21
MD50	AC17
MD51	AD15
MD52	AC20
MD53	AD20
MD54	AF18
MD55	AD17
MD56	AC14
MD57	AD14
MD58	AE12
MD59	AF12
MD60	AE15
MD61	AF15
MD62	AF13
MD63	AD13
MVREF	A14
NC	A13
NC	B3
NC	C1
NC	C5
NC	AD10
PAR	AA3
PLLTP2	C10
RAS0#	AA25
RAS1#	AB24
REQ0#	AC7
REQ1#	AC11
REQ2#	AD7
RST#	AD9
SDCLK0	AF17
SDCLK0#	AE17
SDCLK1	AF20
SDCLK1#	AE20
SDCLK2	Y26
SDCLK2#	Y25
SDCLK3	U25
SDCLK3#	U26
SDCLK4	A20
SDCLK4#	B20
SDCLK5	B17
SDCLK5#	A17
SMI#	M2
STOP#	Y4
SUSP#	K3
SUSPA# (Strap)	K4
SYS_AV_{DD}	AF10
SYS_AV_{SS}	AE10
SYS_V_{DD}	AF9
SYS_V_{SS}	AE9
SYSREF	Y1
TCLK	A12
TDBGI	C11
TDBGO	B12
TDI	C12
TDN	N3
TDO	D13
TDP	N1
TMS	B9
TRDY#	AA2
V_{CORE}	D7
V_{CORE}	D9
V_{CORE}	D11
V_{CORE}	D16
V_{CORE}	D19
V_{CORE}	E12
V_{CORE}	E15
V_{CORE}	H23
V_{CORE}	J4
V_{CORE}	L2
V_{CORE}	L4
V_{CORE}	L23
V_{CORE}	M5

Signal Definitions (Continued)

Table 2-8. GX2-FP-DDR Ball Assignment - Sorted Alphabetically by Signal Name (Continued)

Signal Name	Ball No.
V_{CORE}	M22
V_{CORE}	R5
V_{CORE}	R22
V_{CORE}	T4
V_{CORE}	T23
V_{CORE}	V4
V_{CORE}	W23
V_{CORE}	AB12
V_{CORE}	AB15
V_{CORE}	AC8
V_{CORE}	AC10
V_{CORE}	AC16
V_{CORE}	AC19
V_{CORE}	AE5
V_{IO}	A2
V_{IO}	A4
V_{IO}	A11
V_{IO}	B1
V_{IO}	C3
V_{IO}	D5
V_{IO}	E2
V_{IO}	H2
V_{IO}	P2
V_{IO}	T2
V_{IO}	W2
V_{IO}	AB2
V_{IO}	AD3
V_{IO}	AE1

Signal Name	Ball No.
V_{IO}	AE8
V_{IO}	AE11
V_{IO}	AF2
V_{MEM}	A25
V_{MEM}	B13
V_{MEM}	B16
V_{MEM}	B19
V_{MEM}	B26
V_{MEM}	C24
V_{MEM}	E25
V_{MEM}	H25
V_{MEM}	L25
V_{MEM}	P25
V_{MEM}	T25
V_{MEM}	W25
V_{MEM}	AB25
V_{MEM}	AD24
V_{MEM}	AE13
V_{MEM}	AE16
V_{MEM}	AE19
V_{MEM}	AE22
V_{MEM}	AE26
V_{MEM}	AF25
V_{SS}	A1
V_{SS}	A3
V_{SS}	A16
V_{SS}	A19
V_{SS}	A22

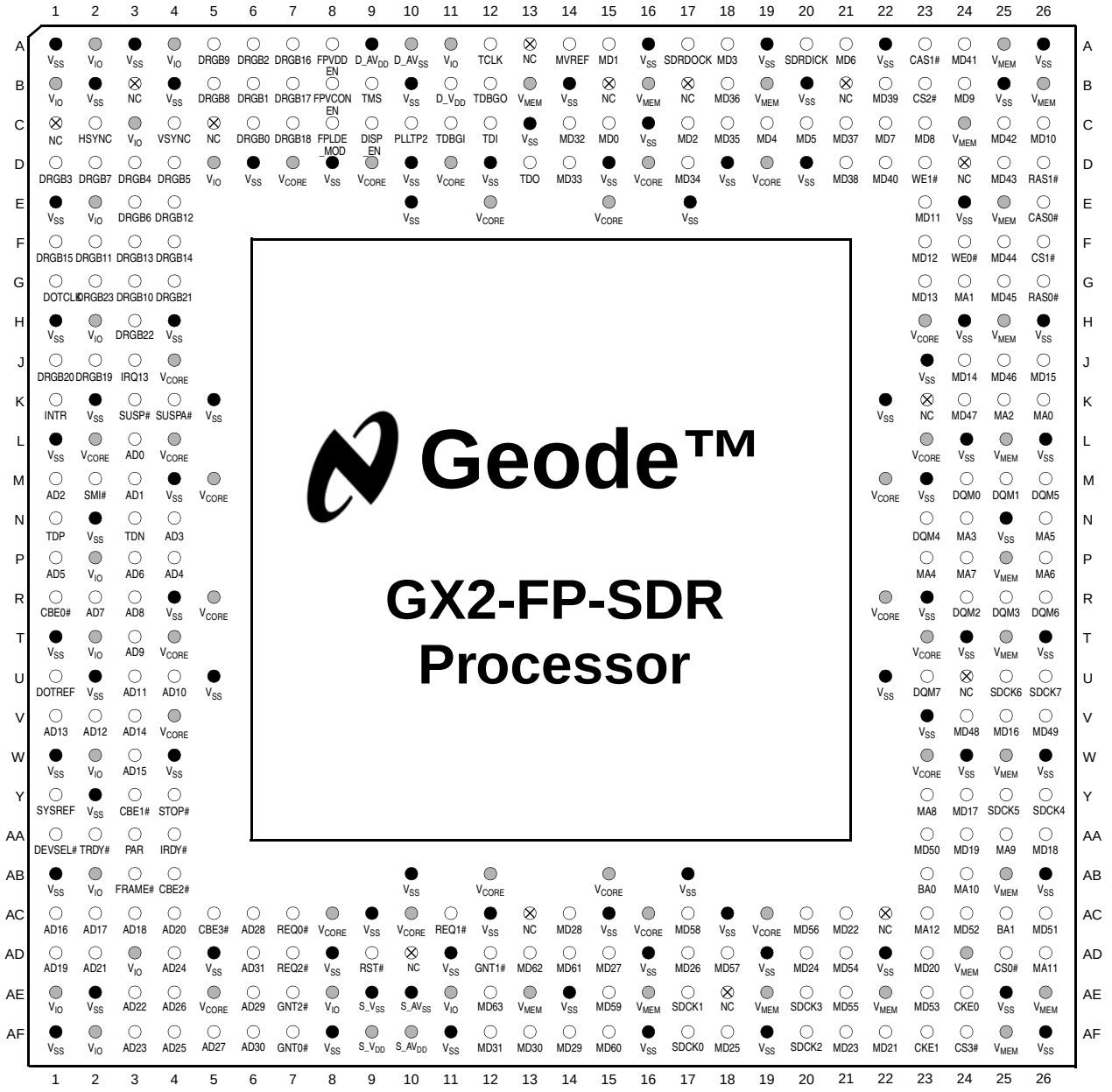
Signal Name	Ball No.
V_{SS}	A26
V_{SS}	B2
V_{SS}	B4
V_{SS}	B10
V_{SS}	B14
V_{SS}	B25
V_{SS}	C13
V_{SS}	C16
V_{SS}	D6
V_{SS}	D8
V_{SS}	D10
V_{SS}	D12
V_{SS}	D15
V_{SS}	D18
V_{SS}	D20
V_{SS}	E1
V_{SS}	E10
V_{SS}	E17
V_{SS}	E24
V_{SS}	H1
V_{SS}	H4
V_{SS}	H24
V_{SS}	H26
V_{SS}	J23
V_{SS}	K2
V_{SS}	K5
V_{SS}	K22
V_{SS}	L1

Signal Name	Ball No.
V_{SS}	L24
V_{SS}	L26
V_{SS}	M4
V_{SS}	M23
V_{SS}	N2
V_{SS}	N25
V_{SS}	R4
V_{SS}	R23
V_{SS}	T1
V_{SS}	T24
V_{SS}	T26
V_{SS}	U2
V_{SS}	U5
V_{SS}	U22
V_{SS}	V23
V_{SS}	W1
V_{SS}	W4
V_{SS}	W24
V_{SS}	W26
V_{SS}	Y2
V_{SS}	AB1
V_{SS}	AB10
V_{SS}	AB17
V_{SS}	AB26
V_{SS}	AC9
V_{SS}	AC12
V_{SS}	AC15
V_{SS}	AC18

Signal Name	Ball No.
V_{SS}	AD5
V_{SS}	AD8
V_{SS}	AD11
V_{SS}	AD16
V_{SS}	AD19
V_{SS}	AD22
V_{SS}	AE2
V_{SS}	AE14
V_{SS}	AE25
V_{SS}	AF1
V_{SS}	AF8
V_{SS}	AF11
V_{SS}	AF16
V_{SS}	AF19
V_{SS}	AF26
VSYNC	C4
WE0#	AB23
WE1#	AC25

Signal Definitions (Continued)

2.1.4 GX2-FP-SDR Ball Assignments



Note: Signal names have been abbreviated in this figure due to space constraints.
- ● = GND terminal
- ○ = PWR terminal
- ⊗ = No Connection

Figure 2-5. GX2-FP-SDR Ball Assignment Diagram (Top View)

Signal Definitions (Continued)

Table 2-9. GX2-FP-SDR Ball Assignment - Sorted by Ball Number

Ball No.	Signal Name	Type (PD)	Buffer Type
A1	V_{SS}	GND	---
A2	V_{IO}	PWR	---
A3	V_{SS}	GND	---
A4	V_{IO}	PWR	---
A5	DRGB9	O (PD)	24/Q5
A6	DRGB2	O (PD)	24/Q5
A7	DRGB16	O (PD)	24/Q5
A8	FP_VDDEN	O (PD)	24/Q5
A9	DOT_AV_{DD}	APWR	---
A10	DOT_AV_{SS}	AGND	---
A11	V_{IO}	PWR	---
A12	TCLK	I	24/Q7
A13	NC	---	---
A14	MVREF	AI	Wire
A15	MD1	I/O	SDRAM
A16	V_{SS}	GND	---
A17	SD_RD_OUT_CLK	O	SDCLK
A18	MD3	I/O	SDRAM
A19	V_{SS}	GND	---
A20	SD_RD_IN_CLK	I	SDCLK
A21	MD6	I/O	SDRAM
A22	V_{SS}	GND	---
A23	CAS1#	O	SDRAM
A24	MD41	I/O	SDRAM
A25	V_{MEM}	PWR	---
A26	V_{SS}	GND	---
B1	V_{IO}	PWR	---
B2	V_{SS}	GND	---
B3	NC	---	---
B4	V_{SS}	GND	---
B5	DRGB8	O (PD)	24/Q5
B6	DRGB1	O (PD)	24/Q5
B7	DRGB17	O (PD)	24/Q5
B8	FP_VCONEN	O (PD)	24/Q5
B9	TMS	I	24/Q7
B10	V_{SS}	GND	---
B11	DOT_V_{DD}	PWR	---
B12	TDBGO	O (PD)	24/Q3
B13	V_{MEM}	PWR	---
B14	V_{SS}	GND	---
B15	NC	---	---
B16	V_{MEM}	PWR	---
B17	NC	---	---
B18	MD36	I/O	SDRAM
B19	V_{MEM}	PWR	---
B20	V_{SS}	GND	---
B21	NC	---	---
B22	MD39	I/O	SDRAM
B23	CS2#	O	SDRAM
B24	MD9	I/O	SDRAM
B25	V_{SS}	GND	---
B26	V_{MEM}	PWR	---
C1	NC	---	---
C2	HSYNC	O (PD)	5V/4
C3	V_{IO}	PWR	---
C4	VSYNC	O (PD)	5V/4
C5	NC	---	---
C6	DRGB0	O (PD)	24/Q5
C7	DRGB18	O (PD)	24/Q5
C8	FP_LDE_MOD	O (PD)	24/Q5
C9	DISP_EN	O (PD)	24/Q5
C10	PLLTP2	AO	Wire
C11	TDBGI	I	24/Q7
C12	TDI	I	24/Q7
C13	V_{SS}	GND	---
C14	MD32	I/O	SDRAM
C15	MD0	I/O	SDRAM
C16	V_{SS}	GND	---
C17	MD2	I/O	SDRAM
C18	MD35	I/O	SDRAM
C19	MD4	I/O	SDRAM
C20	MD5	I/O	SDRAM
C21	MD37	I/O	SDRAM
C22	MD7	I/O	SDRAM
C23	MD8	I/O	SDRAM
C24	V_{MEM}	PWR	---
C25	MD42	I/O	SDRAM
C26	MD10	I/O	SDRAM
D1	DRGB3	O (PD)	24/Q5
D2	DRGB7	O (PD)	24/Q5
D3	DRGB4	O (PD)	24/Q5
D4	DRGB5	O (PD)	24/Q5
D5	V_{IO}	PWR	---
D6	V_{SS}	GND	---
D7	V_{CORE}	PWR	---
D8	V_{SS}	GND	---
D9	V_{CORE}	PWR	---
D10	V_{SS}	GND	---
D11	V_{CORE}	PWR	---
D12	V_{SS}	GND	---
D13	TDO	O	24/Q5
D14	MD33	I/O	SDRAM
D15	V_{SS}	GND	---
D16	V_{CORE}	PWR	---
D17	MD34	I/O	SDRAM
D18	V_{SS}	GND	---
D19	V_{CORE}	PWR	---
D20	V_{SS}	GND	---
D21	MD38	I/O	SDRAM
D22	MD40	I/O	SDRAM
D23	WE1#	O	SDRAM
D24	NC	---	---
D25	MD43	I/O	SDRAM
D26	RAS1#	O	SDRAM
E1	V_{SS}	GND	---
E2	V_{IO}	PWR	---
E3	DRGB6	O (PD)	24/Q5
E4	DRGB12	O (PD)	24/Q5
E10	V_{SS}	GND	---
E12	V_{CORE}	PWR	---
E15	V_{CORE}	PWR	---
E17	V_{SS}	GND	---
E23	MD11	I/O	SDRAM
E24	V_{SS}	GND	---
E25	V_{MEM}	PWR	---
E26	CAS0#	O	SDRAM
F1	DRGB15	O (PD)	24/Q5
F2	DRGB11	O (PD)	24/Q5
F3	DRGB13	O (PD)	24/Q5
F4	DRGB14	O (PD)	24/Q5
F23	MD12	I/O	SDRAM
F24	WE0#	O	SDRAM
F25	MD44	I/O	SDRAM
F26	CS1#	O	SDRAM
G1	DOTCLK	O (PD)	24/Q3
G2	DRGB23	O (PD)	24/Q5
G3	DRGB10	O (PD)	24/Q5
G4	DRGB21	O (PD)	24/Q5
G23	MD13	I/O	SDRAM
G24	MA1	O	SDRAM
G25	MD45	I/O	SDRAM
G26	RAS0#	O	SDRAM
H1	V_{SS}	GND	---
H2	V_{IO}	PWR	---
H3	DRGB22	O (PD)	24/Q5
H4	V_{SS}	GND	---
H23	V_{CORE}	PWR	---
H24	V_{SS}	GND	---
H25	V_{MEM}	PWR	---
H26	V_{SS}	GND	---
J1	DRGB20	O (PD)	24/Q5
J2	DRGB19	O (PD)	24/Q5
J3	IRQ13 (Strap)	I/O (PD)	24/Q5
J4	V_{CORE}	PWR	---
J23	V_{SS}	GND	---
J24	MD14	I/O	SDRAM
J25	MD46	I/O	SDRAM
J26	MD15	I/O	SDRAM
K1	INTR	I	24/Q7
K2	V_{SS}	GND	---
K3	SUSP#	I	24/Q7
K4	SUSPA# (Strap)	I/O	24/Q5

Signal Definitions (Continued)

Table 2-9. GX2-FP-SDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
K5	V_{SS}	GND	---
K22	V_{SS}	GND	---
K23	NC	---	---
K24	MD47	I/O	SDRAM
K25	MA2	O	SDRAM
K26	MA0	O	SDRAM
L1	V_{SS}	GND	---
L2	V_{CORE}	PWR	---
L3	AD0	I/O	PCI
L4	V_{CORE}	PWR	---
L23	V_{CORE}	PWR	---
L24	V_{SS}	GND	---
L25	V_{MEM}	PWR	
L26	V_{SS}	GND	---
M1	AD2	I/O	PCI
M2	SMI#	I	24/Q7
M3	AD1	I/O	PCI
M4	V_{SS}	GND	---
M5	V_{CORE}	PWR	---
M22	V_{CORE}	PWR	---
M23	V_{SS}	GND	---
M24	DQM0	O	SDRAM
M25	DQM1	O	SDRAM
M26	DQM5	O	SDRAM
N1	TDP	AI	Wire
N2	V_{SS}	GND	---
N3	TDN	AO	Wire
N4	AD3	I/O	PCI
N23	DQM4	O	SDRAM
N24	MA3	O	SDRAM
N25	V_{SS}	GND	---
N26	MA5	O	SDRAM
P1	AD5	I/O	PCI
P2	V_{IO}	PWR	---
P3	AD6	I/O	PCI
P4	AD4	I/O	PCI
P23	MA4	O	SDRAM
P24	MA7	O	SDRAM
P25	V_{MEM}	PWR	---
P26	MA6	O	SDRAM
R1	C/BE0#	I/O	PCI
R2	AD7	I/O	PCI
R3	AD8	I/O	PCI
R4	V_{SS}	GND	---
R5	V_{CORE}	PWR	---
R22	V_{CORE}	PWR	---
R23	V_{SS}	GND	---
R24	DQM2	O	SDRAM
R25	DQM3	O	SDRAM
R26	DQM6	O	SDRAM
T1	V_{SS}	GND	---
T2	V_{IO}	PWR	---
T3	AD9	I/O	PCI
T4	V_{CORE}	PWR	---
T23	V_{CORE}	PWR	---
T24	V_{SS}	GND	---
T25	V_{MEM}	PWR	---
T26	V_{SS}	GND	---
U1	DOTREF	I	24/Q3
U2	V_{SS}	GND	---
U3	AD11	I/O	PCI
U4	AD10	I/O	PCI
U5	V_{SS}	GND	---
U22	V_{SS}	GND	---
U23	DQM7	O	SDRAM
U24	NC	---	---
U25	SDCLK6	O	SDCLK
U26	SDCLK7	O	SDCLK
V1	AD13	I/O	PCI
V2	AD12	I/O	PCI
V3	AD14	I/O	PCI
V4	V_{CORE}	PWR	---
V23	V_{SS}	GND	---
V24	MD48	I/O	SDRAM
V25	MD16	I/O	SDRAM
V26	MD49	I/O	SDRAM
W1	V_{SS}	GND	---
W2	V_{IO}	PWR	---
W3	AD15	I/O	PCI
W4	V_{SS}	GND	---
W23	V_{CORE}	PWR	---
W24	V_{SS}	GND	---
W25	V_{MEM}	PWR	---
W26	V_{SS}	GND	---
Y1	SYSREF	I	24/Q3
Y2	V_{SS}	GND	---
Y3	C/BE1#	I/O	PCI
Y4	STOP#	I/O	PCI
Y23	MA8	O	SDRAM
Y24	MD17	I/O	SDRAM
Y25	SDCLK5	O	SDCLK
Y26	SDCLK4	O	SDCLK
AA1	DEVSEL#	I/O	PCI
AA2	TRDY#	I/O	PCI
AA3	PAR	I/O	PCI
AA4	IRDY#	I/O	PCI
AA23	MD50	I/O	SDRAM
AA24	MD19	I/O	SDRAM
AA25	MA9	O	SDRAM
AA26	MD18	I/O	SDRAM
AB1	V_{SS}	GND	---
AB2	V_{IO}	PWR	---
AB3	FRAME#	I/O	PCI
AB4	C/BE2#	I/O	PCI
AB10	V_{SS}	GND	---
AB12	V_{CORE}	PWR	---
AB15	V_{CORE}	PWR	---
AB17	V_{SS}	GND	---
AB23	BA0	O	SDRAM
AB24	MA10	O	SDRAM
AB25	V_{MEM}	PWR	---
AB26	V_{SS}	GND	---
AC1	AD16	I/O	PCI
AC2	AD17	I/O	PCI
AC3	AD18	I/O	PCI
AC4	AD20	I/O	PCI
AC5	C/BE3#	I/O	PCI
AC6	AD28	I/O	PCI
AC7	REQ0#	I	PCI
AC8	V_{CORE}	PWR	---
AC9	V_{SS}	GND	---
AC10	V_{CORE}	PWR	---
AC11	REQ1#	I	PCI
AC12	V_{SS}	GND	---
AC13	NC	---	---
AC14	MD28	I/O	SDRAM
AC15	V_{SS}	GND	---
AC16	V_{CORE}	PWR	---
AC17	MD58	I/O	SDRAM
AC18	V_{SS}	GND	---
AC19	V_{CORE}	PWR	---
AC20	MD56	I/O	SDRAM
AC21	MD22	I/O	SDRAM
AC22	NC	---	---
AC23	MA12	O	SDRAM
AC24	MD52	I/O	SDRAM
AC25	BA1	O	SDRAM
AC26	MD51	I/O	SDRAM
AD1	AD19	I/O	PCI
AD2	AD21	I/O	PCI
AD3	V_{IO}	PWR	---
AD4	AD24	I/O	PCI
AD5	V_{SS}	GND	---
AD6	AD31	I/O	PCI
AD7	REQ2#	I	PCI
AD8	V_{SS}	GND	---
AD9	RST#	I	RST
AD10	NC	---	---
AD11	V_{SS}	GND	---
AD12	GNT1# (Strap)	I/O	PCI

Signal Definitions (Continued)

Table 2-9. GX2-FP-SDR Ball Assignment - Sorted by Ball Number (Continued)

Ball No.	Signal Name	Type (PD)	Buffer Type
AD13	MD62	I/O	SDRAM
AD14	MD61	I/O	SDRAM
AD15	MD27	I/O	SDRAM
AD16	V_{SS}	GND	---
AD17	MD26	I/O	SDRAM
AD18	MD57	I/O	SDRAM
AD19	V_{SS}	GND	---
AD20	MD24	I/O	PCI
AD21	MD54	I/O	SDRAM
AD22	V_{SS}	GND	---
AD23	MD20	I/O	SDRAM
AD24	V_{MEM}	PWR	---
AD25	CS0#	O	SDRAM
AD26	MA11	O	SDRAM
AE1	V_{IO}	PWR	---
AE2	V_{SS}	GND	---
AE3	AD22	I/O	PCI
AE4	AD26	I/O	PCI
AE5	V_{CORE}	PWR	---
AE6	AD29	I/O	PCI
AE7	GNT2# (Strap)	I/O	PCI
AE8	V_{IO}	PWR	---
AE9	SYS_V_{SS}	GND	---
AE10	SYS_AV_{SS}	AGND	---
AE11	V_{IO}	PWR	---
AE12	MD63	I/O	SDRAM
AE13	V_{MEM}	PWR	---
AE14	V_{SS}	GND	---
AE15	MD59	I/O	SDRAM
AE16	V_{MEM}	PWR	---
AE17	SDCLK1	O	SDCLK
AE18	NC	---	---
AE19	V_{MEM}	PWR	---
AE20	SDCLK3	O	SDCLK
AE21	MD55	I/O	SDRAM
AE22	V_{MEM}	PWR	---
AE23	MD53	I/O	SDRAM
AE24	CKE0	O	SDRAM
AE25	V_{SS}	GND	---
AE26	V_{MEM}	PWR	---
AF1	V_{SS}	GND	---
AF2	V_{IO}	PWR	---
AF3	AD23	I/O	PCI
AF4	AD25	I/O	PCI
AF5	AD27	I/O	PCI
AF6	AD30	I/O	PCI
AF7	GNT0# (Strap)	I/O	PCI
AF8	V_{SS}	GND	---
AF9	SYS_V_{DD}	PWR	---
AF10	SYS_AV_{DD}	APWR	---
AF11	V_{SS}	GND	---
AF12	MD31	I/O	SDRAM
AF13	MD30	I/O	SDRAM
AF14	MD29	I/O	SDRAM
AF15	MD60	I/O	SDRAM
AF16	V_{SS}	GND	---
AF17	SDCLK0	O	SDCLK
AF18	MD25	I/O	SDRAM
AF19	V_{SS}	GND	---
AF20	SDCLK2	O	SDCLK
AF21	MD23	I/O	SDRAM
AF22	MD21	I/O	SDRAM
AF23	CKE1	O	SDRAM
AF24	CS3#	O	SDRAM
AF25	V_{MEM}	PWR	---
AF26	V_{SS}	GND	---

Signal Definitions (Continued)

Table 2-10. GX2-FP-SDR Ball Assignment - Sorted Alphabetically Signal Name

Signal Name	Ball No.
AD0	L3
AD1	M3
AD2	M1
AD3	N4
AD4	P4
AD5	P1
AD6	P3
AD7	R2
AD8	R3
AD9	T3
AD10	U4
AD11	U3
AD12	V2
AD13	V1
AD14	V3
AD15	W3
AD16	AC1
AD17	AC2
AD18	AC3
AD19	AD1
AD20	AC4
AD21	AD2
AD22	AE3
AD23	AF3
AD24	AD4
AD25	AF4
AD26	AE4
AD27	AF5
AD28	AC6
AD29	AE6
AD30	AF6
AD31	AD6
BA0	AB23
BA1	AC25
C/BE0#	R1
C/BE1#	Y3
C/BE2#	AB4
C/BE3#	AC5
CAS0#	E26
CAS1#	A23
CKE0	AE24
CKE1	AF23
CS0#	AD25
CS1#	F26
CS2#	B23
CS3#	AF24
DEVSEL#	AA1
DISP_EN	C9
DOT_AV_{DD}	A9
DOT_AV_{SS}	A10
DOT_V_{DD}	B11
DOTCLK	G1
DOTREF	U1
DQM0	M24
DQM1	M25
DQM2	R24
DQM3	R25
DQM4	N23
DQM5	M26
DQM6	R26
DQM7	U23
DRGB0	C6
DRGB1	B6
DRGB2	A6
DRGB3	D1
DRGB4	D3
DRGB5	D4
DRGB6	E3
DRGB7	D2
DRGB8	B5
DRGB9	A5
DRGB10	G3
DRGB11	F2
DRGB12	E4
DRGB13	F3
DRGB14	F4
DRGB15	F1
DRGB16	A7
DRGB17	B7
DRGB18	C7
DRGB19	J2
DRGB20	J1
DRGB21	G4
DRGB22	H3
DRGB23	G2
FP_LDE_MOD	C8
FP_VCONEN	B8
FP_VDDEN	A8
FRAME#	AB3
GNT0# (Strap)	AF7
GNT1# (Strap)	AD12
GNT2# (Strap)	AE7
HSYNC	C2
INTR	K1
IRDY#	AA4
IRQ13 (Strap)	J3
MA0	K26
MA1	G24
MA2	K25
MA3	N24
MA4	P23
MA5	N26
MA6	P26
MA7	P24
MA8	Y23
MA9	AA25
MA10	AB24
MA11	AD26
MA12	AC23
MD0	C15
MD1	A15
MD2	C17
MD3	A18
MD4	C19
MD5	C20
MD6	A21
MD7	C22
MD8	C23
MD9	B24
MD10	C26
MD11	E23
MD12	F23
MD13	G23
MD14	J24
MD15	J26
MD16	V25
MD17	Y24
MD18	AA26
MD19	AA24
MD20	AD23
MD21	AF22
MD22	AC21
MD23	AF21
MD24	AD20
MD25	AF18
MD26	AD17
MD27	AD15
MD28	AC14
MD29	AF14
MD30	AF13
MD31	AF12
MD32	C14
MD33	D14
MD34	D17
MD35	C18
MD36	B18
MD37	C21
MD38	D21
MD39	B22
MD40	D22
MD41	A24
MD42	C25
MD43	D25
MD44	F25
MD45	G25
MD46	J25
MD47	K24
MD48	V24
MD49	V26
MD50	AA23
MD51	AC26
MD52	AC24
MD53	AE23
MD54	AD21
MD55	AE21
MD56	AC20
MD57	AD18
MD58	AC17
MD59	AE15
MD60	AF15
MD61	AD14
MD62	AD13
MD63	AE12
MVREF	A14
NC	A13
NC	B3
NC	B15
NC	B17
NC	B21
NC	C1
NC	C5
NC	D24
NC	K23
NC	U24
NC	AC13
NC	AC22
NC	AD10
NC	AE18
PAR	AA3
PLLTP2	C10
RAS0#	G26
RAS1#	D26
REQ0#	AC7
REQ1#	AC11
REQ2#	AD7
RST#	AD9
SD_RD_IN_CLK	A20
SD_RD_OUT_CLK	A17
SDCLK0	AF17
SDCLK1	AE17
SDCLK2	AF20
SDCLK3	AE20
SDCLK4	Y26
SDCLK5	Y25
SDCLK6	U25
SDCLK7	U26
SMI#	M2
STOP#	Y4
SUSP#	K3
SUSPA# (Strap)	K4
SYS_AV_{DD}	AF10
SYS_AV_{SS}	AE10
SYS_V_{DD}	AF9
SYS_V_{SS}	AE9
SYSREF	Y1
TCLK	A12
TDBGI	C11
TDBGO	B12
TDI	C12
TDN	N3
TDO	D13
TDP	N1
TMS	B9
TRDY#	AA2
V_{CORE}	D7
V_{CORE}	D9
V_{CORE}	D11
V_{CORE}	D16
V_{CORE}	D19
V_{CORE}	E12
V_{CORE}	E15
V_{CORE}	H23
V_{CORE}	J4
V_{CORE}	L2
V_{CORE}	L4
V_{CORE}	L23
V_{CORE}	M5

Signal Definitions (Continued)

Table 2-10. GX2-FP-SDR Ball Assignment - Sorted Alphabetically Signal Name (Continued)

Signal Name	Ball No.
V_{CORE}	M22
V_{CORE}	R5
V_{CORE}	R22
V_{CORE}	T4
V_{CORE}	T23
V_{CORE}	V4
V_{CORE}	W23
V_{CORE}	AB12
V_{CORE}	AB15
V_{CORE}	AC8
V_{CORE}	AC10
V_{CORE}	AC16
V_{CORE}	AC19
V_{CORE}	AE5
V_{IO}	A2
V_{IO}	A4
V_{IO}	A11
V_{IO}	B1
V_{IO}	C3
V_{IO}	D5
V_{IO}	E2
V_{IO}	H2
V_{IO}	P2
V_{IO}	T2
V_{IO}	W2
V_{IO}	AB2
V_{IO}	AD3

Signal Name	Ball No.
V_{IO}	AE1
V_{IO}	AE8
V_{IO}	AE11
V_{IO}	AF2
V_{MEM}	A25
V_{MEM}	B13
V_{MEM}	B16
V_{MEM}	B19
V_{MEM}	B26
V_{MEM}	C24
V_{MEM}	E25
V_{MEM}	H25
V_{MEM}	L25
V_{MEM}	P25
V_{MEM}	T25
V_{MEM}	W25
V_{MEM}	AB25
V_{MEM}	AD24
V_{MEM}	AE13
V_{MEM}	AE16
V_{MEM}	AE19
V_{MEM}	AE22
V_{MEM}	AE26
V_{MEM}	AF25
V_{SS}	A1
V_{SS}	A3
V_{SS}	A16

Signal Name	Ball No.
V_{SS}	A19
V_{SS}	A22
V_{SS}	A26
V_{SS}	B2
V_{SS}	B4
V_{SS}	B10
V_{SS}	B14
V_{SS}	B20
V_{SS}	B25
V_{SS}	C13
V_{SS}	C16
V_{SS}	D6
V_{SS}	D8
V_{SS}	D10
V_{SS}	D12
V_{SS}	D15
V_{SS}	D18
V_{SS}	D20
V_{SS}	E1
V_{SS}	E10
V_{SS}	E17
V_{SS}	E24
V_{SS}	H1
V_{SS}	H4
V_{SS}	H24
V_{SS}	H26
V_{SS}	J23

Signal Name	Ball No.
V_{SS}	K2
V_{SS}	K5
V_{SS}	K22
V_{SS}	L1
V_{SS}	L24
V_{SS}	L26
V_{SS}	M4
V_{SS}	M23
V_{SS}	N2
V_{SS}	N25
V_{SS}	R4
V_{SS}	R23
V_{SS}	T1
V_{SS}	T24
V_{SS}	T26
V_{SS}	U2
V_{SS}	U5
V_{SS}	U22
V_{SS}	V23
V_{SS}	W1
V_{SS}	W4
V_{SS}	W24
V_{SS}	W26
V_{SS}	Y2
V_{SS}	AB1
V_{SS}	AB10
V_{SS}	AB17

Signal Name	Ball No.
V_{SS}	AB26
V_{SS}	AC9
V_{SS}	AC12
V_{SS}	AC15
V_{SS}	AC18
V_{SS}	AD5
V_{SS}	AD8
V_{SS}	AD11
V_{SS}	AD16
V_{SS}	AD19
V_{SS}	AD22
V_{SS}	AE2
V_{SS}	AE14
V_{SS}	AE25
V_{SS}	AF1
V_{SS}	AF8
V_{SS}	AF11
V_{SS}	AF16
V_{SS}	AF19
V_{SS}	AF26
VSYNC	C4
WE0#	F24
WE1#	D23

Signal Definitions (Continued)

2.2 SIGNAL DESCRIPTIONS

2.2.1 System Interface Signals

Signal Name	Ball No.	Type	Description
SYSREF	Y1	I	**System Reference.** PCI input clock; typically 33 or 66 MHz. See Figure 6-6 on page 397.
RST#	AD9	I	**PCI Reset.** RST# aborts all operations in progress and places the GX2 processor into a reset state. RST# forces the CPU and peripheral functions to begin executing at a known state. All data in the on-chip cache is invalidated upon a reset. RST# is an asynchronous input, but must meet specified setup and hold times to guarantee recognition at a particular clock edge. This input is typically generated during the power-on-reset (POR) sequence.
INTR	K1	I	**(Maskable) Interrupt Request.** INTR is a level-sensitive input that causes the GX2 processor to suspend execution of the current instruction stream and begin execution of an interrupt service routine. The INTR input can be masked through the EFLAGS register IF bit.
IRQ13	J3 (Strap)	I/O (PD)	**Interrupt Request Level 13.** When a floating point error occurs, the GX2 processor asserts IRQ13. The floating point interrupt handler then performs an OUT instruction to I/O address F0h or F1h. The GX2 processor accepts either of these cycles and clears the IRQ13 pin. IRQ13 is an output during normal operation. It is an input at reset and functions as a boot strap for tester features on a board. It must be pulled low to invoke the strap.
SMI#	M2	I	**System Management Interrupt.** SMI# is a level-sensitive interrupt. SMI# puts the GX2 processor into System Management Mode (SMM).
SUSP#	K3	I	**Suspend Request.** This signal is used as a suspend request or as a serial input stream. Section 5.5 "GeodeLink Control Processor Register Descriptions" on page 325, and Section 5.7 "Geode I/O Companion Register Descriptions" on page 371 This signal is used to request that the GX2 processor enter Suspend mode. After recognition of an active SUSP# input, the processor completes execution of the current instruction, any pending decoded instructions, and associated bus cycles. SUSP# is enabled by setting the SUSP bit (MSR 00001900h[12]), and is ignored following a reset. Since the GX2 processor includes system logic functions as well as the CPU Core, there are special modes designed to support the different power management states associated with APM, ACPI, and portable designs. The part can be configured to stop only the CPU Core clocks, or all clocks. When all clocks are stopped, the external clock can also be stopped.

Signal Definitions (Continued)

2.2.1 System Interface Signals (Continued)

Signal Name	Ball No.	Type	Description
SUSPA#	K4 (Strap)	I/O	**Suspend Acknowledge.** Suspend Acknowledge indicates that the GX2 processor has entered low-power Suspend mode as a result of SUSP# assertion or execution of a HLT instruction. (The GX2 enters Suspend mode following execution of a HLT instruction if the SUSP_HLT bit, MSR 00001210h[0], is set.) SUSPA# floats following a reset and is enabled by setting the SUSP bit (MSR 00001900h[12]). The SYSREF input may be stopped after SUSPA# has been asserted to further reduce power consumption if the system is configured for 3 Volt Suspend mode. SUSPA# is an output during normal operation. It is an input at reset and functions as a boot strap for tester features on a board. It must be pulled low to invoke the strap.
SYS_AV_{DD}	AF10	APWR	**System Analog Power.** Connect to 3.3V. See Figure 6-6 "Typical System PLL Connection Diagram" on page 397.
SYS_AV_{SS}	AE10	AGND	**System Analog Ground.** Connect to ground. See Figure 6-6 "Typical System PLL Connection Diagram" on page 397.
SYS_V_{DD}	AF9	PWR	**System Power.** Connect to 3.3V. See Figure 6-6 "Typical System PLL Connection Diagram" on page 397.
SYS_V_{SS}	AE9	GND	**System Ground.** Connect to ground. See Figure 6-6 "Typical System PLL Connection Diagram" on page 397.

2.2.2 PCI Interface Signals

Signal Name	Ball No.	Type	Description
FRAME#	AB3	I/O	**Frame.** FRAME# is driven by the current master to indicate the beginning and duration of an access. FRAME# is asserted to indicate a bus transaction is beginning. While FRAME# is asserted, data transfers continue. When FRAME# is de-asserted, the transaction is in the final data phase.
IRDY#	AA4	I/O	**Initiator Ready.** IRDY# is asserted to indicate that the bus master is able to complete the current data phase of the transaction. IRDY# is used in conjunction with TRDY#. A data phase is completed on any SYSREF in which both IRDY# and TRDY# are sampled asserted. During a write, IRDY# indicates valid data is present on AD[31:0]. During a read, it indicates the master is prepared to accept data. Wait cycles are inserted until both IRDY# and TRDY# are asserted together.
TRDY#	AA2	I/O	**Target Ready.** TRDY# is asserted to indicate that the target agent is able to complete the current data phase of the transaction. TRDY# is used in conjunction with IRDY#. A data phase is complete on any SYSREF in which both TRDY# and IRDY# are sampled asserted. During a read, TRDY# indicates that valid data is present on AD[31:0]. During a write, it indicates the target is prepared to accept data. Wait cycles are inserted until both IRDY# and TRDY# are asserted together.
STOP#	Y4	I/O	**Target Stop.** STOP# is asserted to indicate that the current target is requesting the master to stop the current transaction. This signal is used with DEVSEL# to indicate retry, disconnect, or target abort. If STOP# is sampled active while a master, FRAME# is be de-asserted and the cycle is stopped within three SYSREFs. STOP# can be asserted when the PCI write buffers are full or a previously buffered cycle has not completed.

Signal Definitions (Continued)

2.2.2 PCI Interface Signals (Continued)

Signal Name	Ball No.	Type	Description
AD[31:0]	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-DDR: See Table 2-8 on page 37. GX2-FP-SDR: See Table 2-10 on page 43.	I/O	**Multiplexed Address and Data.** Addresses and data are multiplexed together on the same pins. A bus transaction consists of an address phase in the cycle in which FRAME# is asserted followed by one or more data phases. During the address phase, AD[31:0] contain a physical 32-bit address. During data phases, AD[7:0] contain the least significant byte (LSB) and AD[31:24] contain the most significant byte (MSB). Write data is stable and valid when IRDY# is asserted and read data is stable and valid when TRDY# is asserted. Data is transferred during the SYSREF when both IRDY# and TRDY# are asserted.
C/BE[3:0]#	AC5, AB4, Y3, R1	I/O	**Multiplexed Command and Byte Enables.** C/BE# are the bus commands and byte enables. They are multiplexed together on the same PCI pins. During the address phase of a transaction when FRAME# is active, C/BE[3:0]# define the bus command. During the data phase C/BE[3:0]# are used as byte enables. The byte enables are valid for the entire data phase and determine which byte lanes carry meaningful data. C/BE0# applies to byte 0 (LSB) and C/BE3# applies to byte 3 (MSB). The command encoding and types are listed below: 0000: Interrupt Acknowledge 0001: Special Cycle 0010: I/O Read 0011: I/O Write 0100: Reserved 0101: Reserved 0110: Memory Read 0111: Memory Write 1000: Reserved 1001: Reserved 1010: Configuration Read 1011: Configuration Write 1100: Memory Read Multiple 1101: Dual Address Cycle (Rsvd) 1110: Memory Read Line 1111: Memory Write and Invalidate
PAR	AA3	I/O	**Parity.** PAR is used with AD[31:0] and C/BE[3:0]# to generate even parity. Parity generation is required by all PCI agents: the master drives PAR for address and write-data phases and the target drives PAR for read-data phases. For address phases, PAR is stable and valid one SYSREF after the address phase. For data phases, PAR is stable and valid one SYSREF after either IRDY# is asserted on a write transaction or after TRDY# is asserted on a read transaction. Once PAR is valid, it remains valid until one SYSREF after the completion of the data phase.
DEVSEL#	AA1	I/O	**Device Select.** DEVSEL# indicates that the driving device has decoded its address as the target of the current access. As an input, DEVSEL# indicates whether any device on the bus has been selected. DEVSEL# is also driven by any agent that has the ability to accept cycles on a subtractive decode basis. As a master, if no DEVSEL# is detected within and up to the subtractive decode clock, a master abort cycle results, except for special cycles that do not expect a DEVSEL# returned.
REQ0#, REQ1#, REQ2#	AC7, AC11, AD7	I	**Request Lines.** REQ# indicates to the arbiter that an agent desires use of the bus. Each master has its own REQ# line. REQ# priorities are based on the arbitration scheme chosen. REQ2# is reserved for the interface with the Geode CS5535 I/O Companion.

Signal Definitions (Continued)

2.2.2 PCI Interface Signals (Continued)

Signal Name	Ball No.	Type	Description
GNT0#, GNT1#, GNT2#	AF7, AD12, AE7 (Straps)	I/O	**Grant Lines.** GNT# indicates to the requesting master that it has been granted access to the bus. Each master has its own GNT# line. GNT# can be pulled away any time a higher REQ# is received or if the master does not begin a cycle within a set period of time. In normal operation, the GNT# signals function as outputs. However, multiplexed on the GNT# balls are strap options that are read at GLCP_SYS_RSTPLL (MSR 4C000014h). The intended use of these straps are for CPU Core clock and memory speed settings. GNT2# is reserved for the interface with the Geode CS5535 I/O Companion.

2.2.3 Memory Interface Signals

2.2.3.1 GX2-DDR Interface Signals

Signal Name	Ball No.	Type	Description
MD[63:0]	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-FP-DDR: See Table 2-8 on page 37.	I/O	**Memory Data Bus.** The data bus lines driven to/from system memory.
MA[12:0]	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-FP-DDR: See Table 2-8 on page 37.	O	**Memory Address Bus.** The multiplexed row/column address lines driven to the system memory. Supports 256-Mbit SDRAM.
BA0, BA1	Y23, P24	O	**Bank Address Bits.** These bits are used to select the component bank within the SDRAM.
CS0#, CS1#, CS2#, CS3#	AD26, AD25, AF23, AF24	O	**Chip Selects.** The chip selects are used to select the module bank within the system memory. Each chip select corresponds to a specific module bank. If CS# is high, the bank(s) do not respond to RAS#, CAS#, or WE# until the bank is selected again.
RAS0#, RAS1#	AA25, AB24	O	**Row Address Strobe.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. RAS0# is used with CS0# and CS1#. RAS1# is used with CS2# and CS3#.
CAS0#, CAS1#	AC23, AE24	O	**Column Address Strobe.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. CAS0# is used with CS0# and CS1#. CAS1# is used with CS2# and CS3#.
WE0#, WE1#	AB23, AC25	O	**Write Enable.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. WE0# is used with CS0# and CS1#. WE1# is used with CS2# and CS3#.
CKE0, CKE1	A23, B23	O	**Clock Enable.** For normal operation, CKE is held high. CKE goes low during Suspend. CKE0 is used with CS0# and CS1#. CKE1 is used with CS2# and CS3#.

Signal Definitions (Continued)

2.2.3.1 GX2-DDR Interface Signals (Continued)

Signal Name	Ball No.	Type	Description
DQM0, DQM1, DQM2, DQM3, DQM4, DQM5, DQM6, DQM7	D17, B22, D25, K24, V26, AD23, AD18, AF14	O	**Data Mask Control Bits.** During memory read cycles, these outputs control whether the SDRAM output buffers are driven on the MD bus or not. All DQM signals are asserted during read cycles. During memory write cycles, these outputs control whether or not MD data is written into the SDRAM. DQM[0] is associated with MD[7:0]. DQM[7] is associated with MD[63:56].
DQS0, DQS1, DQS2, DQS3, DQS4, DQS5, DQS6, DQS7	B15, B21, D24, K23, U24, AC22, AE18, AC13	I/O	**DDR Lower Data Strobe.**
SDCLK0, SDCLK0# SDCLK1, SDCLK1# SDCLK2, SDCLK2# SDCLK3, SDCLK3# SDCLK4, SDCLK4# SDCLK5 SDCLK5#	AF17, AE17 AF20, AE20 Y26, Y25 U25, U26 A20, B20 B17, A17	O	**SDRAM Clock Differential Pairs.** The SDRAM devices sample all the control, address, and data based on these clocks. All clocks are differential clock outputs.
MVREF	A14	AI	**Memory Voltage Reference.** This input operates at half the V_{MEM} voltage.
NC	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-FP-DDR: See Table 2-8 on page 37.	NC	**No Connection.** A line designated as NC must be left disconnected. Connecting an NC ball to a pull-up/down resistor, or an active signal could cause unexpected results and possible circuit malfunctions.
V_{MEM}	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-FP-DDR: See Table 2-8 on page 37.	PWR	**Memory Power Connection (Total of 20).**

Signal Definitions (Continued)

2.2.3.2 GX2-SDR Interface Signals

Signal Name	Ball No.	Type	Description
MD[63:0]	GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-SDR: See Table 2-10 on page 43.	I/O	**Memory Data Bus.** The data bus lines driven to/from system memory.
MA[12:0]	GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-SDR: See Table 2-10 on page 43.	O	**Memory Address Bus.** The multiplexed row/column address lines driven to the system memory. Supports 256-Mbit SDRAM.
BA0, BA1	AB23, AC25	O	**Bank Address Bits.** These bits are used to select the component bank within the SDRAM.
CS0#, CS1#, CS2#, CS3#	AD25, F26, B23, AF24	O	**Chip Selects.** The chip selects are used to select the module bank within the system memory. Each chip select corresponds to a specific module bank. If CS# is high, the bank(s) do not respond to RAS#, CAS#, or WE# until the bank is selected again.
RAS0#, RAS1#	G26, D26	O	**Row Address Strobe.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. RAS0# is used with CS0# and CS1#. RAS1# is used with CS2# and CS3#.
CAS0#, CAS1#	E26, A23	O	**Column Address Strobe.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. CAS0# is used with CS0# and CS1#. CAS1# is used with CS2# and CS3#.
WE0#, WE1#	F24, D23	O	**Write Enable.** RAS#, CAS#, WE#, and CKE are encoded to support the different SDRAM commands. WE0# is used with CS0# and CS1#. WE1# is used with CS2# and CS3#.
CKE0, CKE1	AE24, AF23	O	**Clock Enable.** For normal operation, CKE is held high. CKE goes low during Suspend. CKE0 is used with CS0# and CS1#. CKE1 is used with CS2# and CS3#.
DQM0, DQM1, DQM2, DQM3, DQM4, DQM5, DQM6, DQM7	M24, M25, R24, R25, N23, M26, R26, U23	O	**Data Mask Control Bits.** During memory read cycles, these outputs control whether the SDRAM output buffers are driven on the MD bus or not. All DQM signals are asserted during read cycles. During memory write cycles, these outputs control whether or not MD data is written into the SDRAM. DQM[0] is associated with MD[7:0]. DQM[7] is associated with MD[63:56].
SDCLK0, SDCLK1, SDCLK2, SDCLK3, SDCLK4, SDCLK5, SDCLK6, SDCLK7	AF17, AE17, AF20, AE20, Y26, Y25, U25, U26	O	**SDRAM Clocks.** The SDRAM devices sample all the control, address, and data based on these clocks.
SD_RD_IN_CLK	A20	I	**SDRAM Read In Clock.**

Signal Definitions (Continued)

2.2.3.2 GX2-SDR Interface Signals (Continued)

Signal Name	Ball No.	Type	Description
SD_RD_OUT_CLK	A17	O	**SDRAM Read Out Clock.**
MVREF	A14	AI	**Memory Voltage Reference.** This input operates at half the V_{MEM} voltage.
V_{MEM}	GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-SDR: See Table 2-10 on page 43.	PWR	**Memory Power Connection (Total of 20).**
NC	GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-SDR: See Table 2-10 on page 43.	---	**No Connection (GX2-SDR Only).** A line designated as NC must be left disconnected. Connecting an NC ball to a pull-up/down resistor, or an active signal could cause unexpected results and possible circuit malfunctions.

2.2.4 Display Interface

2.2.4.1 GX2-CRT Interface Signals

Signal Name	Ball No.	Type	Description
HSYNC	C2	O (PD)	**Horizontal Sync.** Horizontal Sync establishes the line rate and horizontal retrace interval for an attached CRT. The polarity is programmable.
VSYNC	C4	O (PD)	**Vertical Sync.** Vertical Sync establishes the screen refresh rate and vertical retrace interval for an attached CRT. The polarity is programmable.
DOTCLK	G1	O (PD)	**Dot Clock.** Output clock from DOTCLK PLL.
DOTREF	U1	I	**Dot Clock Reference.** Input clock for DOTCLK PLL.
DOT_AV_{DD}	A9	APWR	**Dot Clock PLL Analog Power Connection.** Connect to 3.3V. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
DOT_AV_{SS}	A10	AGND	**Dot Clock PLL Analog Ground Connection.** Connect to ground. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
DOT_V_{DD}	B11	PWR	**Dot Clock PLL Power Connection.** Connect to 3.3V. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
SETRES	C6	AO	**Video DAC Current Reference.** Connect this pin to a 464 Ω resistor.
VREF	B5	AI	**Video DAC Voltage Reference.** Connect this pin to a 1.235V voltage reference.
IOUTR (Video DAC)	B6	AO	**Red DAC Output.** Red analog output.
IOUTG (Video DAC)	B7	AO	**Green DAC Output.** Green analog output.
IOUTB (Video DAC)	B8	AO	**Blue DAC Output.** Blue analog output.
AV_{DD}	A6, A7, C8, C9	APWR	**Analog Power Connection.**
AV_{SS}	A5, A8, C7	AGND	**Analog Ground Connection.**

Signal Definitions (Continued)

2.2.4.2 GX2-FP Interface Signals

Signal Name	Ball No.	Type	Description
DRGB[23:0]	GX2-FP-DDR: See Table 2-8 on page 37. GX2-FP-SDR: See Table 2-10 on page 43.	O (PD)	**Display Data Bus.**
HSYNC	C2	O (PD)	**Horizontal Sync Input.** When the input data stream is in a horizontal blanking period, this input is asserted. It is a pulse used to synchronize display lines and to indicate when the pixel data stream is not valid due to blanking.
VSYNC	C4	O (PD)	**Flat Panel Vertical Sync Input.** When the input data stream is in a vertical blanking period, this input is asserted. It is a pulse used to synchronize display frames and to indicate when the pixel data stream is not valid due to blanking.
DOTCLK	G1	O (PD)	**Dot Clock. Output clock from DOTCLK PLL.**
DOTREF	U1	I	**Dot Clock Reference.** Input clock for DOTCLK PLL.
DOT_AV_{DD}	A9	APWR	**Dot Clock PLL Analog Power Connection.** Connect to 3.3V. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
DOT_AV_{SS}	A10	AGND	**Dot Clock PLL Analog Ground Connection.** Connect to ground. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
DOT_V_{DD}	B11	PWR	**Dot Clock PLL Power Connection.** Connect to 3.3V. See Figure 6-7 "Typical DOTPLL Connection Diagram" on page 398.
DISP_EN	C9	O (PD)	**Flat Panel Backlight Enable.**
FP_LDE_MOD	C8	O (PD)	**Flat Panel Display Enable (TFT Panels).**
FP_VCONEN	B8	O (PD)	**LCD Bias Voltage Enable Control.** When this output is asserted high, the contrast voltage is applied to the panel. This signal must be connected directly to the panel.
FP_VDDEN	A8	O (PD)	**LCD VDD FET Control.** When this output is asserted high, VDD voltage is applied to the panel. This signal is intended to control a power FET to the LCD panel. The FET may be internal to the panel or not, depending on the panel manufacturer.

Signal Definitions (Continued)

2.2.5 Power and Ground Signals (Note 1)

Signal Name	Ball No.	Type	Description
V_{CORE}	GX2-CRT-DDR: See Table 2-4 on page 25. GX2-CRT-SDR: See Table 2-6 on page 31. GX2-FP-DDR: See Table 2-8 on page 37 GX2-FP-SDR: See Table 2-10 on page 43.	PWR	**1.5V (Nominal) Core Power Connection (Total of 27).**
V_{IO}		PWR	**3.3V (Nominal) I/O Power Connection (Total of 17).**
V_{SS}		GND	**Ground Connection (Total of 75).**

Note 1. For module specific power and ground signals see:
Section 2.2.1 "System Interface Signals" on page 45
Section 2.2.3.1 "GX2-DDR Interface Signals" on page 48
Section 2.2.3.2 "GX2-SDR Interface Signals" on page 50
Section 2.2.4.1 "GX2-CRT Interface Signals" on page 51
Section 2.2.4.2 "GX2-FP Interface Signals" on page 52

2.2.6 Internal Test and Measurement Signals

Signal Name	Ball No.	Type	Description
TDP	N1	AI	**Thermal Diode Positive (TDP).** TDP is the positive terminal of the thermal diode on the die. The diode is used to do thermal characterization of the device in a system. This signal works in conjunction with TDN.
TDN	N3	AO	**Thermal Diode Negative (TDN).** TDN is the negative terminal of the thermal diode on the die. The diode is used to do thermal characterization of the device in a system. This signal works in conjunction with TDP.
TCLK	A12	I	**Test Clock.** JTAG test clock.
TMS	B9	I	**Test Mode Select.** JTAG test-mode select.
TDI	C12	I	**Test Data Input.** JTAG serial test-data input.
TDO	D13	O	**Test Data Output.** JTAG serial test-data output.
TDBGI	C11	I	**Test Debug Input.**
TDBGO	B12	O (PD)	**Test Debug Output.**

3.0 GeodeLink Interface Unit Functional Description

Many traditional architectures use buses to connect modules together, which usually require unique addressing for each register in every module. This requires that some kind of house-keeping be done as new modules are designed and new devices are created from the module set. Module select signals can be used to create the unique addresses but that can get cumbersome and it requires that the module selects be sourced from some centralized location.

To alleviate this issue, National developed an internal bus architecture called GeodeLink. The GeodeLink architecture connects the internal modules of a device using the data channels provided by GeodeLink Interface Units (GLIUs). Using GLIUs, all internal module port addresses are derived from the distinct channel that the module is connected to. In this way, a module's Model Specific Registers (MSRs) do not have unique addresses until a device is defined. Also, as defined by the GeodeLink architecture, a module's port address depends on the location of the module sourcing the cycle, or source module.

3.1 GX2 MSR SET

The GX2 processor incorporates two GLIUs into its device architecture. Except for the configuration registers that are required for x86 compatibility, all internal registers are accessed through a Model Specific Register (MSR) set. MSRs have a 32-bit address space and a 64-bit data space. The full 64-bit data space is always read or written when accessed.

An MSR can be read using the RDMSR instruction, opcode 0F32h. During an MSR read, the contents of the particular MSR, specified by the ECX register, is loaded into the EDX:EAX registers. An MSR can be written using the WRMSR instruction, opcode 0F30h. During an MSR write, the contents of EDX:EAX are loaded into the MSR specified in the ECX register. The RDMSR and WRMSR instructions are privileged instructions.

3.1.1 Port Address

Each GLIU has seven channels with Channel 0 being the GLIU itself and therefore not considered a physical channel. Figure 3-1 illustrates the GeodeLink architecture in a GX2 processor, showing how the modules are connected to the two GLIUs. GLIU0 has six channels connected, and GLIU1 has four channels connected. To get MSR address/data across the PCI bus, the GLPCI converts the MSR address into PCI cycles and back again.

An MSR address is parsed into two fields, the port address (18 bits) and the index (14 bits). The port address is further parsed into six 3-bit channel address fields. Each 3-bit field represents, from the perspective of the source module, the GLIU channels that are used to get to the destination module, starting from the closest GLIU to the source (left most 3-bit field) to the farthest GLIU (right most 3-bit field).

In a GX2/CS5535 system, the CS5535 I/O companion is connected to the GX2 via the PCI bus. The internal architecture of the CS5535 uses the same GeodeLink architecture with one GLIU being in that device. Hence, in a GX2/CS5535 system there are a total of three GLIUs: two in the GX2 and one in the CS5535. Therefore at most, only the two left most 3-bit fields of the base address field should be needed to access any module in the system. There are exceptions that require more; see Section 3.1.2 "Port Addressing Exceptions". For the CPU Core to access MSR Index 300h in the GeodeLink Control Processor module (GLCP), the address is 010_011_000_000_000_000b (six channel fields of the port address) + 300h (Index), or 4C000300h. The 010b points to Channel 2 of GLIU0, which is the channel connected to GLIU1. The 011b points to the GLIU1 Channel 3, which is the channel to the GeodeLink Control Processor (GLCP) module. From this point on, the the port address is abbreviated by noting each channel address followed by a dot. From the above example this is represented by 2.3.0.0.0.0. It is important to repeat here that the port address is derived from the perspective of the source module.

For a module to access an MSR within itself, the port address is zero.

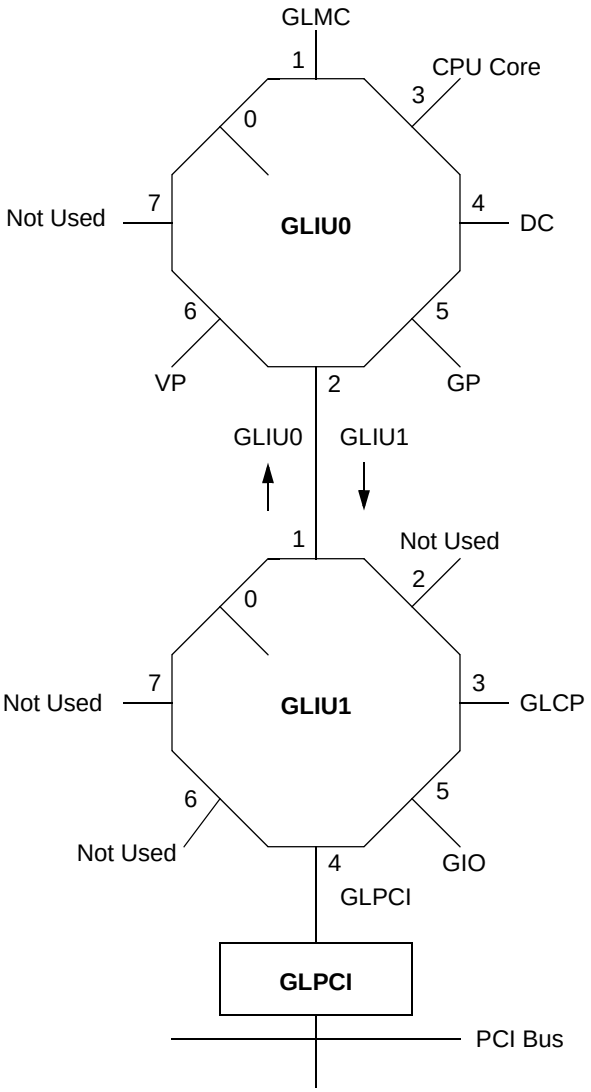


Figure 3-1. GX2 GeodeLink Architecture

GLIU Functional Description (Continued)

3.1.2 Port Addressing Exceptions

As in everything, there are some exceptions to the port addressing rules.

If a module accesses an MSR from within its closest GLIU (CPU Core accessing a GLIU0 MSR for example), then, by convention, the port address should be 0.0.0.0.0.0. But this port address access an MSR within the source module and not the GLIU as desired. To get around this, if the port address contains a 0 in the first channel field and then contains a 1 in any of the other channel fields, the access goes to the GLIU nearest the module sourcing the cycle. By convention, set the MSB of the second channel field, 0.4.0.0.0.0. If the MSR access is to a GLIU farther removed from the module sourcing the cycle, then there is no convention conflict, so no exception is required for that situation.

If a module attempts to access an MSR to the channel that it is connected to, a GLIU error results. This is called a reflective address attempt. An example of this case is the CPU Core accessing 3.0.0.0.0.0. Since the CPU Core is connected to Channel 3 of GLIU0, the access causes a reflective address error. This exception is continued to the next GLIU in the chain. The CPU Core accessing 2.1.0.0.0.0 also causes a reflective address error.

To access modules in the Geode CS5535 I/O companion, the port address must go through the GLPCI (PCI controller) in the GX2 and through the GLPCI in the CS5535. The port address of the MSRs in the GX2's GLPCI when accessed from the CPU Core is 2.4.0.0.0.0. To get the port address to go through the GLPCI, the third field needs a non-zero value. By convention, this is a 2. We now have a port address of 2.4.2.0.0.0. But this accesses the MSRs in the GLPCI in the CS5535, so we must add the channel to be accessed in the fourth field, 2.4.2.5.0.0, to access the AC97 audio bus master, for example.

To access the GLIU in the CS5535, the same addressing exception occurs as with GLIU0 due to the GLPCI's address. A port address of 2.4.2.0.0.0 accesses the CS5535's GLPCI, not the GLIU. To solve this, a non-zero value must be in at least one of the two right-most channel fields. By convention, a 4 in the left-most channel field is used. To access the CS5535's GLIU from the CPU Core, the port address is 2.4.2.0.0.4.

Table 3-1 shows the MSR port address to access all the modules in a GX2/CS5535 system with the CPU Core as the source module. Included in the table is the MSR port address for module access using the GLCP and GLPCI as the source module. However, under normal operating conditions, accessing MSRs is from the CPU Core. Therefore, all MSR addresses in the following chapters of this datasheet are documented using the CPU Core as the source.

Table 3-1. MSR Addressing

Destination	Source (Note 1)		
	CPU Core	GLCP	GLPCI
CPU Core	0000xxxxh	2C00xxxxh	2C00xxxxh
GLIU0	1000xxxxh	2000xxxxh	2000xxxxh
GLMC	2000xxxxh	2400xxxxh	2400xxxxh
GLIU1	4000xxxxh	1000xxxxh	1000xxxxh
GLCP	4C00xxxxh	0000xxxxh	6000xxxxh
GLPCI	5000xxxxh	8000xxxxh	0000xxxxh
GIO	5400xxxxh	A000xxxxh	A000xxxxh
DC	8000xxxxh	3000xxxxh	3000xxxxh
GP	A000xxxxh	3400xxxxh	3400xxxxh
VP	C000xxxxh	3800xxxxh	3800xxxxh
CS5535	51Y0xxxxh (Note 2)	8ZK0xxxxh (Note 3)	NA

Note 1. The xxxx contains the lower two bits of the 18 bits from the channel fields plus the 14-bit MSR offset.

Note 2. Y is the hex value obtained from one bit (always a 0) plus the channel number (#) of the six channel field addresses [0+#]. Example: # = 5, therefore the Y value is [0+101] which is 5h, thus the address = 5150xxxxh.

Note 3. ZK are the hex values obtained from the concatenation of [10+#+000], where # is the channel number from the six channel field address. Example # = 5, the ZK value is [10+101+000] which is [1010,1000]. In hex. it is A8h; thus the address is 8A80xxxxh.

3.1.3 Memory and I/O Mapping

The GLIU decodes the destination ID of memory requests using a series of physical to device (P2D) descriptors. There can be up to 32 descriptors in each GLIU. The GLIU decodes the destination ID of I/O requests using a series of I/O descriptors (IOD).

3.1.3.1 Memory Routing and Translation

Memory addresses are routed and optionally translated from physical space to device space. Physical space is the 32-bit memory address space that is shared between all GeodeLink devices. Device space is the unique address space within a given device. For example, a memory controller may implement a 4M frame buffer region in the 12-16M range of main memory. However, the 4M region may exist in the 4G region of physical space. The actual location of the frame buffer in the memory controller with respect to itself is a device address, while the address that all the devices see in the region of memory is in physical space.

GLIU Functional Description (Continued)

Memory request routing and translation is performed with a choice of six descriptor types. Each GLIU may have any number of each descriptor type up to a total of 32. The P2D descriptor types satisfy different needs for various software models.

Each memory request is compared against all the P2D descriptors. If the memory request does not hit in any of the descriptors, the request is sent to the subtractive port. If the memory requests hit more than one descriptor, the results are undefined. The software must provide a consistent non-overlapping address map.

The way each descriptor checks if the request address hits its descriptor and how to route the request address to the device address is described in Table 3-2.

P2D Base Mask Descriptor (P2D_BM)
P2D_BM is the simplest descriptor. It usually maps a power of two size aligned region of memory to a destination ID. P2D_BM performs no address translation.

P2D Base Mask Offset Descriptor (P2D_BMO)
P2D_BMO has the same routing features as P2D_BM with the addition of a 2s complement address translation to the most-significant bits of the address.

P2D Range Descriptor (P2D_R)
P2D_R maps a range of addresses to a device that is NOT power of 2 size aligned. There is no address translation (see Table 3-2).

P2D Range Offset Descriptor (P2D_RO)
P2D_RO has the same address routing as P2D_R with the addition of address translation with a 2s complement offset.

P2D Swiss Cheese Descriptor (P2D_SC)
The P2D_SC maps a 256 kB region of memory in 16 kB chunks to a device or the subtractive decode port. The descriptor type is useful for legacy address mapping. The Swiss cheese feature implies that the descriptor is used to "poke holes" in memory.

Note: Only one P2D can hit at a time for a given port. If the P2D descriptors are overlapping, the results are undefined.

Table 3-2. GLIU Memory Descriptor Address Hit and Routing Description

Descriptor	Function Description
P2D_BM, P2D_BMO	Checks that the physical address supplied by the device's request on address bits [31:12] with a logical AND with PMASK bits of the descriptor register bits [19:0] are equal to the PBASE bits on the descriptor register (bits [39:20]). Also checks that the BIZZARO bit of the request is equal to the PCMP_BIZ bit of the descriptor register bit [60]. If the above matches, then the descriptor has a hit condition and it routes the received address to the programmed destination PDID1 of the descriptor register (bits [63:61]). For P2D_BM: DEVICE_ADDR = request address For P2D_BMO: DEVICE_ADDR [31:12] = [request address [31:12] + descriptor POFFSET] DEVICE_ADDR [11:0] = request address [11:0]
P2D_R, P2D_RO	Checks that the physical address supplied by the device's request on address bits [31:12] are within the range specified by PMIN and PMASK field bits [39:20] and [19:0], respective of the descriptor register. PMIN is the minimum address range and PMAX is the maximum address range.The condition is: PMAX > physical address [31:12] > PMIN. Also checks that the BIZZARO bit of the request is equal to the PCMP_BIZ bit of the descriptor register bit [60]. If the above matches, then the descriptor has a hit condition and routes the received address to the programmed destination ID, PDID1 of the descriptor register (bits [63:61]). For P2D_R: DEVICE_ADDR = request address For P2D_RO: DEVICE_ADDR [31:12] = [request address [31:12] + descriptor POFFSET] DEVICE_ADDR [11:0] = request address [11:0]
P2D_SC	Checks that the physical address supplied by the device's request on address bits [31:18] are equal to the PBASE field of descriptor register bits [13:0] and that the enable write or read conditions given by the descriptor register fields WEN and REN in bits [47:32] and [31:16], respectively matches the request type and enable fields given on the physical address bits [17:14] of the device's request. If the above matches, then the descriptor has a hit condition and routes the received address to the programmed destination ID, PDID1 field of the descriptor register bits [63:61]. DEVICE_ADDR = request address

GLIU Functional Description (Continued)

3.1.3.2 I/O Routing and Translation

I/O addresses are routed and are never translated. I/O request routing is performed with a choice of two descriptor types. Each GLIU may have any number of each descriptor type. The IOD descriptor types satisfy different needs for various software models.

Each I/O request is compared against all the IOD descriptors. If the I/O request does not hit in any of the descriptors, the request is sent to the subtractive port. If the I/O request hits more than one descriptor, the results are undefined. Software must provide a consistent non-overlapping I/O address map. The methods of check and routing are described in Table 3-3.

IOD Base Mask Descriptors (IOD_BM)

IOD_BM is the simplest descriptor. It usually maps a power of two size aligned region of I/O to a destination ID.

IOD Swiss Cheese Descriptors (IOD_SC)

The IOD_SC maps an 8-byte region of memory in 1 byte chunks to one of two devices. The descriptor type is useful for legacy address mapping. The Swiss cheese feature implies that the descriptor is used to “poke holes” in I/O.

3.1.3.3 Special Cycles

PCI special cycles are performed using I/O writes and setting the BIZARRO flag in the write request. The BIZARRO flag is treated as an additional address bit, providing unaliased I/O address. The I/O descriptors are set up to route the special cycles to the appropriate device (i.e., GLCP, GLPCI, etc.). The I/O descriptors are configured to default to the appropriate device on reset. The PCI special cycles are mapped as:

Name	BIZZARO	Address
Shutdown	1	00000000h
Halt	1	00000001h
x86 specific	1	00000002h
0003h-FFFFh	1	00000002h-0000FFFFh

Table 3-3. GLIU I/O Descriptor Address Hit and Routing Description

Descriptor	Function Description
IOD_BM	Checks that the physical address supplied by the device on address bits [31:12] with a logic AND with PMASK bits of the register bits [19:0] are equal to the PBASE bits of the descriptor register bits [39:20]. Also checks that the BIZZARO bit of the request is equal to the PCMP_PIZ bit of the descriptor register bit [60]. If the above matches, then the descriptor has a hit condition and routes the received address to the programmed destination of the P2D_BM register bit [63:61]. DEVICE_ADDR = request address
IOD_SC	Checks that the physical address supplied by the device’s request on address bits [31:18] are equal to the PBASE field of descriptor register bits [13:0] and that the enable write or read conditions given by the descriptor register fields WEN and REN in bits [47:32] and [31:16], respectively matches the request type and enable fields given on the physical address bits [17:14] of the device’s request. If the above matches, then the descriptor has a hit condition and routes the received address to the programmed destination ID, PDID1 field of the descriptor register bits [63:61]. DEVICE_ADDR = request address

3.2 GLIU REGISTER DESCRIPTIONS

All GLIU registers are Model Specific Registers (MSRs) and are accessed through the RDMSR and WRMSR instructions.

The registers associated with the GLIU are the Standard GeodeLink Device MSRs, GLIU Specific MSRs, P2D Descriptor MSRs, and I/O Descriptor MSRs. The tables that follow are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

Reserved (RSVD) fields do not have any meaningful storage elements. They always return 0.

Table 3-4. GeodeLink Device Standard MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLIU0: 10002000h GLIU1: 40002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_000010xxh	Page 62
GLIU0: 10002001h GLIU1: 40002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)	GLIU0: 00000000_00000002h GLIU1: 00000000_00000004h	Page 62
GLIU0: 10002002h GLIU1: 40002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000001h	Page 63
GLIU0: 10002003h GLIU1: 40002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000001h	Page 64
GLIU0: 10002004h GLIU1: 40002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 67
GLIU0: 10002005h GLIU1: 40002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 68

Table 3-5. GLIU Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLIU0: 10000080h GLIU1: 40000080h	R/W	Coherency (COH)	00000000_00000000h	Page 68
GLIU0: 10000081h GLIU1: 40000081h	R/W	Port Active Enable (PAE)	Boot Strap Dependent	Page 69
GLIU0: 10000082h GLIU1: 40000082h	R/W	Arbitration (ARB)	00000000_00000000h	Page 70
GLIU0: 10000083h GLIU1: 40000083h	R/W	Asynchronous SMI (ASMI)	00000000_00000000h	Page 70
GLIU0: 10000084h GLIU1: 40000084h	R/W	Asynchronous ERR (AERR)	00000000_00000000h	Page 71
GLIU0: 10000085h GLIU1: 40000085h	R/W	Debug (DEBUG)	00000000_00000000h	Page 73
GLIU0: 10000086h GLIU1: 40000086h	RO	Physical Capabilities (PHY_CAP)	GLIU0: 22711830_010C1086h GLIU1: 22691830_01004009h	Page 73
GLIU0: 10000087h GLIU1: 40000087h	RO	Number of Outstanding Responses (NOUT_RESP)	00000000_00000000h	Page 74
GLIU0: 10000088h GLIU1: 40000088h	RO	Number of Outstanding Write Data (NOUT_WDATA)	00000000_00000000h	Page 74
GLIU0: 10000089h GLIU1: 40000089h	RO	SLAVE_ONLY	GLIU0: 00000000_00000002h GLIU1: 00000000_00000020h	Page 75
GLIU0: 1000008Ah GLIU1: 4000008Ah	RO	Reserved	---	---
GLIU0: 1000008Bh GLIU1: 4000008Bh	RO	WHO AM I (WHOAMI)	Master Dependent	Page 76

GLIU Register Descriptions (Continued)

Table 3-5. GLIU Specific MSRs Summary (Continued)

MSR Address	Type	Register	Reset Value	Reference
GLIU0: 1000008Ch GLIU1: 4000008Ch	R/W	Slave Disable (SLV_DIS)	00000000_00000000h	Page 76
GLIU0: 1000008Dh-1000008Fh GLIU1: 4000008Dh-4000008Fh	---	Reserved	---	---
GLIU0: 100000A0h GLIU1: 400000A0h	WO	Descriptor Statistic Counter (STATISTIC_CNT[0])	00000000_00000000h	Page 78
GLIU0: 100000A1h GLIU1: 400000A1h	R/W	Descriptor Statistic Mask (STATISTIC_MASK[0])	00000000_00000000h	Page 79
GLIU0: 100000A2h GLIU1: 400000A2h	R/W	Descriptor Statistic Action (STATISTIC_ACTION[0])	00000000_00000000h	Page 80
GLIU0: 100000A3h GLIU1: 400000A3h	---	Reserved	---	---
GLIU0: 100000A4h GLIU1: 400000A4h	WO	Descriptor Statistic Counter (STATISTIC_CNT[1])	00000000_00000000h	Page 78
GLIU0: 100000A5h GLIU1: 400000A5h	R/W	Descriptor Statistic Mask (STATISTIC_MASK[1])	00000000_00000000h	Page 79
GLIU0: 100000A6h GLIU1: 400000A6h	R/W	Descriptor Statistic Action (STATISTIC_ACTION[1])	00000000_00000000h	Page 80
GLIU0: 100000A7h GLIU1: 400000A7h	---	Reserved	---	---
GLIU0: 100000A8h GLIU1: 400000A8h	WO	Descriptor Statistic Counter (STATISTIC_CNT[2])	00000000_00000000h	Page 78
GLIU0: 100000A9h GLIU1: 400000A9h	R/W	Descriptor Statistic Mask (STATISTIC_MASK[2])	00000000_00000000h	Page 79
GLIU0: 100000AAh GLIU1: 400000AAh	R/W	Descriptor Statistic Action (STATISTIC_ACTION[2])	00000000_00000000h	Page 80
GLIU0: 100000ABh GLIU1: 400000ABh	---	Reserved	---	---
GLIU0: 100000ACh GLIU1: 400000ACh	WO	Descriptor Statistic Counter (STATISTIC_CNT[3])	00000000_00000000h	Page 78
GLIU0: 100000ADh GLIU1: 400000ADh	R/W	Descriptor Statistic Mask (STATISTIC_MASK[3])	00000000_00000000h	Page 79
GLIU0: 100000AEh GLIU1: 400000AEh	R/W	Descriptor Statistic Action (STATISTIC_ACTION[3])	00000000_00000000h	Page 80
GLIU0: 100000AFh-100000BFh GLIU1: 400000AFh-400000BFh	---	Reserved	---	---
GLIU0: 100000C0h GLIU1: 400000C0h	R/W	Request Compare Value (RQ_COMPARE_VAL[0])	001FFFFF_FFFFFFFFh	Page 81
GLIU0: 100000C1h GLIU1: 400000C1h	R/W	Request Compare Mask (RQ_COMPARE_MASK[0])	00000000_00000000h	Page 82
GLIU0: 100000C2h GLIU1: 400000C2h	R/W	Request Compare Value (RQ_COMPARE_VAL[1])	001FFFFF_FFFFFFFFh	Page 81
GLIU0: 100000C3h GLIU1: 400000C3h	R/W	Request Compare Mask (RQ_COMPARE_MASK[1])	00000000_00000000h	Page 82

GLIU Register Descriptions (Continued)

Table 3-5. GLIU Specific MSRs Summary (Continued)

MSR Address	Type	Register	Reset Value	Reference
GLIU0: 100000C4h GLIU1: 400000C4h	R/W	Request Compare Value (RQ_COMPARE_VAL[2])	001FFFFF_FFFFFFFFh	Page 81
GLIU0: 100000C5h GLIU1: 400000C5h	R/W	Request Compare Mask (RQ_COMPARE_MASK[2])	00000000_00000000h	Page 82
GLIU0: 100000C6h GLIU1: 400000C6h	R/W	Request Compare Value (RQ_COMPARE_VAL[3])	001FFFFF_FFFFFFFFh	Page 81
GLIU0: 100000C7h GLIU1: 400000C7h	R/W	Request Compare Mask (RQ_COMPARE_MASK[3])	00000000_00000000h	Page 82
GLIU0: 100000C8h-100000CFh GLIU1: 400000C8h-400000CFh	---	Reserved	---	---
GLIU0: 100000D0h GLIU1: 400000D0h	R/W	Data Compare Value Low (DA_COMPARE_VAL_LO[0])	00001FFF_FFFFFFFFh	Page 82
GLIU0: 100000D1h GLIU1: 400000D1h	R/W	Data Compare Value High (DA_COMPARE_VAL_HI[0])	0000000F_FFFFFFFFh	Page 83
GLIU0: 100000D2h GLIU1: 400000D2h	R/W	Data Compare Mask Low (DA_COMPARE_MASK_LO[0])	00000000_00000000h	Page 84
GLIU0: 100000D3h GLIU1: 400000D3h	R/W	Data Compare Mask High (DA_COMPARE_MASK_HI[0])	00000000_00000000h	Page 85
GLIU0: 100000D4h GLIU1: 400000D4h	R/W	Data Compare Value Low (DA_COMPARE_VAL_LO[1])	00001FFF_FFFFFFFFh	Page 82
GLIU0: 100000D5h GLIU1: 400000D5h	R/W	Data Compare Value High (DA_COMPARE_VAL_HI[1])	0000000F_FFFFFFFFh	Page 83
GLIU0: 100000D6h GLIU1: 400000D6h	R/W	Data Compare Mask Low (DA_COMPARE_MASK_LO[1])	00000000_00000000h	Page 84
GLIU0: 100000D7h GLIU1: 400000D7h	R/W	Data Compare Mask High (DA_COMPARE_MASK_HI[1])	00000000_00000000h	Page 85
GLIU0: 100000D8h GLIU1: 400000D8h	R/W	Data Compare Value Low (DA_COMPARE_VAL_LO[2])	00001FFF_FFFFFFFFh	Page 82
GLIU0: 100000D9h GLIU1: 400000D9h	R/W	Data Compare Value High (DA_COMPARE_VAL_HI[2])	0000000F_FFFFFFFFh	Page 83
GLIU0: 100000DAh GLIU1: 400000DAh	R/W	Data Compare Mask Low (DA_COMPARE_MASK_LO[2])	00000000_00000000h	Page 84
GLIU0: 100000DBh GLIU1: 400000DBh	R/W	Data Compare Mask High (DA_COMPARE_MASK_HI[2])	00000000_00000000h	Page 85
GLIU0: 100000DCh GLIU1: 400000DCh	R/W	Data Compare Value Low (DA_COMPARE_VAL_LO[3])	00001FFF_FFFFFFFFh	Page 82
GLIU0: 100000DDh GLIU1: 400000DDh	R/W	Data Compare Value High (DA_COMPARE_VAL_HI[3])	0000000F_FFFFFFFFh	Page 83
GLIU0: 100000DEh GLIU1: 400000DEh	R/W	Data Compare Mask Low (DA_COMPARE_MASK_LO[3])	00000000_00000000h	Page 84
GLIU0: 100000DFh GLIU1: 400000DFh	R/W	Data Compare Mask High (DA_COMPARE_MASK_HI[3])	00000000_00000000h	Page 85

GLIU Register Descriptions (Continued)

Table 3-6. GLIU P2D Descriptor MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLIU0				
10000020h-10000025h	R/W	P2D Base Mask Descriptor (P2D_BM): P2D_BM[0:5]	000000FF_FFF00000h	Page 85
10000026h-10000027h	R/W	P2D Base Mask Offset Descriptor (P2D_BMO): P2D_BMO[0:1]	00000FF0_FFF00000h	Page 86
10000028h	R/W	P2D Range Descriptor (P2D_R): P2D_R[0]	00000000_000FFFFFh	Page 87
10000029h-1000002Bh	R/W	P2D Range Offset Descriptor (P2D_RO): P2D_RO[0:2]	00000000_000FFFFFh	Page 87
1000002Ch	R/W	P2D Swiss Cheese Descriptor (P2D_SC): P2D_SC[0]	00000000_00000000h	Page 88
1000002Dh-1000003Fh	R/W	P2D Reserved Descriptors	---	---
GLIU1				
40000020h-40000028h	R/W	P2D Base Mask Descriptor (P2D_BM): P2D_BM[0:8]	000000FF_FFF00000h	Page 85
40000029h-4000002Ch	R/W	P2D Range Descriptor (P2D_R): P2D_R[0:3]	00000000_000FFFFFh	Page 87
4000002Dh	R/W	P2D Swiss Cheese Descriptor (P2D_SC): P2D_SC[0]	00000000_00000000h	Page 88
4000002Eh-4000003Fh	R/W	P2D Reserved Descriptor (P2D_RSVD)	00000000_00000000h	---

Table 3-7. GLIU IOD Descriptor MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLIU0				
100000E0h-100000E2h	R/W	IOD Base Mask Descriptors (IOD_BM): IOD_BM[0:3]	000000FF_FFF00000h	Page 89
100000E3h-100000E8h	R/W	IOD Swiss Cheese Descriptors (IOD_SC): IOD_SC[0:5]	00000000_00000000h	Page 90
100000E9h-100000FFh	R/W	IOD Reserved Descriptors	---	---
GLIU1				
400000E0h-400000E2h	R/W	IOD Base Mask Descriptors (IOD_BM): IOD_BM[0:3]	000000FF_FFF00000h	Page 89
400000E3h-400000E8h	R/W	IOD Swiss Cheese Descriptors (IOD_SC): IOD_SC[0:5]	00000000_00000000h	Page 90
400000E9h-400000FFh	R/W	IOD Reserved Descriptors	---	---

GLIU Register Descriptions (Continued)

Table 3-8. GLIU Reserved MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLIU0: 10002006h-1000200Fh GLIU1: 40002006h-4000200Fh	R/W	Reserved for future use by National.	00000000_00000000h	---
GLIU0: 10000040h-1000004Fh GLIU1: 40000040h-4000004Fh	R/W	Reserved for future use by National.	00000000_00000000h	---
GLIU0: 10000050h-1000007Fh GLIU1: 40000050h-4000007Fh	R/W	Reserved for future use by National.	00000000_00000000h	---

3.2.1 Standard GeodeLink Device MSRs

3.2.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address GLIU0: 10002000h
GLIU1: 40002000h
Type RO
Reset Value 00000000_000010xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved. Reads as 0.**
23:8	DEV_ID	**Device ID.** Identifies device (0010h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

3.2.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address GLIU0: 10002001h
GLIU1: 40002001h
Type R/W
Reset Value GLIU0: 00000000_00000002h
GLIU1: 00000000_00000004h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													SUBP		

GLIU Register Descriptions (Continued)

GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Returns 0.
2:0	SUBP	**Subtractive Port.** Subtractive port assignment for all negative decode requests. 000: Port 0 = GLIU0: GLIU — GLIU1: GLIU 001: Port 1 = GLIU0: GLMC — GLIU1: Interface to GLIU0 010: Port 2 = GLIU0: Interface to GLIU1 — GLIU1: Not Used 011: Port 3 = GLIU0: CPU Core — GLIU1: GLCP 100: Port 4 = GLIU0: DC — GLIU1: GLPCI 101: Port 5 = GLIU0: GP — GLIU1: GIO 110: Port 6 = GLIU0: VP — GLIU1: Not Used 111: Port 7 = GLIU0: Not Used — GLIU1: Not Used

3.2.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address GLIU0: 10002002h
GLIU1: 40002002h
Type R/W
Reset Value 00000000_00000001h

The flags are set with internal conditions. The internal conditions are enabled if the corresponding EN bit is 0. If EN is 1, the condition does not set the flag. Reading the FLAG bit returns the value; writing 1 clears the FLAG; writing 0 has no effect.

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																											STATCNT3_ASMI_FLAG	STATCNT2_ASMI_FLAG	STATCNT1_ASMI_FLAG	STATCNT0_ASMI_FLAG	SSMI_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																											STATCNT3_ASMI_EN	STATCNT2_ASMI_EN	STATCNT1_ASMI_EN	STATCNT0_ASMI_EN	SSMI_EN

GLD_MSR_SMI Bit Descriptions

Bit	Name	Description
63:37	RSVD	**Reserved.** Write as read.
36	STATCNT3_ ASMI_FLAG	**Statistic Counter 3 ASMI Flag.** If high, records that an ASMI was generated due to a Statistic Counter 3 (GLIU0 MSR 100000ACh, GLIU1 MSR 400000ACh) event. Write 1 to clear; writing 0 has no effect. STATCNT3_ASMI_EN (bit 4) must be low to generate ASMI and set flag.

GLIU Register Descriptions (Continued)

GLD_MSR_SMI Bit Descriptions (Continued)

Bit	Name	Description
35	STATCNT2_ ASMI_FLAG	**Statistic Counter 2 ASMI Flag.** If high, records that an ASMI was generated due to a Statistic Counter 2 (GLIU0 MSR 100000A8h, GLIU1 MSR 400000A8h) event. Write 1 to clear; writing 0 has no effect. STATCNT2_ASMI_EN (bit 3) must be low to generate ASMI and set flag.
34	STATCNT1_ ASMI_FLAG	**Statistic Counter 1 ASMI Flag.** If high, records that an ASMI was generated due to a Statistic Counter 1 (GLIU0 MSR 100000A4h, GLIU1 MSR 400000A4h) event. Write 1 to clear; writing 0 has no effect. STATCNT1_ASMI_EN (bit 2) must be low to generate ASMI and set flag.
33	STATCNT0_ ASMI_FLAG	**Statistic Counter 0 ASMI Flag.** If high, records that an ASMI was generated due to a Statistic Counter 0 (GLIU0 MSR 100000A0h, GLIU1 MSR 400000A0h) event. Write 1 to clear; writing 0 has no effect. STATCNT0_ASMI_EN (bit 1) must be low to generate ASMI and set flag.
32	SSMI_FLAG	**SSMI Flag.** If high, records that an SSMI was generated due to a received event. Event sources are: • Illegal request type to GLIU (Port 0), meaning anything other than MSR read/write, debug request, and null. • A self-referencing packet (i.e., a packet sent to the GLIU that finds its destination port is the source port). • The destination of the packet is to a port where the GLIU slave for that port has been disabled. • Trap on a descriptor with device port set to 0. This is the typical operational use of this bit. The data returned with such a trap is the value 0. Write 1 to clear; writing 0 has no effect. SSMI_EN (bit 0) must be low to generate SSMI and set flag.
31:5	RSVD	**Reserved.** Write as read.
4	STATCNT3_ ASMI_EN	**Statistic Counter 3 ASMI Enable.** Write 0 to enable STATCNT3_ASMI_FLAG (bit 36) and to allow a Statistic Counter 3 (GLIU0 MSR 100000ACh, GLIU1 MSR 400000ACh) event to generate an ASMI.
3	STATCNT2_ ASMI_EN	**Statistic Counter 2 ASMI Enable.** Write 0 to enable STATCNT2_ASMI_FLAG (bit 35) and to allow a Statistic Counter 2 (GLIU0 MSR 100000A8h, GLIU1 MSR 400000A8h) event to generate an ASMI.
2	STATCNT1_ ASMI_EN	**Statistic Counter 1 ASMI Enable.** Write 0 to enable STATCNT1_ASMI_FLAG (bit 34) and to allow a Statistic Counter 1 (GLIU0 MSR 100000A4h, GLIU1 MSR 400000A4h) event to generate an ASMI.
1	STATCNT0_ ASMI_EN	**Statistic Counter 0 ASMI Enable.** Write 0 to enable STATCNT0_ASMI_FLAG (bit 33) and to allow a Statistic Counter 0 (GLIU0 MSR 100000A0h, GLIU1 MSR 400000A0h) event to generate an ASMI.
0	SSMI_EN	**SSMI Enable.** Write 0 to enable SSMI_FLAG (bit 32) and to allow a received SSMI event to generate an SSMI. (See bit 32 description for SSMI event sources.)

3.2.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address GLIU0: 10002003h
GLIU1: 40002003h
Type R/W
Reset Value 00000000_00000001h

The flags are set with internal conditions. The internal conditions are enabled if the corresponding EN bit is 0. If EN is 1, the condition does not set the flag. Reading the FLAG bit returns the value; writing 1 clears the FLAG; writing 0 has no effect.

GLIU Register Descriptions (Continued)

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																	DACOMP3_ERR_FLAG	DACOMP2_ERR_FLAG	DACOMP1_ERR_FLAG	DACOMP0_ERR_FLAG	RQCOMP3_ERR_FLAG	RQCOMP2_ERR_FLAG	RQCOMP1_ERR_FLAG	RQCOMP0_ERR_FLAG	STATCNT3_ERR_FLAG	STATCNT2_ERR_FLAG	STATCNT1_ERR_FLAG	STATCNT0_ERR_FLAG	SSMI_ERR_FLAG	UNEXP_ADDR_ERR_FLAG	UNEXP_TYPE_ERR_FLAG
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
RSVD																	DACOMP3_ERR_EN	DACOMP2_ERR_EN	DACOMP1_ERR_EN	DACOMP0_ERR_EN	RQCOMP3_ERR_EN	RQCOMP2_ERR_EN	RQCOMP1_ERR_EN	RQCOMP0_ERR_EN	STATCNT3_ERR_EN	STATCNT2_ERR_EN	STATCNT1_ERR_EN	STATCNT0_ERR_EN	SSMI_ERR_EN	UNEXP_ADDR_ERR_EN	UNEXP_TYPE_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:47	RSVD	**Reserved.** Write as read.
46	DACOMP3_ ERR_FLAG	**Data Comparator 3 Error Flag.** If high, records that an ERR was generated due to a Data Comparator 3 (DA_COMPARE_VAL_LO0/DA_COMPARE_VAL_HI0, GLIU0 MSR 100000DCh/100000DDh, GLIU1 MSR 400000DCh/400000DDh) event. Write 1 to clear; writing 0 has no effect. DACOMP3_ERR_EN (bit 14) must be low to generate ERR and set flag.
45	DACOMP2_ ERR_FLAG	**Data Comparator 2 Error Flag.** If high, records that an ERR was generated due to a Data Comparator 2 (DA_COMPARE_VAL_LO2/DA_COMPARE_VAL_HI2, GLIU0 MSR 100000D8h/100000D9h, GLIU1 MSR 400000D8h/400000D9h) event. Write 1 to clear; writing 0 has no effect. DACOMP2_ERR_EN (bit 13) must be low to generate ERR and set flag.
44	DACOMP1_ ERR_FLAG	**Data Comparator 1 Error Flag.** If high, records that an ERR was generated due to a Data Comparator 1 (DA_COMPARE_VAL_LO1/DA_COMPARE_VAL_HI1, GLIU0 MSR 100000D4h/100000D5h, GLIU1 MSR 400000D4h/400000D5h) event. Write 1 to clear; writing 0 has no effect. DACOMP1_ERR_EN (bit 12) must be low to generate ERR and set flag.
43	DACOMP0_ ERR_FLAG	**Data Comparator 0 Error Flag.** If high, records that an ERR was generated due to a Data Comparator 0 (DA_COMPARE_VAL_LO0/DA_COMPARE_VAL_HI0, GLIU0 MSR 100000D0h/100000D1h, GLIU1 MSR 400000D0h/400000D1h) event. Write 1 to clear; writing 0 has no effect. DACOMP0_ERR_EN (bit 11) must be low to generate ERR and set flag.
42	RQCOMP3_ ERR_FLAG	**Request Comparator 3 Error Flag.** If high, records that an ERR was generated due to a Request Comparator 3 (RQ_COMPARE_VAL3, GLIU0 MSR 100000C6h, GLIU1 MSR 400000C6h) event. Write 1 to clear; writing 0 has no effect. RQCOMP3_ERR_EN (bit 10) must be low to generate ERR and set flag.
41	RQCOMP2_ ERR_FLAG	**Request Comparator 2 Error Flag.** If high, records that an ERR was generated due to a Request Comparator 2 (RQ_COMPARE_VAL2, GLIU0 MSR 100000C4h, GLIU1 MSR 400000C4h) event. Write 1 to clear; writing 0 has no effect. RQCOMP2_ERR_EN (bit 9) must be low to generate ERR and set flag.

GLIU Register Descriptions (Continued)

GLD_MSR_ERROR Bit Descriptions (Continued)

Bit	Name	Description
40	RQCOMP1_ ERR_FLAG	**Request Comparator 1 Error Flag.** If high, records that an ERR was generated due to a Request Comparator 1 (RQ_COMPARE_VAL1, GLIU0 MSR 100000C2h, GLIU1 MSR 400000C2h) event. Write 1 to clear; writing 0 has no effect. RQCOMP1_ERR_EN (bit 8) must be low to generate ERR and set flag.
39	RQCOMP0_ ERR_FLAG	**Request Comparator 0 Error Flag.** If high, records that an ERR was generated due to a Request Comparator 0 (RQ_COMPARE_VAL0, GLIU0 MSR 100000C0h, GLIU1 MSR 400000C0h) event. Write 1 to clear; writing 0 has no effect. RQCOMP0_ERR_EN (bit 7) must be low to generate ERR and set flag.
38	STATCNT3_ ERR_FLAG	**Statistic Counter 3 Error Flag.** If high, records that an ERR was generated due to a Statistic Counter 3 (GLIU0 MSR 100000ACh, GLIU1 MSR 400000ACh) event. Write 1 to clear; writing 0 has no effect. STATCNT3_ERR_EN (bit 6) must be low to generate ERR and set flag.
37	STATCNT2_ ERR_FLAG	**Statistic Counter 2 Error Flag.** If high, records that an ERR was generated due to a Statistic Counter 2 (GLIU0 MSR 100000A8h, GLIU1 MSR 400000A8h) event. Write 1 to clear; writing 0 has no effect. STATCNT2_ERR_EN (bit 5) must be low to generate ERR and set flag.
36	STATCNT1_ ERR_FLAG	**Statistic Counter 1 Error Flag.** If high, records that an ERR was generated due to a Statistic Counter 1 (GLIU0 MSR 100000A4h, GLIU1 MSR 400000A4h) event. Write 1 to clear; writing 0 has no effect. STATCNT1_ERR_EN (bit 4) must be low to generate ERR and set flag.
35	STATCNT0_ ERR_FLAG	**Statistic Counter 0 Error Flag.** If high, records that an ERR was generated due to a Statistic Counter 0 (GLIU0 MSR 100000A0h, GLIU1 MSR 400000A0h) event. Write 1 to clear; writing 0 has no effect. STATCNT0_ERR_EN (bit 3) must be low to generate ERR and set flag.
34	SSMI_ERR_ FLAG	**SSMI Error Flag.** If high, records that an ERR was generated due an unhandled SSMI (synchronous error). Write 1 to clear; writing 0 has no effect. SSMI_ERR_EN (bit 2) must be low to generate ERR and set flag.
33	UNEXP_ADDR_ ERR_FLAG	**Unexpected Address Error Flag.** If high, records that an ERR was generated due an unexpected address (synchronous error). Write 1 to clear; writing 0 has no effect. UNEXP_ADD_ERR_EN (bit 1) must be low to generate ERR and set flag.
32	UNEXP_TYPE_ ERR_FLAG	**Unexpected Type Error Flag.** If high, records that an ERR was generated due an unexpected type (synchronous error). Write 1 to clear; writing 0 has no effect. UNEXP_TYPE_ERR_EN (bit 0) must be low to generate ERR and set flag.
31:15	RSVD	**Reserved.** Write as read.
14	DACOMP3_ ERR_EN	**Data Comparator 3 Error Enable.** Write 0 to enable DACOMP3_ERR_FLAG (bit 46) and to allow a Data Comparator 3 (DA_COMPARE_VAL_LO3/DA_COMPARE_VAL_HI3, GLIU0 MSR 100000DCh/100000DDh, GLIU1 MSR 400000DCh/400000DDh) event to generate an ERR and set flag.
13	DACOMP2_ ERR_EN	**Data Comparator 2 Error Enable.** Write 0 to enable DACOMP2_ERR_FLAG (bit 45) and to allow a Data Comparator 2 (DA_COMPARE_VAL_LO2/DA_COMPARE_VAL_HI2, GLIU0 MSR 100000D8h/100000D9h, GLIU1 MSR 400000D8h/400000D9h) event to generate an ERR and set flag.
12	DACOMP1_ ERR_EN	**Data Comparator 1 Error Enable.** Write 0 to enable DACOMP1_ERR_FLAG (bit 44) and to allow a Data Comparator 1 (DA_COMPARE_VAL_LO1/DA_COMPARE_VAL_HI1, GLIU0 MSR 100000D4h/100000D5h, GLIU1 MSR 400000D4h/400000D5h) event to generate an ERR and set flag.
11	DACOMP0_ ERR_EN	**Data Comparator 0 Error Enable.** Write 0 to enable DACOMP0_ERR_FLAG (bit 43) and to allow a Data Comparator 0 (DA_COMPARE_VAL_LO0/DA_COMPARE_VAL_HI0, GLIU0 MSR 100000D4h/100000D5h, GLIU1 MSR 400000D4h/400000D5h) event to generate an ERR and set flag.

GLIU Register Descriptions (Continued)

GLD_MSR_ERROR Bit Descriptions (Continued)

Bit	Name	Description
10	RQCOMP3_ ERR_EN	**Request Comparator 3 Error Enable.** Write 0 to enable RQCOMP3_ERR_FLAG (bit 42) and to allow a Request Comparator 3 (RQ_COMPARE_VAL3, GLIU0 MSR 100000C6h, GLIU1 MSR 400000C6h) event to generate an ERR.
9	RQCOMP2_ ERR_EN	**Request Comparator 2 Error Enable.** Write 0 to enable RQCOMP2_ERR_FLAG (bit 41) and to allow a Request Comparator 2 (RQ_COMPARE_VAL2, GLIU0 MSR 100000C4h, GLIU1 MSR 400000C4h) event to generate an ERR.
8	RQCOMP1_ ERR_EN	**Request Comparator 1 Error Enable.** Write 0 to enable RQCOMP1_ERR_FLAG (bit 40) and to allow a Request Comparator 1 (RQ_COMPARE_VAL1, GLIU0 MSR 100000C2h, GLIU1 MSR 400000C2h) event to generate an ERR.
7	RQCOMP0_ ERR_EN	**Request Comparator 0 Error Enable.** Write 0 to enable RQCOMP0_ERR_FLAG (bit 39) and to allow a Request Comparator 0 (RQ_COMPARE_VAL0, GLIU0 MSR 100000C0h, GLIU1 MSR 400000C0h) event to generate an ERR.
6	STATCNT3_ ERR_EN	**Statistic Counter 3 Error Enable.** Write 0 to enable STATCNT3_ERR_FLAG (bit 38) and to allow a Statistic Counter 3 (GLIU0 MSR 100000ACh, GLIU1 MSR 400000ACh) event to generate an ERR.
5	STATCNT2_ ERR_EN	**Statistic Counter 2 Error Enable.** Write 0 to enable STATCNT2_ERR_FLAG (bit 37) and to allow a Statistic Counter 2 (GLIU0 MSR 100000A8h, GLIU1 MSR 400000A8h) event to generate an ERR.
4	STATCNT1_ ERR_EN	**Statistic Counter 1 Error Enable.** Write 0 to enable STATCNT1_ERR_FLAG (bit 36) and to allow a Statistic Counter 1 (GLIU0 MSR 100000A4h, GLIU1 MSR 400000A4h) event to generate an ERR.
3	STATCNT0_ ERR_EN	**Statistic Counter 0 Error Enable.** Write 0 to enable STATCNT0_ERR_FLAG (bit 35) and to allow a Statistic Counter 0 (GLIU0 MSR 100000A0h, GLIU1 MSR 400000A0h) event to generate an ERR.
2	SSMI_ERR_ EN	**SSMI Error Enable.** Write 0 to enable SSMI_ERR_FLAG (bit 34) and to allow the unhandled SSMI (synchronous error) event to generate an ERR.
1	UNEXP_ADDR_ ERR_EN	**Unexpected Address Error Enable.** Write 0 to enable UNEXP_ADD_ERR_FLAG (bit 33) and to allow the unexpected address (synchronous error) event to generate an ERR.
0	UNEXP_TYPE_ ERR_EN	**Unexpected Type Error Enable.** Write 0 to enable UNEXP_TYPE_ERR_FLAG (bit 33) and to allow the unexpected type (synchronous error) event to generate an ERR.

3.2.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address GLIU0: 10002004h
GLIU1: 40002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																												PMODE1		PMODE0	

GLIU Register Descriptions (Continued)

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:34	RSVD	**Reserved.** Write as read.
33:32	RSVD	**Reserved.** Write as 0.
31:4	RSVD	**Reserved.** Write as read.
3:2	PMODE1	**Power Mode 1.** Statistics and Time Slice Counters. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
1:0	PMODE0	**Power Mode 0.** Online GLIU logic. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

3.2.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address GLIU0: 10002005h
GLIU1: 40002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

3.2.2 GLIU Specific MSRs

3.2.2.1 Coherency (COH)

MSR Address GLIU0: 10000080h
GLIU1: 40000080h
Type R/W
Reset Value 00000000_00000000h

COH Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													COHP		

COH Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.

GLIU Register Descriptions (Continued)

COH Bit Descriptions (Continued)

Bit	Name	Description
2:0	COHP	**Coherent Device Port.** The port that coherents snoops are routed to. If the coherent device on the other side of a bridge, the COHP points to the bridge. 000: Port 0 = GLIU0: GLIU — GLIU1: GLIU 001: Port 1 = GLIU0: GLMC — GLIU1: Interface to GLIU0 010: Port 2 = GLIU0: Interface to GLIU1 — GLIU1: Not Used 011: Port 3 = GLIU0: CPU Core — GLIU1: GLCP 100: Port 4 = GLIU0: DC — GLIU1: GLPCI 101: Port 5 = GLIU0: GP — GLIU1: GIO 110: Port 6 = GLIU0: VP — GLIU1: Not Used 111: Port 7 = GLIU0: Not Used — GLIU1: Not Used

3.2.2.2 Port Active Enable (PAE)

MSR Address GLIU0: 10000081h
GLIU1: 40000081h
Type R/W
Reset Value Boot Strap Dependent

Ports that are not implemented return 0 (RSVD). Ports that are slave only return 11. (See Section 3.2.2.10 "SLAVE_ONLY" on page 75 for slave only port status.) Master/slave ports return the values as stated.

PAE Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																P0_ PAE		P7_ PAE		P6_ PAE		P5_ PAE		P4_ PAE		P3_ PAE		P2_ PAE		P1_ PAE	

PAE Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:14	P0_PAE	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Port Active Enable.** 00: OFF - Master transactions are disabled. 01: LOW - Master transactions limited to one outstanding transaction. 10: Reserved. 11: ON - Master transactions enabled with no limitations.
13:12	P7_PAE	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Port Active Enable.** See bits [15:14] for decode.
11:10	P6_PAE	**Port 6 (GLIU0: VP; GLIU1: Not Used) Port Active Enable.** See bits [15:14] for decode.
9:8	P5_PAE	**Port 5 (GLIU0: GP; GLIU1: GIO) Port Active Enable.** See bits [15:14] for decode.
7:6	P4_PAE	**Port 4 GLIU0: DC; GLIU1: GLPCI) Port Active Enable.** See bits [15:14] for decode.
5:4	P3_PAE	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Port Active Enable.** See bits [15:14] for decode.
3:2	P2_PAE	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Port Active Enable.** See bits [15:14] for decode.
1:0	P1_PAE	**Port 1 (GLIU0: GLMC; GLIU1: GLIU1: Not Used) Port Active Enable.** See bits [15:14] for decode.

GLIU Register Descriptions (Continued)

3.2.2.3 Arbitration (ARB)

MSR Address GLIU0: 10000082h
GLIU1: 40000082h
Type R/W
Reset Value 00000000_00000000h

ARB Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD	PIPE_DIS	RSVD																													
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

ARB Bit Descriptions

Bit	Name	Description
63	RSVD	**Reserved**. Write as read.
62	PIPE_DIS	**Pipelined Arbitration Disabled.** 0: Pipelined arbitration enabled and the GLIU is not limited to one outstanding transaction. 1: Limit the entire GLIU to one outstanding transaction.
61:0	RSVD	**Reserved**. Write as read.

3.2.2.4 Asynchronous SMI (ASMI)

MSR Address GLIU0: 10000083h
GLIU1: 40000083h
Type R/W
Reset Value 00000000_00000000h

ASMI is a condensed version of the Port ASMI signals. The EN bits ([15:8]) can be used to prevent a device from issuing an ASMI. A write of 1 to the EN bit disables the device's ASMI. The FLAG bits ([7:0]) are status bits; if 1, an ASMI was generated due to the associated device.

ASMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																P7_ASMI_EN	P6_ASMI_EN	P5_ASMI_EN	P4_ASMI_EN	P3_ASMI_EN	P2_ASMI_EN	P1_ASMI_EN	P0_ASMI_EN	P7_ASMI_FLAG	P6_ASMI_FLAG	P5_ASMI_FLAG	P4_ASMI_FLAG	P3_ASMI_FLAG	P2_ASMI_FLAG	P1_ASMI_FLAG	P0_ASMI_FLAG

ASMI Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15	P7_ASMI_EN	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Asynchronous SMI Enable.** Write 0 to allow Port 7 to generate an ASMI. ASMI status is reported in bit 7.

GLIU Register Descriptions (Continued)

ASMI Bit Descriptions (Continued)

Bit	Name	Description
14	P6_ASMI_EN	**Port 6 (GLIU0: VP; GLIU1: Not Used) Asynchronous SMI Enable.** Write 0 to allow Port 6 to generate an ASMI. ASMI status is reported in bit 6.
13	P5_ASMI_EN	**Port 5 (GLIU0: GP; GLIU1: GIO) Asynchronous SMI Enable.** Write 0 to allow Port 5 to generate an ASMI. ASMI status is reported in bit 5.
12	P4_ASMI_EN	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Asynchronous SMI Enable.** Write 0 to allow Port 4 to generate an ASMI. ASMI status is reported in bit 4.
11	P3_ASMI_EN	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Asynchronous SMI Enable.** Write 0 to allow Port 3 to generate an ASMI. ASMI status is reported in bit 3.
10	P2_ASMI_EN	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Asynchronous SMI Enable.** Write 0 to allow Port 2 to generate an ASMI. ASMI status is reported in bit 2.
9	P1_ASMI_EN	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Asynchronous SMI Enable.** Write 0 to allow Port 1 to generate an ASMI. ASMI status is reported in bit 1.
8	P0_ASMI_EN	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Asynchronous SMI Enable.** Write 0 to allow Port 5 to generate an ASMI. ASMI status is reported in bit 0.
7	P7_ASMI_FLAG (RO)	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 0. Cleared by source.
6	P6_ASMI_FLAG (RO)	**Port 6 (GLIU0: VP; GLIU1: Not Used) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 0. Cleared by source.
5	P5_ASMI_FLAG (RO)	**Port 5 (GLIU0: GP; GLIU1: GIO) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 5. Cleared by source.
4	P4_ASMI_FLAG (RO)	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 4. Cleared by source.
3	P3_ASMI_FLAG (RO)	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 3. Cleared by source.
2	P2_ASMI_FLAG (RO)	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 2. Cleared by source.
1	P1_ASMI_FLAG (RO)	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 1. Cleared by source.
0	P0_ASMI_FLAG (RO)	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Asynchronous SMI Flag (Read Only).** If 1, indicates that an ASMI was generated by Port 1. Cleared by source.

3.2.2.5 Asynchronous ERR (AERR)

MSR Address GLIU0: 10000084h
GLIU1: 40000084h
Type R/W
Reset Value 00000000_00000000h

ERR is a condensed version of the port (asynchronous) ERR signals. The EN bits ([15:8]) can be used to prevent a device from issuing an ERR. A write of 1 to the EN bit disables the device's ERR. The FLAG bits ([7:0]) are status bits. If high, an ERR was generated due to the associated device.

GLIU Register Descriptions (Continued)

AERR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																P7_AERR_EN	P6_AERR_EN	P5_AERR_EN	P4_AERR_EN	P3_AERR_EN	P2_AERR_EN	P1_AERR_EN	P0_AERR_EN	P7_AERR_FLAG	P6_AERR_FLAG	P5_AERR_FLAG	P4_AERR_FLAG	P3_AERR_FLAG	P2_AERR_FLAG	P1_AERR_FLAG	P0_AERR_FLAG

AERR Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved**
15	P7_AERR_EN	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Asynchronous Error Enable.** Write 0 to allow Port 7 to generate an AERR. AERR status is reported in bit 7.
14	P6_AERR_EN	**Port 6 (GLIU0: VP; GLIU1: Not Used) Asynchronous Error Enable.** Write 0 to allow Port 6 to generate an AERR. AERR status is reported in bit 6.
13	P5_AERR_EN	**Port 5 (GLIU0: GP; GLIU1: GIO) Asynchronous Error Enable.** Write 0 to allow Port 5 to generate an AERR. AERR status is reported in bit 5.
12	P4_AERR_EN	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Asynchronous Error Enable.** Write 0 to allow Port 4 to generate an AERR. AERR status is reported in bit 4.
11	P3_AERR_EN	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Asynchronous Error Enable.** Write 0 to allow Port 3 to generate an AERR. AERR status is reported in bit 3.
10	P2_AERR_EN	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Asynchronous Error Enable.** Write 0 to allow Port 2 to generate an AERR. AERR status is reported in bit 2.
9	P1_AERR_EN	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Asynchronous Error Enable.** Write 0 to allow Port 1 to generate an AERR. AERR status is reported in bit 1.
8	P0_AERR_EN	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Asynchronous Error Enable.** Write 0 to allow Port 0 to generate an AERR. AERR status is reported in bit 0.
7	P7_AERR_FLAG (RO)	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Asynchronous Error Flag.** If 1, indicates that an AERR was generated by Port 7. Cleared by source.
6	P6_AERR_FLAG (RO)	**Port 6 (GLIU0: VP; GLIU1: Not Used) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 6. Cleared by source.
5	P5_AERR_FLAG (RO)	**Port 5 (GLIU0: GP; GLIU1: GIO) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 5. Cleared by source.
4	P4_AERR_FLAG (RO)	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 4. Cleared by source.
3	P3_AERR_FLAG (RO)	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 3. Cleared by source.
2	P2_AERR_FLAG (RO)	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 2. Cleared by source.
1	P1_AERR_FLAG (RO)	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 1. Cleared by source.
0	P0_AERR_FLAG (RO)	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Asynchronous Error Flag (Read Only).** If 1, indicates that an AERR was generated by Port 0. Cleared by source.

GLIU Register Descriptions (Continued)

3.2.2.6 Debug (DEBUG)

MSR Address GLIU0: 10000085h
GLIU1: 40000085h
Type R/W
Reset Value 00000000_00000000h

DEBUG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

DEBUG Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** Write as read.

3.2.2.7 Physical Capabilities (PHY_CAP)

MSR Address GLIU0: 10000086h
GLIU1: 40000086h
Type RO
Reset Value GLIU0: 22711830_010C1086h
GLIU1: 22691830_01004009h

PHY_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD	NSTAT_CNT			NDBG_DA_CMP			NDBG_RQ_CMP			NPORTS			NCOH			NIOD_SC						NIOD_BM						NP2D_BMK			
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NP2D_BMK	NP2D_SC						NP2D_RO						NP2D_R							NP2D_BMO						NP2D_BM					

PHY_CAP Bit Descriptions

Bit	Name	Description
63	RSVD	**Reserved.** Write as read.
62:60	NSTAT_CNT	**Number of Statistic Counters.**
59:57	NDBG_DA_CMP	**Number of Data Comparators.**
56:54	NDBG_RQ_CMP	**Number of Request Comparators.**
53:51	NPORTS	**Number of +Ports on the GLIU.**
50:48	NCOH	**Number of Coherent Devices.**
47:42	NIOD_SC	**Number of IOD_SC Descriptors.**
41:36	NIOD_BM	**Number of IOD_BM Descriptors.**
35:30	NP2D_BMK	**Number of P2D_BMK Descriptors.**
29:24	NP2D_SC	**Number of P2D_SC Descriptors.**
23:18	NP2D_RO	**Number of P2D_RO Descriptors.**
17:12	NP2D_R	**Number of P2D_R Descriptors.**

GLIU Register Descriptions (Continued)

PHY_CAP Bit Descriptions (Continued)

Bit	Name	Description
11:6	NP2D_BMO	**Number of P2D_BMO Descriptors.**
5:0	NP2D_BM	**Number of P2D_BM Descriptors.**

3.2.2.8 Number of Outstanding Responses (NOUT_RESP)

MSR Address GLIU0: 10000087h
GLIU1: 40000087h
Type RO
Reset Value 00000000_00000000h

NOUT_RESP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
NOUT_RESP7								NOUT_RESP6								NOUT_RESP5								NOUT_RESP4							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NOUT_RESP3								NOUT_RESP2								NOUT_RESP1								NOUT_RESP0							

NOUT_RESP Bit Descriptions

Bit	Name	Description
63:56	NOUT_RESP7	**Number of Outstanding Responses on Port 7 (GLIU0: Not Used; GLIU1: Not Used).**
55:48	NOUT_RESP6	**Number of Outstanding Responses on Port 6 (GLIU0: VP; GLIU1: Not Used).**
47:40	NOUT_RESP5	**Number of Outstanding Responses on Port 5 (GLIU0: GP; GLIU1: GIO).**
39:32	NOUT_RESP4	**Number of Outstanding Responses on Port 4 (GLIU0: DC; GLIU1: GLPCI).**
31:24	NOUT_RESP3	**Number of Outstanding Responses on Port 3 (GLIU0: CPU Core; GLIU1: GLCP).**
23:16	NOUT_RESP2	**Number of Outstanding Responses on Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used).**
15:8	NOUT_RESP1	**Number of Outstanding Responses on Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0).**
7:0	NOUT_RESP0	**Number of Outstanding Responses on Port 0 (GLIU0: GLIU; GLIU1: GLIU).**

3.2.2.9 Number of Outstanding Write Data (NOUT_WDATA)

MSR Address GLIU0: 10000088h
GLIU1: 40000088h
Type RO
Reset Value 00000000_00000000h

NOUT_WDATA Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
NOUT_WDATA7								NOUT_WDATA6								NOUT_WDATA5								NOUT_WDATA4							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NOUT_WDATA3								NOUT_WDATA2								NOUT_WDATA1								NOUT_WDATA0							

GLIU Register Descriptions (Continued)

NOUT_WDATA Bit Descriptions

Bit	Name	Description
63:56	NOUT_WDATA7	**Number of Outstanding Write Data on Port 7 (GLIU0: Not Used; GLIU1: Not Used).**
55:48	NOUT_WDATA6	**Number of Outstanding Write Data on Port 6 (GLIU0: VP; GLIU1: Not Used).**
47:40	NOUT_WDATA5	**Number of Outstanding Write Data on Port 5 (GLIU0: GP; GLIU1: GIO).**
39:32	NOUT_WDATA4	**Number of Outstanding Write Data on Port 4 (GLIU0: DC; GLIU1: GLPCI).**
31:24	NOUT_WDATA3	**Number of Outstanding Write Data on Port 3 (GLIU0: CPU Core; GLIU1: GLCP).**
23:16	NOUT_WDATA2	**Number of Outstanding Write Data on Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used).**
15:8	NOUT_WDATA1	**Number of Outstanding Write Data on Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0).**
7:0	NOUT_WDATA0	**Number of Outstanding Write Data on Port 0 (GLIU0: GLIU; GLIU1: GLIU).**

3.2.2.10 SLAVE_ONLY

MSR Address GLIU0: 10000089h
GLIU1: 40000089h
Type RO
Reset Value GLIU0: 00000000_00000002h
GLIU1: 00000000_00000020h

This read only register indicates whether the Port is a slave only port, or if it is a master/slave port. Unused ports return 0.

SLAVE_ONLY Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								P0_SLAVE_ONLY	P7_SLAVE_ONLY	P6_SLAVE_ONLY	P5_SLAVE_ONLY	P4_SLAVE_ONLY	P3_SLAVE_ONLY	P2_SLAVE_ONLY	P1_SLAVE_ONLY

SLAVE_ONLY Bit Descriptions

Bit	Name	Description
63:8	RSVD	**Reserved.** Returns 0.
7	P0_SLAVE_ ONLY	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Slave Only.** If low, indicates that Port 0 is a slave port. If high, Port 0 is a master/slave port.
6	P7_SLAVE_ ONLY	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Slave Only.** If low, indicates that Port 7 is a slave port. If high, Port 7 is a master/slave port.
5	P6_SLAVE_ ONLY	**Port 6 (GLIU0: VP; GLIU1: Not Used) Slave Only.** If low, indicates that Port 6 is a slave port. If high, Port 6 is a master/slave port.
4	P5_SLAVE_ ONLY	**Port 5 (GLIU0: GP; GLIU1: GIO) Slave Only.** If low, indicates that Port 5 is a slave port. If high, Port 5 is a master/slave port.

GLIU Register Descriptions (Continued)

SLAVE_ONLY Bit Descriptions (Continued)

Bit	Name	Description
3	P4_SLAVE_ ONLY	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Slave Only.** If low, indicates that Port 4 is a slave port. If high, Port 4 is a master/slave port.
2	P3_SLAVE_ ONLY	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Slave Only.** If low, indicates that Port 3 is a slave port. If high, Port 3 is a master/slave port.
1	P2_SLAVE_ ONLY	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Slave Only.** If low, indicates that Port 2 is a slave port. If high, Port 2 is a master/slave port.
0	P1_SLAVE_ ONLY	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Slave Only.** If low, indicates that Port 1 is a slave port. If high, Port 1 is a master/slave port.

3.2.2.11 WHO AM I (WHOAMI)

MSR Address GLIU0: 1000008Bh
GLIU1: 4000008Bh
Type RO
Reset Value Master Dependent

WHOAMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													DSID		

WHOAMI Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.**
2:0	DSID	**Source ID of the Initiating Device.** Used to prevent self referencing transactions. 000: Port 0 = GLIU0: GLIU GLIU1: GLIU 001: Port 1 = GLIU0: GLMC GLIU1: Interface to GLIU0 010: Port 2 = GLIU0: Interface to GLIU1 GLIU1: Not Used 011: Port 3 = GLIU0: CPU Core GLIU1: GLCP 100: Port 4 = GLIU0: DC GLIU1: GLPCI 101: Port 5 = GLIU0: GP GLIU1: GIO 110: Port 6 = GLIU0: VP GLIU1: Not Used 111: Port 7 = GLIU0: Not Used GLIU1: Not Used

3.2.2.12 Slave Disable (SLV_DIS)

MSR Address GLIU0: 1000008Ch
GLIU1: 4000008Ch
Type R/W
Reset Value 00000000_00000000h

The slave disable registers are available for the number of ports on the GLIU. Unused ports return 0.

GLIU Register Descriptions (Continued)

SLV_DIS Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								P7_SLAVE_DIS	P6_SLAVE_DIS	P5_SLAVE_DIS	P4_SLAVE_DIS	P3_SLAVE_DIS	P2_SLAVE_DIS	P1_SLAVE_DIS	P0_SLAVE_DIS

SLV_DIS Bit Descriptions

Bit	Name	Description
63:8	RSVD	**Reserved. Write as read.**
7	P7_SLAVE_DIS	**Port 7 (GLIU0: Not Used; GLIU1: Not Used) Slave Transactions.** Write 1 to disable slave transactions to Port 7.
6	P6_SLAVE_DIS	**Port 6 (GLIU0: VP; GLIU1: Not Used) Slave Transactions.** Write 1 to disable slave transactions to Port 6.
5	P5_SLAVE_DIS	**Port 5 (GLIU0: GP; GLIU1: GIO) Slave Transactions.** Write 1 to disable slave transactions to Port 5.
4	P4_SLAVE_DIS	**Port 4 (GLIU0: DC; GLIU1: GLPCI) Slave Transactions.** Write 1 to disable slave transactions to Port 4.
3	P3_SLAVE_DIS	**Port 3 (GLIU0: CPU Core; GLIU1: GLCP) Slave Transactions.** Write 1 to disable slave transactions to Port 3.
2	P2_SLAVE_DIS	**Port 2 (GLIU0: Interface to GLIU1; GLIU1: Not Used) Slave Transactions.** Write 1 to disable slave transactions to Port 2.
1	P1_SLAVE_DIS	**Port 1 (GLIU0: GLMC; GLIU1: Interface to GLIU0) Slave Transactions.** Write 1 to disable slave transactions to Port 1.
0	P0_SLAVE_DIS	**Port 0 (GLIU0: GLIU; GLIU1: GLIU) Slave Transactions.** Write 1 to disable slave transactions to Port 0.

GLIU Register Descriptions (Continued)

3.2.2.13 Descriptor Statistic Counter (STATISTIC_CNT[0:3])

Descriptor Statistic Counter (STATISTIC_CNT[0])

MSR Address	GLIU0: 100000A0h GLIU1: 400000A0h
Type	WO
Reset Value	00000000_00000000h

Descriptor Statistic Counter (STATISTIC_CNT[1])

MSR Address	GLIU0: 100000A4h GLIU1: 400000A4h
Type	WO
Reset Value	00000000_00000000h

Descriptor Statistic Counter (STATISTIC_CNT[2])

MSR Address	GLIU0: 100000A8h GLIU1: 400000A8h
Type	WO
Reset Value	00000000_00000000h

Descriptor Statistic Counter (STATISTIC_CNT[3])

MSR Address	GLIU0: 100000ACh GLIU1: 400000ACh
Type	WO
Reset Value	00000000_00000000h

STATISTIC_CNT[x] Registers Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
LOAD_VAL																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CNT																															

STATISTIC_CNT[x] Bit Descriptions

Bit	Name	Description
63:32	LOAD_VAL	**Counter Load Value.** A value loaded here will be used as the initial Statistics Counter value when a LOAD action occurs or is commanded.
31:0	CNT	**Counter Value.** These bits provide the current counter value when read.

GLIU Register Descriptions (Continued)

3.2.2.14 Descriptor Statistic Mask (STATISTIC_MASK[0:3]

Descriptor Statistic Mask (STATISTIC_MASK[0])

MSR Address GLIU0: 100000A1h
GLIU1: 400000A1h
Type R/W
Reset Value 00000000_00000000h

Descriptor Statistic Mask (STATISTIC_MASK[1])

MSR Address GLIU0: 100000A5h
GLIU1: 400000A5h
Type R/W
Reset Value 00000000_00000000h

Descriptor Statistic Mask (STATISTIC_MASK[2])

MSR Address GLIU0: 100000A9h
GLIU1: 400000A9h
Type R/W
Reset Value 00000000_00000000h

Descriptor Statistic Mask (STATISTIC_MASK[3])

MSR Address GLIU0: 100000ADh
GLIU1: 400000ADh
Type R/W
Reset Value 00000000_00000000h

STATISTIC_MASK[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IOD_MASK																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
P2D MASK																															

STATISTIC_MASK[x] Bit Descriptions

Bit	Name	Description
63:32	IOD_MASK	**Mask for Hits to each IOD.** Hits are determined after the request is arbitrated. A 'hit' is determined by the following logical equation: hit = |(IOD_MASK[n-1:0] & RQ_DESC_HIT[n-1:0] && is_io) | |(P2D_MASK[n-1:0] & RQ_DESC_HIT[n-1:0] && is_mem).
31:0	P2D_MASK	**Mask for Hits to each P2D.** A 'hit' is determined by the following logical equation: hit = |(IOD_MASK[n-1:0] & RQ_DESC_HIT[n-1:0] && is_io) | |(P2D_MASK[n-1:0] & RQ_DESC_HIT[n-1:0] && is_mem).

GLIU Register Descriptions (Continued)

3.2.2.15 Descriptor Statistic Action (STATISTIC_ACTION[0:3]

Descriptor Statistic Action (STATISTIC_ACTION[0])

MSR Address	GLIU0: 100000A2h GLIU1: 400000A2h
Type	R/W
Reset Value	00000000_00000000h

Descriptor Statistic Action (STATISTIC_ACTION[1])

MSR Address	GLIU0: 100000A6h GLIU1: 400000A6h
Type	R/W
Reset Value	00000000_00000000h

Descriptor Statistic Action (STATISTIC_ACTION[2])

MSR Address	GLIU0: 100000AAh GLIU1: 400000AAh
Type	R/W
Reset Value	00000000_00000000h

Descriptor Statistic Action (STATISTIC_ACTION[3])

MSR Address	GLIU0: 100000AEh GLIU1: 400000AEh
Type	R/W
Reset Value	00000000_00000000h

STATISTIC_ACTION[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								PREDIV																WRAP	ZERO_AERR	ZXERO_ASMI	ALWAYS_DEC	HIT_AERR	HIT_ASMI	HIT_DEC	HIT_LDEN

STATISTIC_ACTION[x] Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved**
23:8	PREDIV	**Pre-divider used for** ALWAYS_DEC**.** The pre-divider is free running and extends the depth of the counter.
7	WRAP	**Decrement Counter Beyond Zero and Wrap.** 0: Disable wrap; counter stops when it reaches zero. 1: Enable wrap; counter decrements through 0 to all ones.
6	ZERO_AERR	**Asset AERR on Cnt = 0.** Assert AERR (internal GLIU_P_SERR) when STATISTIC_CNT[x] = 0. 0: Disable. 1: Enable.
5	ZERO_ASMI	**Assert ASMI on Cnt = 0.** Assert ASMI (internal GLIU_P_ASMI) when STATISTIC_CNT[x] = 0. 0: Disable. 1: Enable.
4	ALWAYS_DEC	**Always Decrement Counter.** If enabled, the counter will decrement on every memory clock, subject to the prescaler value PREDIV (bits [23:8]). Decrementing will continue unless loading is occurring due to another action, or if the counter reaches zero and WRAP is disabled (bit 7). 0: Disable. 1: Enable.
3	HIT_AERR	**Assert AERR on Descriptor Hit.** The descriptor hits are ANDed with the masks and then all ORed together. 0: Disable. 1: Enable.

STATISTIC_ACTION[x] Bit Descriptions (Continued)

Bit	Name	Description
2	HIT_ASMI	**Assert ASMI on Descriptor Hit.** The descriptor hits are ANDed with the masks and then all ORed together. 0: Disable. 1: Enable.
1	HIT_DEC	**Decrement Counter on Descriptor Hit.** The descriptor hits are ANDed with the masks and then all ORed together. 0: Disable. 1: Enable.
0	HIT_LDEN	**Load Counter on Descriptor Hit.** The descriptor hits are ANDed with the masks and then all ORed together. 0: Disable. 1: Enable.

3.2.2.16 Request Compare Value (RQ_COMPARE_VAL[0:3])

Request Compare Value (RQ_COMPARE_VAL[0])
MSR Address GLIU0: 100000C0h
GLIU1: 400000C0h
Type R/W
Reset Value 001FFFFF_FFFFFFFFh

Request Compare Value (RQ_COMPARE_VAL[1])
MSR Address GLIU0: 100000C2h
GLIU1: 400000C2h
Type R/W
Reset Value 001FFFFF_FFFFFFFFh

Request Compare Value (RQ_COMPARE_VAL[2])
MSR Address GLIU0: 100000C4h
GLIU1: 400000C4h
Type R/W
Reset Value 001FFFFF_FFFFFFFFh

Request Compare Value (RQ_COMPARE_VAL[3])
MSR Address GLIU0: 100000C6h
GLIU1: 400000C6h
Type R/W
Reset Value 001FFFFF_FFFFFFFFh

The Request Compare Value and the Request Compare Mask enable traps on specific transactions. A hit to the Request Compare is determined by hit = (RQ_IN & RQ_COMPARE_MASK) == RQ_COMPARE_VAL). A hit can trigger the RQ_CMP error sources when they are enabled. The value is compared only after the packet is arbitrated.

RQ_COMPARE_VAL[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD											RQ_VAL																				
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RQ_VAL																															

RQ_COMPARE_VAL[x] Bit Descriptions

Bit	Name	Description
63:53	RSVD	**Reserved.** Write as read.
52:0	RQ_VAL	**Request Packet Value.** This is the value compared against the logical bit-wise AND of the incoming request packet and the RQ_COMPMASK in order to determine a ‘hit’.

GLIU Register Descriptions (Continued)

3.2.2.17 Request Compare Mask (RQ_COMPARE_MASK[0:3])

Request Compare Mask (RQ_COMPARE_MASK[0])

MSR Address	GLIU0: 100000C1h GLIU1: 400000C1h
Type	R/W
Reset Value	00000000_00000000h

Request Compare Mask (RQ_COMPARE_MASK[1])

MSR Address	GLIU0: 100000C3h GLIU1: 400000C3h
Type	R/W
Reset Value	00000000_00000000h

Request Compare Mask (RQ_COMPARE_MASK[2])

MSR Address	GLIU0: 100000C5h GLIU1: 400000C5h
Type	R/W
Reset Value	00000000_00000000h

Request Compare Mask (RQ_COMPARE_MASK[3])

MSR Address	GLIU0: 100000C7h GLIU1: 400000C7h
Type	R/W
Reset Value	00000000_00000000h

The Request Compare Value and the Request Compare Mask enable traps on specific transactions. A hit to the Request Compare is determined by hit = (RQ_IN & RQ_COMPARE_MASK) == RQ_COMPARE_VAL). A hit can trigger the RQ_CMP error sources when they are enabled. The value is compared only after the packet is arbitrated.

RQ_COMPARE_MASK[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD											RQ_MASK																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RQ_MASK																															

RQ_COMPARE_MASK[x] Bit Descriptions

Bit	Name	Description
63:53	RSVD	**Reserved.** Write as read.
52:0	RQ_MASK	**Request Packet Mask.** This field is bit-wise logically ANDed with the incoming request packet before it is compared to the RQ_COMPVAL.

3.2.2.18 Data Compare Value Low (DA_COMPARE_VAL_LO[0:3])

Data Compare Value Low (DA_COMPARE_VAL_LO[0])

MSR Address	GLIU0: 100000D0h GLIU1: 400000D0h
Type	R/W
Reset Value	00001FFF_FFFFFFFFh

Data Compare Value Low (DA_COMPARE_VAL_LO[1])

MSR Address	GLIU0: 100000D4h GLIU1: 400000D4h
Type	R/W
Reset Value	00001FFF_FFFFFFFFh

Data Compare Value Low (DA_COMPARE_VAL_LO[2])

MSR Address	GLIU0: 100000D8h GLIU1: 400000D8h
Type	R/W
Reset Value	00001FFF_FFFFFFFFh

Data Compare Value Low (DA_COMPARE_VAL_LO[3])

MSR Address	GLIU0: 100000DCh GLIU1: 400000DCh
Type	R/W
Reset Value	00001FFF_FFFFFFFFh

The Data Compare Value and the Data Compare Mask enable traps on specific transactions. A hit to the Data Compare is determined by hit = (DA_IN & DA_COMPARE_MASK) == DA_COMPARE_VAL). A hit can trigger the DA_CMP error sources when they are enabled. The value is compared only after the packet is arbitrated.

DA_COMPARE_VAL_LO[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																			DALO_VAL													
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DALO_VAL																															

DA_COMPARE_VAL_LO[x] Bit Descriptions

Bit	Name	Description
63:45	RSVD	**Reserved.** Write as read.
44:0	DALO_VAL	**Data Packet Compare Value [44:0].** This field forms the lower portion of the data value which is compared to the logical bit-wise AND of the incoming data value and the data value compare mask in order to determine a 'hit'. The "HI" and "LO" portions of the incoming data, the compare value, and the compare mask, are assembled into complete bit patterns before these operations occur.

3.2.2.19 Data Compare Value High (DA_COMPARE_VAL_HI[0:3]

Data Compare Value High (DA_COMPARE_VAL_HI[0])

MSR Address GLIU0: 100000D1h
GLIU1: 400000D1h
Type R/W
Reset Value 0000000F_FFFFFFFFh

Data Compare Value High (DA_COMPARE_VAL_HI[1])

MSR Address GLIU0: 100000D5h
GLIU1: 400000D5h
Type R/W
Reset Value 0000000F_FFFFFFFFh

Data Compare Value High (DA_COMPARE_VAL_HI[2])

MSR Address GLIU0: 100000D9h
GLIU1: 400000D9h
Type R/W
Reset Value 0000000F_FFFFFFFFh

Data Compare Value High (DA_COMPARE_VAL_HI[3])

MSR Address GLIU0: 100000DDh
GLIU1: 400000DDh
Type R/W
Reset Value 0000000F_FFFFFFFFh

The Data Compare Value and the Data Compare Mask enable traps on specific transactions. A hit to the Data Compare is determined by hit = (DA_IN & DA_COMPARE_MASK) == DA_COMPARE_VAL). A hit can trigger the DA_CMP error sources when they are enabled. The value is compared only after the packet is arbitrated.

DA_COMPARE_VAL_HI[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																												DAHI_VAL			
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DAHI_VAL																															

DA_COMPARE_VAL_HI[x] Bit Descriptions

Bit	Name	Description
63:36	RSVD	**Reserved.** Write as read.
35:0	DAHI_VAL	**Data Packet Compare Value [80:45].** This field forms the upper portion of the data value which is compared to the logical bit-wise AND of the incoming data value AND the data value compare mask in order to determine a 'hit'. The "HI" and "LO" portions of the incoming data, the compare value, and the compare mask, are assembled into complete bit patterns before these operations occur.

GLIU Register Descriptions (Continued)

3.2.2.20 Data Compare Mask Low (DA_COMPARE_MASK_LO[0:3])

Data Compare Mask Low (DA_COMPARE_MASK_LO[0])

MSR Address	GLIU0: 100000D2h GLIU1: 400000D2h
Type	R/W
Reset Value	00000000_00000000h

Data Compare Mask Low (DA_COMPARE_MASK_LO[1])

MSR Address	GLIU0: 100000D6h GLIU1: 400000D6h
Type	R/W
Reset Value	00000000_00000000h

Data Compare Mask Low (DA_COMPARE_MASK_LO[2])

MSR Address	GLIU0: 100000DAh GLIU1: 400000DAh
Type	R/W
Reset Value	00000000_00000000h

Data Compare Mask Low (DA_COMPARE_MASK_LO[3])

MSR Address	GLIU0: 100000DEh GLIU1: 400000DEh
Type	R/W
Reset Value	00000000_00000000h

The Data Compare Value and the Data Compare Mask enable traps on specific transactions. A hit to the Data Compare is determined by hit = (DA_IN & DA_COMPARE_MASK) == DA_COMPARE_VAL). A hit can trigger the DA_CMP error sources when they are enabled. The value is compared only after the packet is arbitrated.

DA_COMPARE_MASK_LO[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																			DALO_MASK												
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DALO_MASK																															

DA_COMPARE_MASK_LO[x] Bit Descriptions

Bit	Name	Description
63:45	RSVD	**Reserved.** Write as read.
44:0	DALO_MASK	**Data Packet Compare Value [44:0].** This field is forms the lower portion of the data COMPMASK value, which is then bit-wise logically ANDed with the incoming data value before it is compared to the DA_COMPVAL. The “HI” and “LO” portions of the incoming data, the compare value, and the compare mask, are assembled into complete bit patterns before these operations occur.

GLIU Register Descriptions (Continued)

3.2.2.21 Data Compare Mask High (DA_COMPARE_MASK_HI[0:3])

Data Compare Mask High (DA_COMPARE_MASK_HI[0])
MSR Address GLIU0: 100000D3h
GLIU1: 400000D3h
Type R/W
Reset Value 00000000_00000000h

Data Compare Mask High (DA_COMPARE_MASK_HI[1])
MSR Address GLIU0: 100000D7h
GLIU1: 400000D7h
Type R/W
Reset Value 00000000_00000000h

Data Compare Mask High (DA_COMPARE_MASK_HI[2])
MSR Address GLIU0: 100000DBh
GLIU1: 400000DBh
Type R/W
Reset Value 00000000_00000000h

Data Compare Mask High (DA_COMPARE_MASK_HI[3])
MSR Address GLIU0: 100000DFh
GLIU1: 400000DFh
Type R/W
Reset Value 00000000_00000000h

DA_COMPARE_MASK_HI[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																												DAHI_MASK			
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DAHI_MASK																															

DA_COMPARE_MASK_HI[x] Bit Descriptions

Bit	Name	Description
63:36	RSVD	**Reserved.** Write as read.
35:0	DAHI_MASK	**Data Packet Compare Mask [80:45].** This field is forms the upper portion of the data COMPMASK value, which is then bit-wise logically ANDed with the incoming data value before it is compared to the DA_COMPVAL.The “HI” and “LO” portions of the incoming data. the compare value, and the compare mask, are assembled into complete bit patterns before these operations occur.

3.2.3 P2D Descriptor MSRs

See Section 3.1.3.1 "Memory Routing and Translation" on page 55 for further details on the descriptor usage.

3.2.3.1 P2D Base Mask Descriptor (P2D_BM)

GLIU0 P2D_BM[0:5]
MSR Address 10000020h-10000025h
Type R/W
Reset Value 000000FF_FFF00000h

GLIU1 P2D_BM[0:8]
MSR Address 40000020h-40000028h
Type R/W
Reset Value 000000FF_FFF00000h

These registers set up the Physical-to-Device Base Mask descriptors for determining an address ‘hit’.

P2D_BM[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PDID1			PCMP_BIZ	RSVD																				PBASE							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PBASE												PMASK																			

GLIU Register Descriptions (Continued)

P2D_BM[x] Bit Descriptions

Bit	Name	Description
63:61	PDID1	**Descriptor Destination ID.** These bits define which Port to route the request to, if it is a 'hit' based the other settings in this register. 000: Port 0 = GLIU0: GLIU — GLIU1: GLIU 001: Port 1 = GLIU0: GLMC — GLIU1: Interface to GLIU0 010: Port 2 = GLIU0: Interface to GLIU1 — GLIU1: Not Used 011: Port 3 = GLIU0: CPU Core — GLIU1: GLCP 100: Port 4 = GLIU0: DC — GLIU1: GLPCI 101: Port 5 = GLIU0: GP — GLIU1: GIO 110: Port 6 = GLIU0: VP — GLIU1: Not Used 111: Port 7 = GLIU0: Not Used — GLIU1: Not Used
60	PCMP_BIZ	**Compare Bizarro Flag.** 0: Consider only transactions whose Bizzaro flag is low as a potentially valid address hit. A low Bizarro flag indicates a normal transaction cycle such as a memory or I/O. 1: Consider only transactions whose Bizarro flag is high as a potentially valid address hit. A high Bizzaro flag indicates a 'special' transaction, such as a PCI Shutdown or Halt cycle
59:40	RSVD	**Reserved.** Write as read.
39:20	PBASE	**Physical Memory Address Base.** These bits form the matching value against which the masked value of the physical address, bits [31:12] are directly compared. If a match is found, then a "hit' is declared, depending on the setting of the Bizzaro flag comparator.
19:0	PMASK	**Physical Memory Address Mask.** These bits are used to mask address bits [31:12] for the purposes of this 'hit' detection.

3.2.3.2 P2D Base Mask Offset Descriptor (P2D_BMO)

GLIU0 **P2D_BMO[0:1]**
MSR Address 10000026h-10000027h
Type R/W
Reset Value 00000FF0_FFF00000h

P2D_BMO[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PDID1			PCMP_BIZ	POFFSET																				PBASE							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PBASE												PMASK																			

P2D_BMO[x] Bit Descriptions

Bit	Name	Description
63:61	PDID1	**Descriptor Destination ID.**
60	PCMP_BIZ	**Compare Bizzaro Flag.**
59:40	POFFSET	**Physical Memory Address 2s Complement Offset.**
39:20	PBASE	**Physical Memory Address Base.**
19:0	PMASK	**Physical Memory Address Mask**

GLIU Register Descriptions (Continued)

3.2.3.3 P2D Range Descriptor (P2D_R)

GLIU0	P2D_R[0]	GLIU1	P2D_R[0:3]
MSR Address	10000028h	MSR Address	40000029h-4000002Ch
Type	R/W	Type	R/W
Reset Value	00000000_000FFFFFh	Reset Value	00000000_000FFFFFh

P2D_R[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PDID1			PCMP_BIZ	RSVD																				PMAX							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PMAX												PMIN																			

P2D_R[x] Bit Descriptions

Bit	Name	Description
63:61	PDID1	**Descriptor Destination ID.**
60	PCMP_BIZ	**Compare Bizzaro Flag.**
59:40	RSVD	**Reserved.**
39:20	PMAX	**Physical Memory Address Maximum.**
19:0	PMIN	**Physical Memory Address Minimum.**

3.2.3.4 P2D Range Offset Descriptor (P2D_RO)

GLIU0	P2D_RO[0:2]
MSR Address	10000029h-1000002Bh
Type	R/W
Reset Value	00000000_000FFFFFh

P2D_RO[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PDID1			PCMP_BIZ	OFFSET																				PMAX							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PMAX												PMIN																			

P2D_RO[x] Bit Descriptions

Bit	Name	Description
63:61	PDID1	**Descriptor Destination ID.**
60	PCMP_BIZ	**Compare Bizzaro Flag.**
59:40	POFFSET	**Physical Memory Address 2s Complement Offset.**
39:20	PMAX	**Physical Memory Address Maximum.**
19:0	PMIN	**Physical Memory Address Minimum.**

GLIU Register Descriptions (Continued)

3.2.3.5 P2D Swiss Cheese Descriptor (P2D_SC)

GLIU0	P2D_SC[0]	GLIU1	P2D_SC[0]
MSR Address	1000002Ch	MSR Address	4000002Dh
Type	R/W	Type	R/W
Reset Value	00000000_00000000h	Reset Value	00000000_00000000h

P2D_SC0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PDID1			PCMP_BIZ	RSVD												WEN															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
REN																RSVD		PSCBASE													

P2D_SC0 Bit Descriptions

Bit	Name	Description
63:61	PDID1	**Descriptor Destination ID 1.**
60	PCMP_BIZ	**Compare Bizzaro Flag.**
59:48	RSVD	**Reserved.**
47:32	WEN	**Enable hits to the base for the *ith* 16 kB page for writes.**
31:16	REN	**Enable hits to the base for the *ith* 16kB page for reads.**
15:14	RSVD	**Reserved.**
13:0	PBASE	**Physical Memory Address Base for Hit.**

GLIU Register Descriptions (Continued)

3.2.4 I/O Descriptor MSRs

See Section 3.1.3.2 "I/O Routing and Translation" on page 57 for further details on the descriptor usage.

3.2.4.1 IOD Base Mask Descriptors (IOD_BM)

GLIU0	**IOD_BM[0:3]**	**GLIU1**	**IOD_BM[0:3]**
MSR Address	100000E0h-100000E2h	MSR Address	400000E0h-400000E2h
Type	R/W	Type	R/W
Reset Value	000000FF_FFF00000h	Reset Value	000000FF_FFF00000h

IOD_BM[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IDID			ICMP_BIZ	RSVD																				IBASE							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IBASE												IMASK																			

IOD_BM[x] Bit Descriptions

Bit	Name	Description
63:61	IDID	**I/O Descriptor Destination ID.** These bits define which Port to route the request to, if it is a 'hit' based the other settings in this register. 000: Port 0 = GLIU0: GLIU — GLIU1: GLIU 001: Port 1 = GLIU0: GLMC — GLIU1: Interface to GLIU0 010: Port 2 = GLIU0: Interface to GLIU1 — GLIU1: Not Used 011: Port 3 = GLIU0: CPU Core — GLIU1: GLCP 100: Port 4 = GLIU0: DC — GLIU1: GLPCI 101: Port 5 = GLIU0: GP — GLIU1: GIO 110: Port 6 = GLIU0: VP — GLIU1: Not Used 111: Port 7 = GLIU0: Not Used — GLIU1: Not Used
60	ICMP_BIZ	**Compare Bizzaro Flag.** 0: Consider only transactions whose Bizzaro flag is low as a potentially valid address hit. A low Bizarro flag indicates a normal transaction cycle such as a memory or I/O. 1: Consider only transactions whose Bizarro flag is high as a potentially valid address hit. A high Bizzaro flag indicates a 'special' transaction, such as a PCI Shutdown or Halt cycle.
59:40	RSVD	**Reserved.** Write as read.
39:20	IBASE	**Physical I/O Address Base.** These bits form the matching value against which the masked value of the physical address, bits [31:12] are directly compared. If a match is found, then a "hit' is declared, depending on the setting of the Bizzaro flag comparator.
19:0	IMASK	**Physical I/O Address Mask.** These bits are used to mask address bits [31:12] for the purposes of this 'hit' detection.

GLIU Register Descriptions (Continued)

3.2.4.2 IOD Swiss Cheese Descriptors (IOD_SC)

GLIU0	IOD_SC[0:5]	GLIU1	IOD_SC[0:5]
MSR Address	100000E3h-100000E8h	MSR Address	400000E3h-400000E8h
Type	R/W	Type	R/W
Reset Value	00000000_00000000h	Reset Value	00000000_00000000h

IOD_SC[x] Register

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IDID1			ICMP_BIZ	RSVD																											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EN								RSVD		WEN	REN	IBASE																	RSVD		

IOD_SC Bit Descriptions

Bit	Name	Description
63:61	IDID1	**Descriptor Destination ID 1.** Encoded port number of the destination of addresses which produce a 'hit' based on the other fields in this descriptor.
60	ICMP_BIZ	**Compare Bizzaro Flag.** Used to check that the Bizzaro flag of the request is equal to the PICMP_BIZ_SC bit (this bit). If a match does not occur, then the incoming request cannot generate a hit. The Bizzaro flag, if set in the incoming request, signifies a "special' cycle such as a PCI Shutdown or Halt.
59:32	RSVD	**Reserved.** Write as read.
31:24	EN	**Enable for Hits to IDID1 or else SUBP.** This bit enables hits to IDID1. If not enabled, subtractive port is selected per GLD_MSR_CONFIG, bits [2:0] (MSR GLIU0: 10002001h; GLIU1: 40002001h). (See Section 3.2.1.2 "GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)" on page 62 for bit descriptions).
21	WEN	**Descriptor Hits IDID1 on Write Request Types else SUBP.** If set, causes the incoming request to be routed to the port specified in IDID1 if the incoming request is a Write type. If not set, subtractive port is selected per GLD_MSR_CONFIG, bits [2:0] (MSR GLIU0: 10002001h; GLIU1: 40002001h). (See Section 3.2.1.2 "GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)" on page 62 for bit descriptions).
20	REN	**Descriptors Hit IDID1 on Read Request Types else SUBP.** If set, causes the incoming request to be routed to the port specified in IDID1 if the incoming request is a Read type. If not set, subtractive port is selected per GLD_MSR_CONFIG, bits [2:0] (MSR GLIU0: 10002001h; GLIU1: 40002001h). (See Section 3.2.1.2 "GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)" on page 62 for bit descriptions).
19:3	IBASE	**I/O Memory Base.** This field forms the basis of comparison with the incoming checks that the physical address supplied by the device's request on address bits [31:18] are equal to the PBASE field of descriptor register bits [13:0].
2:0	RSVD	**Reserved.** Write as read.

4.0 CPU Core Functional Description

This section describes the internal operations of the Geode GX2 CPU core from a programmer's point of view. It includes a description of the traditional "core" processing and FPU operations. The integrated function registers are described in the next chapter.

The primary register sets within the processor core include:

- Application Register Set
- System Register Set

4.1 CORE PROCESSOR INITIALIZATION

The GX2 CPU core is initialized when the RST# (Reset) signal is asserted. The CPU core is placed in real mode and the registers listed in Table 4-1 are set to their initialized values. RST# invalidates and disables the CPU cache, and turns off paging. When RST# is asserted, the CPU terminates all local bus activity and all internal execution. While RST# is asserted, the internal pipeline is flushed and no instruction execution or bus activity occurs.

Approximately 150 to 250 external clock cycles after RST# is de-asserted, the processor begins executing instructions at the top of physical memory (address location FFFFFFF0h). The actual number of clock cycles depends on the clock scaling in use. Also, before execution begins, an additional 2^{20} clock cycles are needed when self-test is requested.

Typically, an intersegment jump is placed at FFFFFFF0h. This instruction forces the processor to begin execution in the lowest 1 MB of address space.

Table 4-1 lists the CPU core registers and illustrates how they are initialized.

Table 4-1. Initialized Core Register Controls

Register	Register Name	Initialized Contents (Note 1)	Comments
EAX	Accumulator	xxxxxxxxh	00000000h indicates self-test passed.
EBX	Base	xxxxxxxxh	
ECX	Count	xxxxxxxxh	
EDX	Data	xxxx 04 [DIR0]h	DIR0 = Device ID
EBP	Base Pointer	xxxxxxxxh	
ESI	Source Index	xxxxxxxxh	
EDI	Destination Index	xxxxxxxxh	
ESP	Stack Pointer	xxxxxxxxh	
EFLAGS	Extended Flags	00000002h	See Table 4-4 on page 95 for bit definitions.
EIP	Instruction Pointer	0000FFF0h	
ES	Extra Segment	0000h	Base address set to 00000000h. Limit set to FFFFh.
CS	Code Segment	F000h	Base address set to FFFF0000h. Limit set to FFFFh.
SS	Stack Segment	0000h	Base address set to 00000000h. Limit set to FFFFh.
DS	Data Segment	0000h	Base address set to 00000000h. Limit set to FFFFh.
FS	Extra Segment	0000h	Base address set to 00000000h. Limit set to FFFFh.
GS	Extra Segment	0000h	Base address set to 00000000h. Limit set to FFFFh.
IDTR	Interrupt Descriptor Table Register	Base = 0, Limit = 3FFh	
GDTR	Global Descriptor Table Register	xxxxxxxxh	
LDTR	Local Descriptor Table Register	xxxxh	
TR	Task Register	xxxxh	
CR0	Control Register 0	60000010h	See Table 4-10 on page 98 for bit descriptions.
CR2	Control Register 2	xxxxxxxxh	See Table 4-9 on page 98 for bit descriptions.
CR3	Control Register 3	xxxxxxxxh	See Table 4-8 on page 98 for bit descriptions.
CR4	Control Register 4	00000000h	See Table 4-7 on page 97 for bit descriptions.

Note 1. x = Undefined value.

4.2 INSTRUCTION SET OVERVIEW

The GX2 CPU core instruction set can be divided into nine types of operations:

- Arithmetic
- Bit Manipulation
- Shift/Rotate
- String Manipulation
- Control Transfer
- Data Transfer
- Floating Point
- High-Level Language Support
- Operating System Support

The instructions operate on as few as zero operands and as many as three operands. A NOP (no operation) instruction is an example of a zero-operand instruction. Two-operand instructions allow the specification of an explicit source and destination pair as part of the instruction. These two-operand instructions can be divided into ten groups according to operand types:

- Register to Register
- Register to Memory
- Memory to Register
- Memory to Memory
- Register to I/O
- I/O to Register
- Memory to I/O
- I/O to Memory
- Immediate Data to Register
- Immediate Data to Memory

An operand can be held in the instruction itself (as in the case of an immediate operand), in one of the processor's registers or I/O ports, or in memory. An immediate operand is fetched as part of the opcode for the instruction.

Operand lengths of 8, 16, 32 or 48 bits are supported as well as 64 or 80 bits associated with floating-point instructions. Operand lengths of 8 or 32 bits are generally used when executing code written for 386- or 486-class (32-bit code) processors. Operand lengths of 8 or 16 bits are generally used when executing existing 8086 or 80286 code (16-bit code). The default length of an operand can be overridden by placing one or more instruction prefixes in front of the opcode. For example, the use of prefixes allows a 32-bit operand to be used with 16-bit code or a 16-bit operand to be used with 32-bit code.

The Processor Core Instruction Set contains the clock count table that lists each instruction in the CPU instruction set. Included in the table are the associated opcodes, execution clock counts, and effects on the EFLAGS register.

4.2.1 Lock Prefix

The LOCK prefix may be placed before certain instructions that read, modify, then write back to memory. The PCI will not be granted access in the middle of locked instructions. The LOCK prefix can be used with the following instructions only when the result is a write operation to memory.

- Bit Test Instructions (BTS, BTR, BTC)
- Exchange Instructions (XADD, XCHG, CMPXCHG)
- One-Operand Arithmetic and Logical Instructions (DEC, INC, NEG, NOT)
- Two-Operand Arithmetic and Logical Instructions (ADC, ADD, AND, OR, SBB, SUB, XOR).

An invalid opcode exception is generated if the LOCK prefix is used with any other instruction or with one of the instructions above when no write operation to memory occurs (for example, when the destination is a register).

4.2.2 Register Sets

The accessible registers in the processor are grouped into two sets:

1) The **Application Register Set** contains the registers frequently used by application programmers. Table 4-2 on page 93 shows the General Purpose, Segment, Instruction Pointer and EFLAGS registers.
2) The **System Register Set** contains the registers typically reserved for operating systems programmers: Control, System Address, Debug, Configuration, and Test registers. All accesses to the these registers use special CPU instructions.

Both of these register sets are discussed in detail in the subsections that follow.

4.3 APPLICATION REGISTER SET

The Application Register Set consists of the registers most often used by the applications programmer. These registers are generally accessible, although some bits in the EFLAGS registers are protected.

The **General Purpose Register** contents are frequently modified by instructions and typically contain arithmetic and logical instruction operands.

In real mode, **Segment Registers** contain the base address for each segment. In protected mode, the Segment registers contain segment selectors. The segment selectors provide indexing for tables (located in memory) that contain the base address for each segment, as well as other memory addressing information.

The **Instruction Pointer Register** points to the next instruction that the processor will execute. This register is automatically incremented by the processor as execution progresses.

The **EFLAGS Register** contains control bits used to reflect the status of previously executed instructions. This register also contains control bits that affect the operation of some instructions.

Table 4-2. Application Register Set

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
General Purpose Registers																															
																AX															
																AH								AL							
EAX (Extended A Register)																															
																BX															
																BH								BL							
EBX (Extended B Register)																															
																CX															
																CH								CL							
ECX (Extended C Register)																															
																DX															
																DH								DL							
EDX (Extended D Register)																															
																SI (Source Index)															
ESI (Extended Source Index)																															
																DI (Destination Index)															
EDI (Extended Destination Index)																															
																BP (Base Pointer)															
EBP (Extended Base Pointer)																															
																SP (Stack Pointer)															
ESP (Extended Stack Pointer)																															
Segment (Selector) Registers																															
																CS (Code Segment)															
																SS (Stack Segment)															
																DS (D Data Segment)															
																ES (E Data Segment)															
																FS (F Data Segment)															
																GS (G Data Segment)															
Instruction Pointer and EFLAGS Registers																															
EIP (Extended Instruction Pointer)																															
ESP (Extended EFLAGS Register)																															

CPU Core Functional Description (Continued)

4.3.1 General Purpose Registers

The General Purpose Registers are divided into four data registers, two pointer registers, and two index registers as shown in Table 4-2 on page 93.

The **Data Registers** are used by the applications programmer to manipulate data structures and to hold the results of logical and arithmetic operations. Different portions of general data registers can be addressed by using different names.

An “E” prefix identifies the complete 32-bit register. An “X” suffix without the “E” prefix identifies the lower 16 bits of the register.

The lower two bytes of a data register are addressed with an “H” suffix (identifies the upper byte) or an “L” suffix (identifies the lower byte). These _L and _H portions of the data registers act as independent registers. For example, if the AH register is written to by an instruction, the AL register bits remain unchanged.

The **Pointer and Index registers** are listed below.

SI or ESI	Source Index
DI or EDI	Destination Index
SP or ESP	Stack Pointer
BP or EBP	Base Pointer

These registers can be addressed as 16- or 32-bit registers, with the “E” prefix indicating 32 bits. The Pointer and Index registers can be used as general purpose registers; however, some instructions use a fixed assignment of these registers. For example, repeated string operations always use ESI as the source pointer, EDI as the destination pointer, and ECX as a counter. The instructions that use fixed registers include multiply and divide, I/O access, string operations, stack operations, loop, variable shift and rotate, and translate instructions.

The CPU Core implements a stack using the ESP register. This stack is accessed during the PUSH and POP instructions, procedure calls, procedure returns, interrupts, exceptions, and interrupt/exception returns. The GX2 processor automatically adjusts the value of the ESP during operations that result from these instructions.

The EBP register may be used to refer to data passed on the stack during procedure calls. Local data may also be placed on the stack and accessed with BP. This register provides a mechanism to access stack data in high-level languages.

4.3.2 Segment Registers

The 16-bit segment registers, part of the main memory addressing mechanism. The six segment registers are:

CS	-	Code Segment
DS	-	Data Segment
SS	-	Stack Segment
ES	-	Extra Segment
FS	-	Additional Data Segment
GS	-	Additional Data Segment

The segment registers are used to select segments in main memory. A segment acts as private memory for different elements of a program such as code space, data space and stack space. There are two segment mechanisms, one for real and virtual 8086 operating modes and one for protected mode.

The active segment register is selected according to the rules listed in Table 4-3 and the type of instruction being currently processed. In general, the DS register selector is used for data references. Stack references use the SS register, and instruction fetches use the CS register. While some selections may be overridden, instruction fetches, stack operations, and the destination write operation of string operations cannot be overridden. Special segment-override instruction prefixes allow the use of alternate segment registers. These segment registers include the ES, FS, and GS registers.

4.3.2.1 Instruction Pointer Register

The **Instruction Pointer (EIP) register** contains the offset into the current code segment of the next instruction to be executed. The register is normally incremented by the length of the current instruction with each instruction execution unless it is implicitly modified through an interrupt, exception, or an instruction that changes the sequential execution flow (for example JMP and CALL).

Table 4-3. Segment Register Selection Rules

Type of Memory Reference	Implied (Default) Segment	Segment-Override Prefix
Code Fetch	CS	None
Destination of PUSH, PUSHF, INT, CALL, PUSHA instructions	SS	None
Source of POP, POPA, POPF, IRET, RET instructions	SS	None
Destination of STOS, MOVS, REP STOS, REP MOVS instructions	ES	None
Other data references with effective address using base registers of: EAX, EBX, ECX, EDX, ESI, EDI, EBP, ESP	DS SS	CS, ES, FS, GS, SS CS, DS, ES, FS, GS

CPU Core Functional Description (Continued)

4.3.3 EFLAGS Register

The EFLAGS register contains status information and controls certain operations on the GX2 processor. The lower 16 bits of this register are used when executing 8086 or 80286 code. Table 4-4 gives the bit formats for the EFLAGS register.

Table 4-4. EFLAGS Register

Bit	Name	Flag Type	Description
31:22	RSVD	--	**Reserved:** Set to 0.
21	ID	System	**Identification Bit**: The ability to set and clear this bit indicates that the CPUID instruction is supported. The ID can be modified only if the CPUID bit in CCR4 (Index E8h[7]) is set.
20:19	RSVD	--	**Reserved:** Set to 0.
18	AC	System	**Alignment Check Enable:** In conjunction with the AM flag (bit 18) in CR0, the AC flag determines whether or not misaligned accesses to memory cause a fault. If AC is set, alignment faults are enabled.
17	VM	System	**Virtual 8086 Mode:** If set while in protected mode, the processor switches to virtual 8086 operation handling segment loads as the 8086 does, but generating exception 13 faults on privileged opcodes. The VM bit can be set by the IRET instruction (if current privilege level is 0) or by task switches at any privilege level.
16	RF	Debug	**Resume Flag:** Used in conjunction with debug register breakpoints. RF is checked at instruction boundaries before breakpoint exception processing. If set, any debug fault is ignored on the next instruction.
15	RSVD	--	**Reserved:** Set to 0.
14	NT	System	**Nested Task:** While executing in protected mode, NT indicates that the execution of the current task is nested within another task.
13:12	IOPL	System	**I/O Privilege Level:** While executing in protected mode, IOPL indicates the maximum current privilege level (CPL) permitted to execute I/O instructions without generating an exception 13 fault or consulting the I/O permission bit map. IOPL also indicates the maximum CPL allowing alteration of the IF bit when new values are popped into the EFLAGS register.
11	OF	Arithmetic	**Overflow Flag:** Set if the operation resulted in a carry or borrow into the sign bit of the result but did not result in a carry or borrow out of the high-order bit. Also set if the operation resulted in a carry or borrow out of the high-order bit but did not result in a carry or borrow into the sign bit of the result.
10	DF	Control	**Direction Flag:** When cleared, DF causes string instructions to auto-increment (default) the appropriate index registers (ESI and/or EDI). Setting DF causes auto-decrement of the index registers to occur.
9	IF	System	**Interrupt Enable Flag:** When set, maskable interrupts (INTR input pin) are acknowledged and serviced by the CPU.
8	TF	Debug	**Trap Enable Flag:** Once set, a single-step interrupt occurs after the next instruction completes execution. TF is cleared by the single-step interrupt.
7	SF	Arithmetic	**Sign Flag:** Set equal to high-order bit of result (0 indicates positive, 1 indicates negative).
6	ZF	Arithmetic	**Zero Flag:** Set if result is zero; cleared otherwise.
5	RSVD	--	**Reserved:** Set to 0.
4	AF	Arithmetic	**Auxiliary Carry Flag:** Set when a carry out of (addition) or borrow into (subtraction) bit position 3 of the result occurs; cleared otherwise.
3	RSVD	--	**Reserved:** Set to 0.
2	PF	Arithmetic	**Parity Flag:** Set when the low-order 8 bits of the result contain an even number of ones; otherwise PF is cleared.
1	RSVD		**Reserved:** Set to 1.
0	CF	Arithmetic	**Carry Flag:** Set when a carry out of (addition) or borrow into (subtraction) the most significant bit of the result occurs; cleared otherwise.

CPU Core Functional Description (Continued)

4.4 SYSTEM REGISTER SET

The System Register Set, shown in Table 4-5, consists of registers not generally used by application programmers. These registers are either initialized by the system BIOS or employed by system level programmers who generate operating systems and memory management programs. Associated with the System Register Set are certain tables and segments that are listed in Table 4-5.

The **Control Registers** control certain aspects of the CPU core such as paging, coprocessor functions, and segment protection.

The **CPU Core Configuration Registers** are used to initialize, provide for, test or define most of the features of the GX2's CPU Core. These attributes of these registers include:

- CPU setup - Enable cache, features, operating modes.
- Debug support - Provide debugging facilities for the GX2 processor and enable the use of data access breakpoints and code execution breakpoints.
- Built-in Self-test (BIST) support.
- Test - Support a mechanism to test the contents of the on-chip caches and the Translation Lookaside Buffers (TLBs).
- In Circuit Emulation (ICE) - Provide for a alternative accessing path to support an ICE.
- CPU identification - Allow the BIOS and other software to identify the specific CPU and stepping.
- Power Management.
- Performance Monitoring - Enables test software to measure the performance of application software.

The **Descriptor Table Register** hold descriptors that manage memory segments and tables, interrupts and task switching. The tables are defined by corresponding registers.

The two **Task State Segment Tables** defined by TSS register are used to save and load the computer state when switching tasks.

Table 4-5 lists the system register sets along with their size and function.

Table 4-5. System Register Set

Group	Name	Function	Width (Bits)
Control Registers	CR0	System Control Register	32
	CR2	Page Fault Linear Address Register	32
	CR3	Page Directory Base Register	32
	CR4	Time Stamp Counter	32
CPU Core Configuration Registers	PLn	Pipeline Control Registers	64
	IMn	Instruction Memory Control Registers	64
	DMn	Data Memory Control Registers	64
	BCn	Bus Controller Control Registers	64
	FPUn	Floating Point Unit Shadow Registers	64
Descriptor Tables	GDT	General Descriptor Table	32
	IDT	Interrupt Descriptor Table	32
	LDT	Local Descriptor Table	16
Descriptor Table Registers	GDTR	GDT Register	32
	IDTR	IDT Register	32
	LDTR	LDT Register	16
Task State Segment and Registers	TSS	Task State Segment Table	16
	TR	TSS Register Setup	16
Performance Registers	PCRn	Performance Control Registers	8

CPU Core Functional Description (Continued)

4.4.1 Control Registers

A map of the Control Registers (CR0, CR1, CR2, CR3, and CR4) is shown in Table 4-6 and the bit descriptions are in the tables that follow. (These registers should not be confused with the CRRn registers.) CR0 contains system control bits that configure operating modes and indicate the general state of the CPU. The lower 16 bits of CR0 are referred to as the Machine Status Word (MSW).

When operating in real mode, any program can read and write the control registers. In protected mode, however, only privilege level 0 (most-privileged) programs can read and write these registers.

L1 Cache Controller

The GX2 processor contains an on-board 16 kB unified data/instruction write-back L1 cache. With the memory controller on-board, the L1 cache requires no external logic to maintain coherency. All DMA cycles automatically snoop the L1 cache.

The CD bit (Cache Disable, bit 30) in CR0 globally controls the operating mode of the L1 cache. LCD and LWT, Local Cache Disable and Local Write-through bits in the Translation Lookaside Buffer, control the mode on a page-by-page basis. Additionally, memory configuration control can specify certain memory regions as non-cacheable.

If the cache is disabled, no further cache line fills occur. However, data already present in the cache continues to be used. For the cache to be completely disabled, the cache must be invalidated with a WBINVD instruction after the cache has been disabled.

Write-back caching improves performance by relieving congestion on slower external buses. With four dirty bits, the cache marks dirty locations on a double-word (DWORD) basis. This further reduces the number of DWORD write operations needed during a replacement or flush operation.

The GX2 processor caches SMM regions, reducing system management overhead to allow for hardware emulation such as VGA.

Table 4-6. Control Registers Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CR4 Register																**Control Register 4 (R/W)**															
RSVD																													TSC	RSVD	
CR3 Register																**Control Register 3 (R/W)**															
PDBR (Page Directory Base Register)																				RSVD							0	0	RSVD		
CR2 Register																**Control Register 2 (R/W)**															
PFLA (Page Fault Linear Address)																															
CR1 Register																**Control Register 1 (R/W)**															
RSVD																															
CR0 Register																**Control Register 0 (R/W)**															
PG	CD	NW	RSVD										AM	RSVD	WP	RSVD									NE	RSVD	T		EM	MP	PE
																Machine Status Word (MSW)															

Table 4-7. CR4 Bit Descriptions

Bit	Name	Description
31:3	RSVD	**Reserved:** Set to 0 (always returns 0 when read).
2	TSC	**Time Stamp Counter Instruction:** 0: RDTSC instruction enabled for all CPL states. 1: RDTSC instruction enabled for CPL = 0 only; reset state.
1:0	RSVD	**Reserved:** Set to 0 (always returns 0 when read).

CPU Core Functional Description (Continued)

Table 4-8. CR3 Bit Descriptions

Bit	Name	Description
31:12	PDBR	**Page Directory Base Register:** Identifies page directory base address on a 4 kB page boundary.
11:0	RSVD	**Reserved:** Set to 0.

Table 4-9. CR2 Bit Descriptions

Bit	Name	Description
31:0	PFLA	**Page Fault Linear Address:** With paging enabled and after a page fault, PFLA contains the linear address of the address that caused the page fault.

Table 4-10. CR0 Bit Descriptions

Bit	Name	Description
31	PG	**Paging Enable Bit**: If PG = 1 and protected mode is enabled (PE = 1), paging is enabled. After changing the state of PG, software must execute an unconditional branch instruction (e.g., JMP, CALL) to have the change take effect.
30	CD	**Cache Disable**: If CD = 1, no further cache line fills occur. However, data already present in the cache continues to be used if the requested address hits in the cache. Writes continue to update the cache and cache invalidations due to inquiry cycles occur normally. The cache must also be invalidated with a WBINVD instruction to completely disable any cache activity.
29	NW	**Not Write-Through**: If NW = 1, the on-chip cache operates in write-back mode. In write-back mode, writes are issued to the external bus only for a cache miss, a line replacement of a modified line, execution of a locked instruction, or a line eviction as the result of a flush cycle. If NW = 0, the on-chip cache operates in write-through mode. In write-through mode, all writes (including cache hits) are issued to the external bus. This bit cannot be changed if LOCK_NW = 1 in CCR2.
28:19	RSVD	**Reserved**
18	AM	**Alignment Check Mask**: If AM = 1, the AC bit in the EFLAGS register is unmasked and allowed to enable alignment check faults. Setting AM = 0 prevents AC faults from occurring.
17	RSVD	**Reserved**
16	WP	**Write Protec**t: Protects read-only pages from supervisor write access. WP = 0 allows a read-only page to be written from privilege level 0-2. WP = 1 forces a fault on a write to a read-only page from any privilege level.
15:6	RSVD	**Reserved**
5	NE	**Numerics Exception**: NE = 1 to allow FPU exceptions to be handled by interrupt 16. NE = 0 if FPU exceptions are to be handled by external interrupts.
4	RSVD	**Reserved**: Do not attempt to modify, always 1.
3	TS	**Task Switched**: Set whenever a task switch operation is performed. Execution of a floating point instruction with TS = 1 causes a DNA fault. If MP = 1 and TS = 1, a WAIT instruction also causes a DNA fault.
2	EM	**Emulate Processor Extension**: If EM = 1, all floating point instructions cause a DNA fault 7.

Table 4-10. CR0 Bit Descriptions (Continued)

Bit	Name	Description
1	MP	**Monitor Processor Extension**: If MP = 1 and TS = 1, a WAIT instruction causes Device Not Available (DNA) fault 7. The TS bit is set to 1 on task switches by the CPU. Floating point instructions are not affected by the state of the MP bit. The MP bit should be set to one during normal operations.
0	PE	**Protected Mode Enable**: Enables the segment based protection mechanism. If PE = 1, protected mode is enabled. If PE = 0, the CPU operates in real mode and addresses are formed as in an 8086-style CPU.

Table 4-11. Effects of Various Combinations of EM, TS, and MP Bits

CR0[3:1]			Instruction Type	
TS	EM	MP	WAIT	ESC
0	0	0	Execute	Execute
0	0	1	Execute	Execute
1	0	0	Execute	Fault 7
1	0	1	Fault 7	Fault 7
0	1	0	Execute	Fault 7
0	1	1	Execute	Fault 7
1	1	0	Execute	Fault 7
1	1	1	Fault 7	Fault 7

4.5 CPU CORE REGISTER DESCRIPTIONS

All CPU Core registers are Model Specific Registers (MSRs) and are accessed via the RDMSR and WRMSR instructions.

Each module inside the processor is assigned a 256 register section of the address space. The module responds to any reads or writes in that range. Unused addresses within a module's address space are reserved, meaning the module returns zeroes on a read and ignores writes. Addresses that are outside all the module address spaces are invalid, meaning a RDMSR/WRMSR instruction attempting to use the address generates a General Protection Fault.

The registers associated with the CPU Core are the Standard GeodeLink Device MSRs and CPU Core Specific MSRs. Table 4-12 and Table 4-13 are register summary tables that include reset values and page references where the bit descriptions are provided. Note that the standard GeodeLink Device MSRs for the CPU Core start at 00002000h.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

Table 4-12. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Name	Reset Value	Reference
00002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP) - Not Used	00000000_000860xxh	Page 107
00002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG) - Not Used	00000000_00000000h	Page 107
00002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI) - Not Used	00000000_00000000h	Page 108
00002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR) - Not Used	00000000_00000000h	Page 108
00002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM) - Not Used	00000000_00000000h	Page 108
00002005h	R/W	GeodeLink Device Diagnostic Bus Control MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 108

Table 4-13. CPU Core Specific MSRs Summary

MSR Address	Type	Name	Reset Value	Reference
x86 Compatible MSRs				
00000010h	R/W	Time Stamp Counter Register	00000000_00000000h	Page 108
000000C1h	R/W	Performance Counter 0 Register	00000000_00000000h	Page 109
000000C2h	R/W	Performance Counter 1 Register	00000000_00000000h	Page 109
00000174h	R/W	System Code Segment Selector Register	00000000_00000000h	Page 109
00000175h	R/W	System Stack Pointer Selector Register	00000000_00000000h	Page 110
00000176h	R/W	System Instruction Pointer Register	00000000_00000000h	Page 110
00000186h	R/W	Performance Counter 0 Control Register	00000000_00000000h	Page 111
00000187h	R/W	Performance Counter 1 Control Register	00000000_00000000h	Page 111
CPU Core MSRs				
00001100h	R/W	BTB Enable Register	00000000_00000000h	Page 112
00001108h	R/W	BTB Address Test Register	00000000_00000000h	Page 112
00001109h	R/W	BTB Data Test Register	0000xxxx_xxxxxxxxh	Page 113
0000110Ah	R/W	Return Stack Address Test Register	00000000_00000xxxh	Page 114
0000110Bh	R/W	Return Stack Data Test Register	0000000x_xxxxxxxxh	Page 115
0000110Ch	R/W	BTB RAM BIST Test Register	00000000_0000xxxxh	Page 115

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001210h	R/W	Suspend-On-Halt Register	00000000_00000000h	Page 116
00001211h	RO	XC Mode Register	00000000_00000000h	Page 117
00001212h	RO	XC History Register	00000000_00000000h	Page 118
00001250h	R/W	Pipeline Control Register	00000000_00000000h	Page 119
00001301h	R/W	SMI Control Register	00000000_00000000h	Page 119
00001302h	R/W	DMI Control Register	00000000_00000000h	Page 120
00001310h	R/W	Temp0 Register	00000000_0000FFF0h	Page 121
00001311h	R/W	Temp1 Register	00000000_00000000h	Page 122
00001312h	R/W	Temp2 Register	00000000_0000FFF0h	Page 121
00001313h	R/W	Temp3 Register	00000000_00000000h	Page 121
00001320h	R/W	ES Segment Selector Register	00000000_00920000h	Page 122
00001321h	R/W	CS Segment Selector Register	00000000_0092F000h	Page 122
00001322h	R/W	SS Segment Selector Register	00000000_00920000h	Page 122
00001323h	R/W	DS Segment Selector Register	00000000_00920000h	Page 122
00001324h	R/W	FS Segment Selector Register	00000000_00920000h	Page 122
00001325h	R/W	GS Segment Selector Register	00000000_00920000h	Page 122
00001326h	R/W	LDT Segment Selector Register	00000000_00820000h	Page 122
00001327h	R/W	Temp Segment Selector Register	00000000_00810000h	Page 122
00001328h	R/W	TSS Segment Selector Register	00000000_00810000h	Page 122
00001329h	R/W	IDT Segment Selector Register	00000000_00920000h	Page 122
0000132Ah	R/W	GDT Segment Selector Register	00000000_00920000h	Page 122
0000132Bh	R/W	SMM Header Shadow Register	00000000_00000000h	Page 123
0000132Ch	R/W	DMM Header Shadow Register	00000000_00000000h	Page 123
00001330h	R/W	ES Base and Limit Register	0000FFFF_00000000h	Page 124
00001331h	R/W	CS Base and Limit Register	0000FFFF_FFFF0000h	Page 124
00001332h	R/W	SS Base and Limit Register	0000FFFF_00000000h	Page 124
00001333h	R/W	DS Base and Limit Register	0000FFFF_00000000h	Page 124
00001334h	R/W	FS Base and Limit Register	0000FFFF_00000000h	Page 124
00001335h	R/W	GS Base and Limit Register	0000FFFF_00000000h	Page 124
00001336h	R/W	LDT Base and Limit Register	0000FFFF_00000000h	Page 124
00001337h	R/W	Temp Base and Limit Register	0000FFFF_00000000h	Page 124
00001338h	R/W	TSS Base and Limit Register	0000FFFF_00000000h	Page 124
00001339h	R/W	IDT Base and Limit Register	0000FFFF_00000000h	Page 124
0000133Ah	R/W	GDT Base and Limit Register	0000FFFF_00000000h	Page 124
0000133Bh	R/W	SMM Base and Limit Register	00000000_00000000h	Page 124
0000133Ch	R/W	DMM Base and Limit Register	00000000_00000000h	Page 124
00001340h	R/W	DR1 and DR0 Breakpoints Register	00000000_00000000h	Page 125
00001341h	R/W	DR3 and DR2 Breakpoints Register	00000000_00000000h	Page 125
00001343h	R/W	DR7 and DR6 Breakpoints Control and Status Register	00000000_FFFF0FF0h	Page 125
00001350h	R/W	XDR1 and XDR0 Extended Breakpoints Register	00000000_00000000h	Page 126

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001351h	R/W	XDR3 and XDR2 Extended Breakpoints Register	00000000_00000000h	Page 126
00001352h	R/W	XDR5 and XDR4 Opcode Mask and Value 4 Register	FFFFFFFF_00000000h	Page 127
00001353h	R/W	XDR7 and XDR6 Extended Breakpoint Control and Status Register	00000000_FFFFAFC0h	Page 127
00001354h	R/W	XDR9 and XDR8 Opcode Mask and Value 5 Register	FFFFFFFF_00000000h	Page 127
00001360h	R/W	EX Stage Instruction Pointer Register	00000000_00000000h	Page 128
00001361h	R/W	WB Stage Instruction Pointer Register	00000000_00000000h	Page 128
00001370h	R/W	FP Environment Code/Instruction Segment Selector Register	00000000_00000000h	Page 129
00001371h	R/W	FP Environment Code/Instruction Offset/Pointer Register	00000000_00000000h	Page 129
00001372h	R/W	FP Environment Operand/Data Segment Selector Register	00000000_00000000h	Page 129
00001373h	R/W	FP Environment Operand/Data Offset/Pointer Register	00000000_00000000h	Page 130
00001374h	R/W	FP Environment Opcode Register	00000000_00000000h	Page 130
00001408h	R/W	General Register EAX	00000000_00000000h	Page 131
00001409h	R/W	General Register ECX	00000000_00000000h	Page 131
0000140Ah	R/W	General Register EDX	00000000_00000000h	Page 131
0000140Bh	R/W	General Register EBX	00000000_00000000h	Page 131
0000140Ch	R/W	General Register ESP	00000000_00000000h	Page 131
0000140Dh	R/W	General Register EBP	00000000_00000000h	Page 131
0000140Eh	R/W	General Register ESI	00000000_00000000h	Page 131
0000140Fh	R/W	General Register EDI	00000000_00000000h	Page 131
00001410h	R/W	General Register Temp 0	00000000_00000000h	Page 131
00001411h	R/W	General Register Temp 1	00000000_00000000h	Page 131
00001412h	R/W	General Register Temp 2	00000000_00000000h	Page 131
00001413h	R/W	General Register Temp 3	00000000_00000000h	Page 131
00001414h	R/W	General Register Temp 4	00000000_00000000h	Page 131
00001415h	R/W	General Register Temp 5	00000000_00000000h	Page 131
00001416h	R/W	General Register Temp 6	00000000_00000000h	Page 131
00001417h	R/W	General Register Temp 7	00000000_00000000h	Page 131
00001418h	R/W	Flags Register	00000000_00000002h	Page 132
00001420h	R/W	Control Register 0 Shadow Register	00000000_60000010h	Page 132
00001428h	RO	Microcode BIST Register	00000000_00000000h	Page 132
00001700h	R/W	Instruction Memory Configuration Register	00000000_00000000h	Page 133
00001710h	R/W	Instruction Cache Index Register	00000000_00000000h	Page 134
00001711h	R/W	Instruction Cache Data Register	xxxxxxxx_xxxxxxxxh	Page 135
00001712h	R/W	Instruction Cache Read/Write Tag Register	00000000_00000000h	Page 135
00001713h	R/W	Instruction Cache Read/Write Tag w/INC Register	00000000_00000000h	Page 136

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001720h	R/W	Instruction Memory TLB Index Register	00000000_00000000h	Page 136
00001721h	R/W	Instruction Memory TLB MRU Register	00000000_00000000h	Page 137
00001722h	R/W	Instruction Memory TLB Entry Register	xxxxx000_xxxxx000h	Page 138
00001723h	R/W	Instruction Memory TLB Entry w/INC Register	00000000_00000000h	Page 138
00001730h	RO	Instruction Memory Tag BIST Register	00000000_00000000h	Page 139
00001731h	RO	Instruction Memory Data BIST Register	00000000_00000000h	Page 139
00001800h	R/W	Data Memory Configuration Register	00000000_00000000h	Page 140
00001808h	R/W	Default Region Configuration Properties Register	01FFFFF0_10000001h Warm Start Value = 04xxxxx0_1xxxxx01h	Page 143
0000180Ah	R/W	Region Configuration Bypass Register	00000000_00000101h Warm Start Value = 00000000_00000219h	Page 143
0000180Bh	R/W	Region Configuration A0000-BFFFF Register	01010101_01010101h Warm Start Value = 19191919_19191919h	Page 144
0000180Ch	R/W	Region Configuration C0000-DFFFF Register	01010101_01010101h Warm Start Value = 19191919_19191919h	Page 144
0000180Dh	R/W	Region Configuration E0000-FFFFF Register	01010101_01010101h Warm Start Value = 19191919_19191919h	Page 145
0000180Eh	R/W	Region Configuration SMM Register	00000001_00000001h Warm Start Value = xxxxx001_xxxxx005h	Page 145
0000180Fh	R/W	Region Configuration DMM Register	00000001_00000001h Warm Start Value = xxxxx001_xxxxx005h	Page 146
00001810h	R/W	Region Configuration Range 0 Register	00000000_00000000h Warm Start Value = xxxxx000_xxxxx0xxh	Page 147
00001811h	R/W	Region Configuration Range 1 Register	00000000_00000000h Warm Start Value = xxxxx000_xxxxx0xxh	Page 147
00001812h	R/W	Region Configuration Range 2 Register	00000000_00000000h Warm Start Value = xxxxx000_xxxxx0xxh	Page 147
00001813h	R/W	Region Configuration Range 3 Register	00000000_00000000h Warm Start Value = xxxxx000_xxxxx0xxh	Page 147
00001814h	R/W	Region Configuration Range 4 Register	00000000_00000000h Warm Start Value = xxxxx000_xxxxx0xxh	Page 147

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001815h	R/W	Region Configuration Range 5 Register	00000000_00000000h	Page 147
			Warm Start Value = xxxxx000_xxxxx0xxh	
00001816h	R/W	Region Configuration Range 6 Register	00000000_00000000h	Page 147
			Warm Start Value = xxxxx000_xxxxx0xxh	
00001817h	R/W	Region Configuration Range 7 Register	00000000_00000000h	Page 147
			Warm Start Value = xxxxx000_xxxxx0xxh	
00001881h	R/W	CR1 Copy Register	00000000_xxxxxxxxh	Page 148
00001882h	R/W	CR2 Copy Register	00000000_xxxxxxxxh	Page 148
00001883h	R/W	CR3 Copy Register	00000000_xxxxxxxxh	Page 148
00001884h	R/W	CR4 Copy Register	00000000_xxxxxxxxh	Page 148
00001890h	R/W	Data Cache Index Register	00000000_00000000h	Page 148
00001891h	R/W	Data Cache Data Register	00000000_00000000h	Page 149
00001892h	R/W	Data Cache Read/Write Tag Register	00000000_00000000h	Page 149
00001893h	R/W	Data Cache Read/Write Tag w/INC Register	00000000_00000000h	Page 150
00001894h	WO	Data/Instruction Cache Snoop Register	00000000_xxxxxxxxh	Page 151
00001898h	R/W	L1 Data TLB Index Register	00000000_00000000h	Page 151
00001899h	R/W	L1 Data TLB LRU Register	00000000_00000000h	Page 152
0000189Ah	R/W	L1 Data TLB Entry Register	00000000_00000020h	Page 153
0000189Bh	R/W	L1 Data TLB Entry w/INC Register	00000000_00000000h	Page 154
0000189Ch	R/W	L2 TLB/DTE Index Register	00000000_00000000h	Page 154
0000189Dh	R/W	L2 TLB/DTE LRU Register	00000000_00000000h	Page 155
0000189Eh	R/W	L2 TLB/DTE Entry Register	00000000_00000020h	Page 157
0000189Fh	R/W	L2 TLB/DTE Entry w/INC Register	00000000_00000000h	Page 158
000018C0h	R/W	Data Memory BIST Register	00000000_00000000h	Page 159
00001900h	R/W	Bus Controller Configuration 0 Register	00000000_00000111h	Page 161
00001901h	R/W	Bus Controller Configuration 1 Register	00000000_00000000h	Page 162
00001904h	RO	Reserved Status Register	00000000_00000000h	Page 162
00001908h	R/W	MSR Lock Register	00000000_00000000h	Page 163
00001910h	R/W	Real Time Stamp Counter Register	00000000_00000000h	Page 163
00001911h	RO	TSC and RTSC Low DWORDs Register	00000000_00000000h	Page 164
00001980h	R/W	Memory Subsystem Array Control Register	00000000_00000000h	Page 164
FPU MSRs				
00001A00h	R/W	FPU Operation Modes Register	00000000_00000000h	Page 165
00001A03h	R/W	FPU BIST Register	00000000_00000000h	Page 166
00001A10h	R/W	FPU x87 Control Word Register	00000000_00000040h	Page 167
00001A11h	R/W	FPU x87 Status Word Register	00000000_00000000h	Page 168
00001A12h	R/W	FPU x87 Tag Word Register	00000000_00000000h	Page 168
00001A13h	RO	FPU Busy Register	00000000_00000000h	Page 168

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001A14h	RO	FPU Register Map Register	00000000_76543210h	Page 169
00001A40h	R/W	Mantissa of R0 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A41h	R/W	Exponent of R0 Register	00000000_0000xxxxh	Page 171
00001A42h	R/W	Mantissa of R1 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A43h	R/W	Exponent of R1 Register	00000000_0000xxxxh	Page 171
00001A44h	R/W	Mantissa of R2 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A45h	R/W	Exponent of R2 Register	00000000_0000xxxxh	Page 171
00001A46h	R/W	Mantissa of R3 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A47h	R/W	Exponent of R3 Register	00000000_0000xxxxh	Page 171
00001A48h	R/W	Mantissa of R4 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A49h	R/W	Exponent of R4 Register	00000000_0000xxxxh	Page 171
00001A4Ah	R/W	Mantissa of R5 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A4Bh	R/W	Exponent of R5 Register	00000000_0000xxxxh	Page 171
00001A4Ch	R/W	Mantissa of R6 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A4Dh	R/W	Exponent of R6 Register	00000000_0000xxxxh	Page 171
00001A4Eh	R/W	Mantissa of R7 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A4Fh	R/W	Exponent of R7 Register	00000000_0000xxxxh	Page 171
00001A50h	R/W	Mantissa of R8 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A51h	R/W	Exponent of R8 Register	00000000_0000xxxxh	Page 171
00001A52h	R/W	Mantissa of R9 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A53h	R/W	Exponent of R9 Register	00000000_0000xxxxh	Page 171
00001A54h	R/W	Mantissa of R10 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A55h	R/W	Exponent of R10 Register	00000000_0000xxxxh	Page 171
00001A56h	R/W	Mantissa of R11 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A57h	R/W	Exponent of R11 Register	00000000_0000xxxxh	Page 171
00001A58h	R/W	Mantissa of R12 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A59h	R/W	Exponent of R12 Register	00000000_0000xxxxh	Page 171
00001A5Ah	R/W	Mantissa of R13 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A5Bh	R/W	Exponent of R13 Register	00000000_0000xxxxh	Page 171
00001A5Ch	R/W	Mantissa of R14 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A5Dh	R/W	Exponent of R14 Register	00000000_0000xxxxh	Page 171
00001A5Eh	R/W	Mantissa of R15 Register	xxxxxxxx_xxxxxxxxh	Page 170
00001A5Fh	R/W	Exponent of R15 Register	00000000_0000xxxxh	Page 171
00001A60h	R/W	Mantissa of M0 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A61h	R/W	Exponent of M0 Register	00000000_0000xxxxh	Page 173
00001A62h	R/W	Mantissa of M1 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A63h	R/W	Exponent of M1 Register	00000000_0000xxxxh	Page 173
00001A64h	R/W	Mantissa of M2 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A65h	R/W	Exponent of M2 Register	00000000_0000xxxxh	Page 173
00001A66h	R/W	Mantissa of M3 Register	xxxxxxxx_xxxxxxxxh	Page 172

CPU Core Register Descriptions (Continued)

Table 4-13. CPU Core Specific MSRs Summary (Continued)

MSR Address	Type	Name	Reset Value	Reference
00001A67h	R/W	Exponent of M3 Register	00000000_0000xxxxh	Page 173
00001A68h	R/W	Mantissa of M4 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A69h	R/W	Exponent of M4 Register	00000000_0000xxxxh	Page 173
00001A6Ah	R/W	Mantissa of M5 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A6Bh	R/W	Exponent of M5 Register	00000000_0000xxxxh	Page 173
00001A6Ch	R/W	Mantissa of M6 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A6Dh	R/W	Exponent of M6 Register	00000000_0000xxxxh	Page 173
00001A6Eh	R/W	Mantissa of M7 Register	xxxxxxxx_xxxxxxxxh	Page 172
00001A6Fh	R/W	Exponent of M7 Register	00000000_0000xxxxh	Page 173
CPU ID MSRs				
00003000h	Write Once	CPUID0 Register (Standard Levels and Vendor ID String 1)	646F6547_00000001h	Page 174
00003001h	Write Once	CPUID1 Register (Vendor ID Strings 2 and 3)	79622065_43534E20h	Page 174
00003002h	Write Once	CPUID2 Register (Type/Family/Model/Step)	00000000_0000055xh	Page 174
00003003h	Write Once	CPUID3 Register (Feature Flags)	0080A93D_00000000h	Page 174
00003004h	Write Once	CPUID4 Register (N/A)	00000000_00000000h	Page 174
00003005h	Write Once	CPUID5 Register (N/A)	00000000_00000000h	Page 174
00003006h	Write Once	CPUID6 Register (Max Extended Levels 1)	646F6547_80000006h	Page 174
00003007h	Write Once	CPUID7 Register (Max Extended Levels 2)	79622065_43534E20h	Page 174
00003008h	Write Once	CPUID8 Register (Extended Type/Family/Model/Stepping)	00000000_0000055xh	Page 174
00003009h	Write Once	CPUID9 Register (Extended Feature Flags)	C0C0A13D_00000000h	Page 174
0000300Ah	Write Once	CPUIDA Register (CPU Marketing Name 1)	4D542865_646F6547h	Page 174
0000300Bh	Write Once	CPUIDB Register (CPU Marketing Name 2)	72676574_6E492029h	Page 174
0000300Ch	Write Once	CPUIDC Register (CPU Marketing Name 3)	6F725020_64657461h	Page 174
0000300Dh	Write Once	CPUIDD Register (CPU Marketing Name 4)	6220726F_73736563h	Page 174
0000300Eh	Write Once	CPUIDE Register (CPU Marketing Name 5)	6E6F6974_614E2079h	Page 174
0000300Fh	Write Once	CPUIDF Register (CPU Marketing Name 6)	00696D65_53206C61h	Page 174
00003010h	Write Once	CPUID10 Register (L1 TLB Information)	FF08FF08_00000000h	Page 174
00003011h	Write Once	CPUID11 Register (L1 Cache Information)	10040120_10040120h	Page 174
00003012h	Write Once	CPUID12 Register (L2 TLB Information)	00002040_0000F004h	Page 174
00003013h	Write Once	CPUID13 Register (L2 Cache Information)	00000000_00000000h	Page 174

CPU Core Register Descriptions (Continued)

4.5.1 Standard GeodeLink Device MSRs

4.5.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 00002000h
Type RO
Reset Value 00000000_000860xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Reads as 0.
23:8	DEV_ID	**Device ID.** Identifies device (0860h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

4.5.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address 00002001h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													PID		

GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.
2:0	PID	**Priority ID Value.** Priority ID value used for CPU Core GLIU requests. Always write to 0.

CPU Core Register Descriptions (Continued)

4.5.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 00002002h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the CPU Core module.

4.5.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 00002003h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the CPU Core module.

4.5.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 00002004h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the CPU Core module.

4.5.1.6 GeodeLink Device Diagnostic Bus Control MSR (GLD_MSR_DIAG)

MSR Address 00002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

4.5.2 CPU Core Specific MSRs

4.5.2.1 Time Stamp Counter Register

MSR Address 00000010h
Type R/W
Reset Value 00000000_00000000h

Time Stamp Counter Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TSC																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TSC																															

Time Stamp Counter Bit Descriptions

Bit	Name	Description
63:0	TSC	**Time Stamp Counter.** This register is the 64-bit Intel-compatible time stamp counter, also readable via the RDTSC instruction. Bus Controller Configuration 0 Register (MSR 00001900h) contains configuration bits that determine if TSC counts during SMM, DMM, or Suspend modes. Writes to this register clears the upper DWORD to 0 to be compatible with Intel's implementation. The lower DWORD is written normally.

CPU Core Register Descriptions (Continued)

4.5.2.2 Performance Counter 0 Register

MSR Address 000000C1h
Type R/W
Reset Value 00000000_00000000h

Performance Counter 0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																								PERF_CNT0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PERF_CNT0																															

Performance Counter 0 Bit Descriptions

Bit	Name	Description
63:40	RSVD	**Reserved.** Write as read.
39:0	PERF_CNT0	**Event Counter 0.** This register is a 40-bit Intel-compatible event counter used to count events or conditions inside of the CPU Core. This counter is controlled by Performance Counter 0 Control Register (MSR 00000186h).

4.5.2.3 Performance Counter 1 Register

MSR Address 000000C2h
Type R/W
Reset Value 00000000_00000000h

Performance Counter 1 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																								PERF_CNT1							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PERF_CNT1																															

Performance Counter 1 Bit Descriptions

Bit	Name	Description
63:40	RSVD	**Reserved.** Write as read.
39:0	PERF_CNT1	**Event Counter 1.** This register is a 40-bit Intel-compatible event counter used to count events or conditions inside of the CPU Core. This counter is controlled by Performance Counter 1 Control Register (MSR 00000187h).

4.5.2.4 System Code Segment Selector Register

MSR Address 00000174h
Type R/W
Reset Value 00000000_00000000h

System Code Segment Selector Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S_CS																															

CPU Core Register Descriptions (Continued)

System Code Segment Selector Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	S_CS	**System Code Segment Selector.**

4.5.2.5 System Stack Pointer Selector Register

MSR Address 00000175h
Type R/W
Reset Value 00000000_00000000h

System Stack Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S_SS																															

System Stack Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	S_SS	**System Stack Pointer.**

4.5.2.6 System Instruction Pointer Register

MSR Address 00000176h
Type R/W
Reset Value 00000000_00000000h

System Instruction Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S_IP																															

System Instruction Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	S_IP	**System Instruction Pointer.**

CPU Core Register Descriptions (Continued)

4.5.2.7 Performance Counter 0 Control Register

MSR Address 00000186h
Type R/W
Reset Value 00000000_00000000h

Performance Counter 0 Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD									PC_EN	RSVD						PC0_UMASK								PC0_EVENT						

Performance Counter 0 Control Bit Descriptions

Bit	Name	Description
63:23	RSVD	**Reserved.** Write as read.
22	PC_EN	**Performance Counters 0 and 1 Enable.** 0: Disable counters. 1: Enable counters.
21:16	RSVD	**Reserved.** Write as read.
15:8	PC0_UMASK	**Performance Counter 0 Unit Mask.** Selects sub-events. 00h: All sub-events counted.
7:0	PC0_EVENT	**Performance Counter 0 Event Select Value.** See individual module chapters for performance events.

4.5.2.8 Performance Counter 1 Control Register

MSR Address 00000187h
Type R/W
Reset Value 00000000_00000000h

Performance Counter 1 Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																PC1_UMASK								PC1_EVENT						

Performance Counter 1 Control Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:8	PC1_UMASK	**Performance Counter 1 Unit Mask.** Selects sub-events. 00h: All sub-events counted.
7:0	PC1_EVENT	**Performance Counter 1 Event Select Value.** See individual module chapters for performance events.

CPU Core Register Descriptions (Continued)

4.5.2.9 BTB Enable Register

MSR Address 00001100h
Type R/W
Reset Value 00000000_00000000h

BTB Enable Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																							HSE	RSVD			RSE	RSVD			BTBE

BTB Enable Bit Descriptions

Bit	Name	Description
63:9	RSVD	**Reserved.** Write as read.
8	HSE	**High Speculative Mode Enable.** If two or more highly speculative branches are active in the integer pipeline, this mode, when enabled, stalls the Instruction Decode and Pre-Fetch stages in the pipeline until all but one of the branches resolve. 0: HSE disabled. 1: HSE enabled.
7:5	RSVD	**Reserved.** Write as read.
4	RSE	**Return Stack Enable.** Enables the near CALL instruction Return Stack of the BTB. For the Return Stack to function, bit 0 (BTBE) of this register must be enabled. 0: RSE disabled. 1: RSE enabled.
3:1	RSVD	**Reserved.** Write as read.
0	BTBE	**Branch Target Buffer Enable.** Enables the BTB. 0: BTBE disabled. 1: BTBE enabled.

4.5.2.10 BTB Address Test Register

MSR Address 00001108h
Type R/W
Reset Value 00000000_00000000h

BTB Address Test Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD															BTB_TST	RSVD							BTB_INDX								

CPU Core Register Descriptions (Continued)

BTB Address Test Bit Descriptions

Bit	Name	Description
63:17	RSVD	**Reserved.** Write as read.
16	BTB_TST	**BTB Test Mode Enable.** Enables test mode access to the BTB. 0: BTB_TST disable. 1: BTB_TST enable.
15:9	RSVD	**Reserved.** Write as read.
8:0	BTB_INDX	**BTB Index.** Address of one of the 512 BTB entries. The BTB_INDX auto-increments by one each time the BTB Data Test Register is accessed (read or write), and wraps back to 000 after the value of 1FFh is reached.

4.5.2.11 BTB Data Test Register

MSR Address 00001109h
Type R/W
Reset Value 0000xxxx_xxxxxxxxh

BTB Data Test Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																BTB_LRW	BTB_VAL	BTB_CTAG									BTB_ALSB		BTB_IB_SP	BTB_BP	
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BTB_TADD																															

BTB Data Test Bit Descriptions

Bit	Name	Description
63:48	RSVD	**Reserved.** Write as read.
47	BTB_LRW (RO)	**BTB Least Recently Written Bit (Read Only).** Stores the LRW flag for the tag RAM line containing the entry being accessed. It is set according to the LRW algorithm for write accesses. 0: Way 1 was last written. 1: Way 0 was last written.
46	BTB_VAL	**BTB Line Valid Bit.** 0: BTB line is invalid. 1: BTB line is valid.
45:37	BTB_CTAG	**BTB Tag Compare Value.** This value is used to determine a BTB hit for the entry. The bits correspond to bits [18:10] of the linear instruction pointer.
36:35	BTB_ALSB	**BTB Address LSBs.** Stores the two LSBs of the instruction pointer. The BTB can only track one branch per four bytes. These bits are used to confirm that the instruction decoder of the integer pipeline saw the branch that the BTB identified.
34	BTB_IB_SP	**BTB Branch Instruction Spans Instruction Buffer Line Boundary.** Determines if a branch instruction crosses the 8-byte instruction buffer line boundary. 0: BTB branch instruction does not cross the instruction buffer line boundary. 1: BTB branch instruction crosses the instruction buffer line boundary.

CPU Core Register Descriptions (Continued)

BTB Data Test Bit Descriptions (Continued)

Bit	Name	Description
33:32	BTB_BP	**BTB_Branch Predictor.** The predictor state for the branch. 00: Strongly not taken. 01: Weakly not taken. 10: Weakly taken. 11: Strongly taken.
31:0	BTB_TADD	**BTB Target Address.** The 32-bit linear branch target address.

4.5.2.12 Return Stack Address Test Register

MSR Address 0000110Ah
Type R/W
Reset Value 00000000_00000xxxh

Return Stack Address Test Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																							RS_PA	RSVD					RS_INDX		

Return Stack Address Test Bit Descriptions

Bit	Name	Description
63:9	RSVD	**Reserved.** Write as read.
8	RS_PA (RO)	**Return Stack Pointer Access (Read Only).** Data in RS_DATA (MSR 0000110Bh[31:0]) is the Return Stack Target Address or Return Stack Pointer. After a read/write of the Return Stack Data Register, the Return Stack Index (RS_INDX, bits [2:0]) auto-increments. When the value of the index reaches 7h, it remains at this value for two read/write cycles. For the second read/write, RS_PA is a 1 so that the Return Stack Pointer can be read or write. 0: Data is Return Stack Target Address. 1: Data is Return Stack Pointer.
7:3	RSVD	**Reserved.** Write as read.
2:0	RS_INDX	**Return Stack Index.** Contains the address used to access the eight Return Stack entries and the Return Stack Pointer. This register auto-increments when the Return Stack Data register is read/write.

CPU Core Register Descriptions (Continued)

4.5.2.13 Return Stack Data Test Register

MSR Address 0000110Bh
Type R/W
Reset Value 0000000x_xxxxxxxxh

Return Stack Data Test Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															RS_VALID
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RS_DATA																															

Return Stack Data Test Bit Descriptions

Bit	Name	Description
63:33	RSVD	**Reserved.** Write as read.
32	RS_VALID	**Return Stack Valid Bit.** If the RS_PA bit (MSR 0000110Ah[8]) is 0, then this bit indicates that the Return Stack Data (RS_DATA) is valid**.** If = 0 and if RS_PA = 0: RS_DATA is invalid. If = 1 and if RS_PA = 0: RS_DATA is valid. If = 0 or 1 and if RS_PA = 1: RS_DATA = 0.
31:0	RS_DATA	**Return Stack Data.** If the RS_PA bit (MSR 0000110Ah[8]) is 0, then this register contains the Return Stack Data pointed to by the Return Stack Index (RS_INDX). If the RS_PA bit = 1 then bits [31:3] = 0 and bits [2:0] contain the current Return Stack Pointer. The Return Stack Pointer indicates which entry is the top of the Return Stack.

4.5.2.14 BTB RAM BIST Test Register

MSR Address 0000110Ch
Type R/W
Reset Value 00000000_0000xxxxh

BTB RAM BIST Test Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																		BTB_TRCS	BTB_TRGO	RSVD		BTB_TRRE	BTB_TRBE	RSVD		BTB_RCS	BTB_RGO	RSVD		BTB_RRE	BTB_RBE

BTB RAM BIST Test Bit Descriptions

Bit	Name	Description
63:14	RSVD	**Reserved.** Write as read.
13	BTB_TRCS (RO)	**BTB Tag RAM Compare Status (Read Only).** The active high compare status value for the BTB Tag RAMs.

CPU Core Register Descriptions (Continued)

BTB RAM BIST Test Bit Descriptions (Continued)

Bit	Name	Description
12	BTB_TRGO (RO)	**BTB Tag RAM Go (Read Only).** Pass/fail indication for the BTB Tag RAMs. 0: Fail. 1: Pass.
11:10	RSVD	**Reserved.** Write as read.
9	BTB_TRRE	**BTB Tag RAM Retention Enable.** Setting this bit enables the BTB Tag RAM retention test. The BTB_TRBE bit (bit 8) must also be set for the retention test to be preformed. After a write of a 1 to this register, any subsequent read clears this bit.
8	BTB_TRBE	**BTB Tag RAM BIST Enable.** Setting this bit enables BTB Tag RAM Built-in Self-test (BIST). Setting this bit overrides the BTBE bit (bit 0) of the BTB Enable Register (MSR 00001100h) and performs BIST for the BTB Tag RAMs when this register is read. The bit is cleared after a read of this register.
7:6	RSVD	**Reserved.** Write as read.
5	BTB_RCS (RO)	**BTB Target RAM Compare Status (Read Only).** The active high compare status value for the BTB Target RAMs.
4	BTB_RGO	**BTB Target RAM Go (Read Only).** Pass/fail indication for the BTB Target RAMs. 0: Fail. 1: Pass.
3:2	RSVD	**Reserved.** Write as read.
1	BTB_RRE	**BTB Target RAM Retention Enable.** Setting this bit enables the BTB Target RAM retention test. The BTB_TRBE bit (bit 8) must also be set for the retention test to be preformed. After a write of a 1 to this register, any subsequent read clears this bit.
0	BTB_RBE	**BTB Target RAM BIST Enable.** Setting this bit enables BTB Target RAM Built-in Self-test (BIST). Setting this bit overrides the BTBE bit (bit 0) of the BTB Enable Register (MSR 00001100h) and performs BIST for the BTB Target RAMs when this register is read. The bit is cleared after a read of this register.

4.5.2.15 Suspend-On-Halt Register

MSR Address 00001210h
Type R/W
Reset Value 00000000_00000000h

Suspend-On-Halt Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															SUSP_HLT

CPU Core Register Descriptions (Continued)

Suspend-On-Halt Bit Descriptions

Bit	Name	Description
63:1	RSVD	**Reserved.** Write as read.
0	SUSP_HLT	**Suspend-on-Halt.** If enabled, the CPU Core enters the Suspend state after a HLT instruction has been executed. 0: Disable. 1: Enable.

4.5.2.16 XC Mode Register

MSR Address 00001211h
Type RO
Reset Value 00000000_00000000h

XC Mode Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																									WAIT_FPINTR	FLUSHING	HALTED	SUSPENDED	NMM_ACTIVE	DMM_ACTIVE	SMM_ACTIVE

XC Mode Bit Descriptions

Bit	Name	Description
63:7	RSVD	**Reserved (Read Only).**
6	WAIT_FPINTR (RO)	**Wait for FP Interrupt (Read Only).** When this bit is 1, it indicates that the processor is waiting for an external maskable interrupt due to an FP error (CR0 NE bit is set).
5	FLUSHING (RO)	**Flushing (Read Only).** When this bit is 1, it indicates that the processor is flushing the pipeline while waiting for DM to empty.
4	HALTED (RO)	**Halted (Read Only).** When this bit is 1, it indicates that the processor is halted.
3	SUSPENDED (RO)	**Suspended (Read Only).** When this bit is 1, it indicates that the processor is in Suspend.
2	NMM_ACTIVE (RO)	**NMI Management Mode Active (Read Only).** When this bit is 1, it indicates that the processor is in an NMI handler.
1	DMM_ACTIVE (RO)	**Debug Management Mode Active (Read Only).** When this bit is 1, it indicates that the processor is in debug management mode.
0	SMM_ACTIVE (RO)	**System Management Mode Active (Read Only).** When this bit is 1, it indicates that the processor is in system management mode.

CPU Core Register Descriptions (Continued)

4.5.2.17 XC History Register

MSR Address 00001212h
Type RO
Reset Value 00000000_00000000h

XC History Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD				TYPE11					TYPE10					TYPE9					TYPE8					TYPE7					TYPE6[4:2]		
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TYPE6 [1:0]		TYPE5					TYPE4					TYPE3					TYPE2					TYPE1					TYPE0				

XC History Bit Descriptions

Bit	Name	Description (Note 1)
63:60	RSVD (RO)	**Reserved (Read Only).**
59:55	TYPE11 (RO)	**Exception Type 11 (Read Only).**
54:50	TYPE10 (RO)	**Exception Type 10 (Read Only).**
49:45	TYPE9 (RO)	**Exception Type 9 (Read Only).**
44:40	TYPE8 (RO)	**Exception Type 8 (Read Only).**
39:35	TYPE7 (RO)	**Exception Type 7 (Read Only).**
34:30	TYPE6 (RO)	**Exception Type 6 (Read Only).**
29:25	TYPE5 (RO)	**Exception Type 5 (Read Only).**
24:20	TYPE4 (RO)	**Exception Type 4 (Read Only).**
19:15	TYPE3 (RO)	**Exception Type 3 (Read Only).**
14:10	TYPE2 (RO)	**Exception Type 2 (Read Only).**
9:5	TYPE1 (RO)	**Exception Type 1 (Read Only).**
4:0	TYPE0 (RO)	**Exception Type 0 (Read Only).**

Note 1. Table 4-14 shows the definition of the types in the XC_HIST MSR.

Table 4-14. XC History Exception Types

Value	Description	Value	Description	Value	Description
00h	Divide error	0Bh	Segment not present	16h	External system management
01h	Debug	0Ch	Stack fault	17h	External system management during I/O instruction
02h	External non-maskable interrupt	0Dh	General protection fault	18h	Init
03h	Breakpoint	0Eh	Page fault	19h	Reset
04h	Overflow	0Fh	Reserved	1Ah	Internal suspend/stall
05h	Bound	10h	FPU error trap	1Bh	External suspend/stall
06h	Invalid operation code	11h	Alignment fault	1Ch	Unsuspend/unstall
07h	FPU unavailable	12h	FPU error interrupt	1Dh	Triple fault shutdown
08h	Double fault	13h	Internal debug management	1Eh	External maskable interrupt
09h	Reserved	14h	External debug management	1Fh	No exception
0Ah	Invalid task-state segment	15h	I/O-initiated system management	--	--

CPU Core Register Descriptions (Continued)

4.5.2.18 Pipeline Control Register

MSR Address 00001250h
Type R/W
Reset Value 00000000_00000000h

Pipeline Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														INV_3DNOW	PIPE_SER

Pipeline Control Bit Descriptions

Bit	Name	Description
63:2	RSVD	**Reserved.** Write as read.
1	INV_3DNOW	**Inverse 3DNow! Instructions.** Enable/disable the PFRCPV and PFRSQRT inverse 3DNow! instructions. 0: Disable. 1: Enable.
0	PIPE_SER	**Serialize Integer Pipeline.** Serialize the integer pipeline by only allowing one instruction down the pipeline at any given time. This is a debug feature. Normal operation is to not serialize. 0: Normal operation of the integer pipeline. 1: Serialize the integer pipeline.

4.5.2.19 SMI Control Register

MSR Address 00001301h
Type R/W
Reset Value 00000000_00000000h

SMI Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																										SMI_EXTL	SMI_IO	SMI_INST	SMM_NEST	SMM_SUSP	SMM_NMI

SMI Control Bit Descriptions

Bit	Name	Description
63:6	RSVD (RO)	**Reserved (Read Only).**
5	SMI_EXTL	**Enable External SMI Pin.** Enable SMIs caused by the SMI# pin (ball M2). 0: Disable. 1: Enable.

CPU Core Register Descriptions (Continued)

SMI Control Bit Descriptions (Continued)

Bit	Name	Description
4	SMI_IO	**Enable I/O Generated SMI.** Enable SMIs caused by an I/O instruction. 0: Disable. 1: Enable.
3	SMI_INST	**Enable SMI Instructions.** Enable SMI instructions: SMINT, RSM, SVDC, RSDC, SVLDT, RSLDT, SVTS, RSTS. If not enabled, executing an SMI instruction causes an invalid operation fault. 0: Disable. 1: Enable.
2	SMM_NEST	**Enable SMI Nesting.** Enable non-software SMIs during SMM mode. 0: Disable. 1: Enable.
1	SMM_SUSP	**Enable SUSP# during SMM.** Enable SUSP# pin (ball K3) during SMM mode. 0: Disable. 1: Enable.
0	SMM_NMI	**Enable Non-Maskable Interrupts during SMM.** Enable NMI during SMM mode. 0: Disable. 1: Enable.

4.5.2.20 DMI Control Register

MSR Address 00001302h
Type R/W
Reset Value 00000000_00000000h

DMI Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						DMI_TF	DMI_STALL	DMM_SUSP	DMI_TSS	DMM_CACHE	DMI_ICEBP	DMI_DBG	DMI_EXT	DMI_GPF	DMI_INST

DMI Control Register Bit Descriptions

Bit	Name	Description
63:10	RSVD	**Reserved.** Write as read.
9	DMI_TF	**DMI Trap Flag.** 0: Disable DMI single stepping. 1: If DMI_STALL (bit 8) is 0, DMI occurs after the successful execution of each instruction. If DMI_STALL is 1, debug stall occurs after the successful execution of each instruction.
8	DMI_STALL	**DMI Stall.** 0: If not in DMM, DMI conditions cause DMIs. 1: DMI conditions cause a debug stall.

CPU Core Register Descriptions (Continued)

DMI Control Register Bit Descriptions (Continued)

Bit	Name	Description
7	DMM_SUSP	**Enable SUSP# during DMM.** Enable SUSP# during DMM mode. 0: Disable. 1: Enable.
6	DMI_TSS	**Task Switch Debug Fault Control.** 0: Task switch debug faults cause debug exceptions. 1: Task switch debug exceptions cause DMIs when not in DMM.
5	DMM_CACHE	**Cache Control during DMM.** 0: Don't change CR0 CD and NW bits when entering DMM. 1: Set CR0, CD and NW bits when entering DMM.
4	DMI_ICEBP	**Enable DMIs on ICEBP (F1) Instructions.** 0: Disable. 1: Enable.
3	DMI_DBG	**Enable Replacing Debug Exceptions as DMIs.** 0: Disable. 1: Enable.
2	DMI_EXT	**Enable External TDBGI Pin.** Enable DMIs caused by the TDBGI pin (ball C11) when not in DMM. 0: Disable. 1: Enable.
1	DMI_GPF	**Enable General Protection Fault Conditions causing DMIs.** When enabled and not in DMM mode, allow general protection faults to generate DMIs. 0: Disable. 1: Enable.
0	DMI_INST	**Enable DMI Instructions.** Enable DMI instructions DMINT and RDM. If not enabled, executing a DMI instruction generates an invalid operation fault. 0: Disable. 1: Enable.

4.5.2.21 Temp[x] Registers

Temp0 Register

MSR Address	00001310h
Type	R/W
Reset Value	00000000_0000FFF0h

Temp1 Register

MSR Address	00001311h
Type	R/W
Reset Value	00000000_00000000h

Temp2 Register

MSR Address	00001312h
Type	R/W
Reset Value	00000000_0000FFF0h

Temp3 Register

MSR Address	00001313h
Type	R/W
Reset Value	00000000_00000000h

Temp[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TEMP[x]																															

Temp[x] Register Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	TEMP[x]	**Temp[x].**

4.5.2.22 Segment Selector Registers

ES Segment Selector Register
MSR Address 00001320h
Type R/W
Reset Value 00000000_00920000h

CS Segment Selector Register
MSR Address 00001321h
Type R/W
Reset Value 00000000_0092F000h

SS Segment Selector Register
MSR Address 00001322h
Type R/W
Reset Value 00000000_00920000h

DS Segment Selector Register
MSR Address 00001323h
Type R/W
Reset Value 00000000_00920000h

FS Segment Selector Register
MSR Address 00001324h
Type R/W
Reset Value 00000000_00920000h

GS Segment Selector Register
MSR Address 00001325h
Type R/W
Reset Value 00000000_00920000h

LDT Segment Selector Register
MSR Address 00001326h
Type R/W
Reset Value 00000000_00820000h

Temp Segment Selector Register
MSR Address 00001327h
Type R/W
Reset Value 00000000_00810000h

TSS Segment Selector Register
MSR Address 00001328h
Type R/W
Reset Value 00000000_00810000h

IDT Segment Selector Register
MSR Address 00001329h
Type R/W
Reset Value 00000000_00920000h

GDT Segment Selector Register
MSR Address 0000132Ah
Type R/W
Reset Value 00000000_00920000h

Segment Selector Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SS[x]																															

Segment Selector Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	SS[x]	**Segment Selector and Descriptor Control Bits.**

CPU Core Register Descriptions (Continued)

4.5.2.23 SMM Header Shadow Register

MSR Address 0000132Bh
Type R/W
Reset Value 00000000_00000000h

SMM Header Shadow Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SMHR																															

SMM Header Shadow Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	SMHR	**SMM Header Shadow.** Address is DWORD aligned and bits [1:0] are ignored.

4.5.2.24 DMM Header Shadow Register

MSR Address 0000132Ch
Type R/W
Reset Value 00000000_00000000h

DMM Header Shadow Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DMHR																															

DMM Header Shadow Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	DMHR	**DMM Header Shadow.**

CPU Core Register Descriptions (Continued)

4.5.2.25 Base and Limit Registers

ES Base and Limit Register
MSR Address 00001330h
Type R/W
Reset Value 0000FFFF_00000000h

CS Base and Limit Register
MSR Address 00001331h
Type R/W
Reset Value 0000FFFF_FFFF0000h

SS Base and Limit Register
MSR Address 00001332h
Type R/W
Reset Value 0000FFFF_00000000h

DS Base and Limit Register
MSR Address 00001333h
Type R/W
Reset Value 0000FFFF_00000000h

FS Base and Limit Register
MSR Address 00001334h
Type R/W
Reset Value 0000FFFF_00000000h

GS Base and Limit Register
MSR Address 00001335h
Type R/W
Reset Value 0000FFFF_00000000h

LDT Base and Limit Register
MSR Address 00001336h
Type R/W
Reset Value 0000FFFF_00000000h

Temp Base and Limit Register
MSR Address 00001337h
Type R/W
Reset Value 0000FFFF_00000000h

TSS Base and Limit Register
MSR Address 00001338h
Type R/W
Reset Value 0000FFFF_00000000h

IDT Base and Limit Register
MSR Address 00001339h
Type R/W
Reset Value 0000FFFF_00000000h

GDT Base and Limit Register
MSR Address 0000133Ah
Type R/W
Reset Value 0000FFFF_00000000h

SMM Base and Limit Register
MSR Address 0000133Bh
Type R/W
Reset Value 00000000_00000000h

DMM Base and Limit Register
MSR Address 0000133Ch
Type R/W
Reset Value 00000000_00000000h

Base and Limit Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
LIMIT																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																															

Base and Limit Bit Descriptions

Bit	Name	Description
63:32	LIMIT	**Limit.**
31:0	BASE	**Base.**

CPU Core Register Descriptions (Continued)

4.5.2.26 DR1 and DR0 Breakpoints Register

MSR Address 00001340h
Type R/W
Reset Value 00000000_00000000h

DR1 and DR0 Breakpoints Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DR1																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DR0																															

DR1 and DR0 Breakpoints Bit Descriptions

Bit	Name	Description
63:32	DR1	**Breakpoint 1.**
31:0	DR0	**Breakpoint 0.**

4.5.2.27 DR3 and DR2 Breakpoints Register

MSR Address 00001341h
Type R/W
Reset Value 00000000_00000000h

DR3 and DR3 Breakpoints Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DR3																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DR2																															

DR3 and DR2 Breakpoints Bit Descriptions

Bit	Name	Description
63:32	DR3	**Breakpoint 3.**
31:0	DR2	**Breakpoint 2.**

4.5.2.28 DR7 and DR6 Breakpoints Control and Status Register

MSR Address 00001343h
Type R/W
Reset Value 00000000_FFFF0FF0h

DR7 and DR6 Breakpoints Control and Status Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DR7																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DR6																															

CPU Core Register Descriptions (Continued)

DR7 and DR6 Breakpoints Control and Status Register Bit Descriptions

Bit	Name	Description
63:32	DR7	**Breakpoint Control.**
31:0	DR6	**Breakpoint Status.**

4.5.2.29 XDR1 and XDR0 Extended Breakpoints Register

MSR Address 00001350h
Type R/W
Reset Value 00000000_00000000h

DR1 and XDR0 Extended Breakpoints Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
XDR1																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
XDR0																															

XDR1 and XDR0 Extended Breakpoints Bit Descriptions

Bit	Name	Description
63:32	XDR1	**Extended Breakpoint 1.**
31:0	XDR0	**Extended Breakpoint 0.**

4.5.2.30 XDR3 and XDR2 Extended Breakpoints Register

MSR Address 00001351h
Type R/W
Reset Value 00000000_00000000h

XDR3 and XDR2 Extended Breakpoints Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
XDR3																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
XDR2																															

XDR3 and XDR2 Extended Breakpoints Bit Descriptions

Bit	Name	Description
63:32	XDR3	**Extended Breakpoint 3.**
31:0	XDR2	**Extended Breakpoint 2.**

CPU Core Register Descriptions (Continued)

4.5.2.31 XDR5 and XDR4 Opcode Mask and Value 4 Register

MSR Address 00001352h
Type R/W
Reset Value FFFFFFFF_00000000h

XDR5 and XDR4 Opcode Mask and Value 4 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
XDR5																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
XDR4																															

XDR5 and XDR4 Opcode Mask and Value 4 Bit Descriptions

Bit	Name	Description
63:32	XDR5	**Opcode Mask.**
31:0	XDR4	**Value 4.**

4.5.2.32 XDR7 and XDR6 Extended Breakpoint Control and Status Register

MSR Address 00001353h
Type R/W
Reset Value 00000000_FFFFAFC0h

XDR7 and XDR6 Extended Breakpoint Control and Status Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
XDR7																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
XDR6																															

XDR7 and XDR6 Extended Breakpoint Control and Status Bit Descriptions

Bit	Name	Description
63:32	XDR7	**Extended Breakpoint Control.**
31:0	XDR6	**Extended Breakpoint Status.**

4.5.2.33 XDR9 and XDR8 Opcode Mask and Value 5 Register

MSR Address 00001354h
Type R/W
Reset Value FFFFFFFF_00000000h

XDR9 and XDR8 Opcode Mask and Value 5 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
XDR9																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
XDR8																															

CPU Core Register Descriptions (Continued)

XDR9 and XDR8 Opcode Mask and Value 5 Bit Descriptions

Bit	Name	Description
63:32	XDR9	**Opcode Mask.**
31:0	XDR8	**Value 5.**

4.5.2.34 EX Stage Instruction Pointer Register

MSR Address 00001360h
Type R/W
Reset Value 00000000_00000000h

EX Stage Instruction Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EX_IP																															

EX Stage Instruction Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	EX_IP	**EX Stage Instruction Pointer.**

4.5.2.35 WB Stage Instruction Pointer Register

MSR Address 00001361h
Type R/W
Reset Value 00000000_00000000h

WB Stage Instruction Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WP_IP																															

WB Stage Instruction Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	WB_IP	**WB Stage Instruction Pointer.**

CPU Core Register Descriptions (Continued)

4.5.2.36 FP Environment Code/Instruction Segment Selector Register

MSR Address 00001370h
Type R/W
Reset Value 00000000_00000000h

FP Environment Code/Instruction Segment Selector Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPENV_CS																															

FP Environment Code/Instruction Segment Selector Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FPENV_CS	**FP Environment Code/Instruction Segment Selector.**

4.5.2.37 FP Environment Code/Instruction Offset/Pointer Register

MSR Address 00001371h
Type R/W
Reset Value 00000000_00000000h

FP Environment Code/Instruction Offset/Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPENV_IP																															

FP Environment Code/Instruction Offset/Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FPENV_IP	**FP Environment Code/Instruction Offset/Pointer.**

4.5.2.38 FP Environment Operand/Data Segment Selector Register

MSR Address 00001372h
Type R/W
Reset Value 00000000_00000000h

FP Environment Operand/Data Segment Selector Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPENV_DS																															

FP Environment Operand/Data Segment Selector Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FPENV_DS	**FP Environment Operand/Data Segment Selector.**

4.5.2.39 FP Environment Operand/Data Offset/Pointer Register

MSR Address 00001373h
Type R/W
Reset Value 00000000_00000000h

FP Environment Operand/Data Offset/Pointer Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPENV_DP																															

FP Environment Operand/Data Offset/Pointer Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FPENV_DP	**FP Environment Operand/Data Offset/Pointer.**

4.5.2.40 FP Environment Opcode Register

MSR Address 00001374h
Type R/W
Reset Value 00000000_00000000h

FP Environment Opcode Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPENV_OP																															

FP Environment Opcode Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FPENV_OP	**FP Environment Opcode.**

CPU Core Register Descriptions (Continued)

4.5.2.41 General Registers

General Register EAX
MSR Address 00001408h
Type R/W
Reset Value 00000000_00000000h

General Register ECX
MSR Address 00001409h
Type R/W
Reset Value 00000000_00000000h

General Register EDX
MSR Address 0000140Ah
Type R/W
Reset Value 00000000_00000000h

General Register EBX
MSR Address 0000140Bh
Type R/W
Reset Value 00000000_00000000h

General Register ESP
MSR Address 0000140Ch
Type R/W
Reset Value 00000000_00000000h

General Register EBP
MSR Address 0000140Dh
Type R/W
Reset Value 00000000_00000000h

General Register ESI
MSR Address 0000140Eh
Type R/W
Reset Value 00000000_00000000h

General Register EDI
MSR Address 0000140Fh
Type R/W
Reset Value 00000000_00000000h

General Register Temp 0
MSR Address 00001410h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 1
MSR Address 00001411h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 2
MSR Address 00001412h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 3
MSR Address 00001413h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 4
MSR Address 00001414h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 5
MSR Address 00001415h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 6
MSR Address 00001416h
Type R/W
Reset Value 00000000_00000000h

General Register Temp 7
MSR Address 00001417h
Type R/W
Reset Value 00000000_00000000h

General Registers Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GR_REG																															

General Registers Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	GR_REG	**General Register.**

CPU Core Register Descriptions (Continued)

4.5.2.42 Flags Register

MSR Address 00001418h
Type R/W
Reset Value 00000000_00000002h

Flags Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FLAGS																															

Flags Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	FLAGS	**Flags.**

4.5.2.43 Control Register 0 Shadow Register

MSR Address 00001420h
Type R/W
Reset Value 00000000_60000010h

Control Register 0 Shadow Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CR0																															

Control Register 0 Shadow Register Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	CR0	**Control Register 0.**

4.5.2.44 Microcode BIST Register

MSR Address 00001428h
Type RO
Reset Value 00000000_00000000h

Microcode BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
UBIST																															

CPU Core Register Descriptions (Continued)

Microcode BIST Register Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	UBIST (RO)	**Enable Microcode BIST (Read Only).** Reading this register enables the microcode BIST and returns the test results. 00000000h: Reserved 00000001h: Pass 00000002h: Fail 00000003h >: Reserved

4.5.2.45 Instruction Memory Configuration Register

MSR Address 00001700h
Type R/W
Reset Value 00000000_00000000h

Instruction Memory Configuration Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD											IM_QWT	RSVD			IM_DRT	IM_LOCK				RSVD			IM_CE	RSVD			IM_BEN	RSVD			IM_CEN

Instruction Memory Configuration Bit Descriptions

Bit	Name	Description
63:21	RSVD	**Reserved.** Write as read.
20	IM_QWT	**Enable QW Request Pacing when in Write Serialized Regions.** When the write serialized attribute from the TLB is set for a request, the IM waits for the pipeline to empty before issuing the QW read request to BC. Note that speculative requests to write serialized pages are aborted. 0: Disable. 1: Enable.
19:17	RSVD	**Reserved.** Write as read.
16	IM_DRT	**Dynamic Retention Test.** Enable dynamic retention test for BIST of tag array. 0: Disable 1: Enable
15:12	IM_LOCK	**Lock Instruction Memory Cache.** Locks Way of the IM cache from being allocated or replaced on an instruction cache miss. If all Ways are locked, bits [15:12] = 1111, the IM cache is effectively disabled. 0000: Way[3:0] enabled. xxx1: At least Way0 disabled. xx1x: At least Way1 disabled. x1xx: At least Way2 disabled. 1xxx: At least Way3 disabled. 1111: Way[3:0] disabled.
11:9	RSVD	**Reserved.** Write as read.

CPU Core Register Descriptions (Continued)

Instruction Memory Configuration Bit Descriptions (Continued)

Bit	Name	Description
8	IM_CE	**Instruction Memory Cache Enable.** 0: Enabled. 1: Disabled. Cache contents are modified.
7:5	RSVD	**Reserved.** Write as read.
4	IM_BEN	**Overlapped Requests to Bus Controller Enable.** 0: Disable overlapped requests to BC. 1: Enable overlapped requests to BC.
3:1	RSVD	**Reserved.** Write as read.
0	IM_CEN	**Cache Reads During Cache Line Fills Enable.** 0: Disable cache reads during line fills. 1: Enable cache reads during line fills.

4.5.2.46 Instruction Cache Index Register

MSR Address 00001710h
Type R/W
Reset Value 00000000_00000000h

Instruction Cache Index Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														IC_ DSEL		RSVD							IC_ WAY		IC_LINE						

Instruction Cache Index Bit Descriptions

Bit	Name	Description
63:18	RSVD	**Reserved.** Write as read.
17:16	IC_DSEL	**Data QWORD Select.** Determines which QWORD in a cache line is accessed by a read or a write to IC_DATA (MSR 00001711h). IC_DSEL increments on accesses to IC_DATA and resets to 0 on accesses to the Instruction Cache Read/Write Tag register or the Instruction Cache Read/Write Tag w/INC register (MSR 00001712h and 00001713h, respectively).
15:9	RSVD (RO)	**Reserved (Read Only).**
8:7	IC_WAY	**Cache Way Select.** Forms the high 2 bits of a 9-bit counter. IC_LINE (bits [6:0]) forms the low 7 bits of the counter. This field increments when the IC_LINE overflows on an access to the Instruction Cache Read/Write Tag w/INC register (MSR 00001713h).
6:0	IC_LINE	**Cache Line Select.** Forms the low 7 bits of a 9-bit counter. IC_WAY (bits [8:7] forms the high 2 bits of the counter. This field post-increments on accesses to the Instruction Cache Read/Write Tag w/INC register (MSR 00001713h).

CPU Core Register Descriptions (Continued)

4.5.2.47 Instruction Cache Data Register

MSR Address 00001711h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Instruction Cache Data Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IC_DATA																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IC_DATA																															

Instruction Cache Data Bit Descriptions

Bit	Name	Description
63:0	IC_DATA	**Instruction Cache Data.** QWORD read from or written to the instruction cache. The address to the QWORD is specified by the IC_LINE, IC_WAY, and IC_DSEL fields from the Instruction Cache Index register (MSR 00001710h). Each access to IC_DATA increments IC_DSEL.

4.5.2.48 Instruction Cache Read/Write Tag Register

MSR Address 00001712h
Type R/W
Reset Value 00000000_00000000h

Instruction Cache Read/Write Tag Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IC_TAG																				RSVD					IC_LRU			RSVD			IC_V

Instruction Cache Read/Write Tag Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back 0.
31:12	IC_TAG	**Instruction Cache Tag.** Tag value for the way/line selected by IC_WAY and IC_LINE of the Instruction Cache Index register (MSR 00001710h bits [8:7] and [6:0], respectively).
11:7	RSVD (RO)	**Reserved (Read Only).** Reads back 0.
6:4	IC_LRU	**Instruction Cache LRU.** LRU value for the Way/Line selected by IC_WAY and IC_LINE of the Instruction Cache Index register (MSR 00001710h bits [8:7] and [6:0], respectively). 0xx: Way[1:0] more recent than Way[3:2]. 1xx: Way[3:2] more recent than Way[1:0]. x0x: Way2 more recent than Way3. x1x: Way3 more recent than Way2. xx0: Way0 more recent than Way1. xx1: Way1 more recent than Way0.

CPU Core Register Descriptions (Continued)

Instruction Cache Read/Write Tag Bit Descriptions (Continued)

Bit	Name	Description
3:1	RSVD (RO)	**Reserved (Read Only).** Reads back 0.
0	IC_V	**Instruction Cache Valid Bit.** Valid value for the Way/Line selected by IC_WAY and IC_LINE of the Instruction Cache Index register (MSR 00001710h bit [8:7] and [6:0], respectively).

4.5.2.49 Instruction Cache Read/Write Tag w/INC Register

MSR Address 00001713h
Type R/W
Reset Value 00000000_00000000h

Instruction Cache Read/Write Tag w/INC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IC_TAG																				RSVD					IC_LRU			RSVD			IC_V

Instruction Cache Read/Write Tag w/INC Bit Descriptions

Bit	Name	Description
63:0	---	**Definition same as Instruction Cache Read/Write Tag Register (MSR 00001712h).** Except read/write of this register causes an auto-increment on the Instruction Cache Index register (MSR 00001710h)

4.5.2.50 Instruction Memory TLB Index Register

MSR Address 00001720h
Type R/W
Reset Value 00000000_00000000h

Instruction Memory TLB Index Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													ITLB_INDX		

Instruction Memory TLB Index Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.
2:0	ITLB_INDX	**Instruction Memory TLB Index.** Determines which TLB entry in the Instruction Memory TLB Entry register (MSR 00001722h) or the Instruction Memory TLB Entry w/INC register (MSR 00001723h) is accessed. This register auto increments when the Instruction Memory TLB Entry w/INC register is accessed.

CPU Core Register Descriptions (Continued)

4.5.2.51 Instruction Memory TLB MRU Register

MSR Address 00001721h
Type R/W
Reset Value 00000000_00000000h

Instruction Memory TLB MRU Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						ITLB_MR9	ITLB_MR8	ITLB_MR7	ITLB_MR6	ITLB_MR5	ITLB_MR4	ITLB_MR3	ITLB_MR2	ITLB_MR1	ITLB_MR0

Instruction Memory TLB MRU Bit Descriptions

Bit	Name	Description
63:10	RSVD (RO)	**Reserved (Read Only).**
9	ITLB_MRU9	**Most Recent Used 9.** 0: Entry index 6/7 more recent than entry index 4/5. 1: Entry index 4/5 more recent than entry index 6/7.
8	ITLB_MRU8	**Most Recent Used 8.** 0: Entry index 6/7 more recent than entry index 2/3. 1: Entry index 2/3 more recent than entry index 6/7.
7	ITLB_MRU7	**Most Recent Used 7.** 0: Entry index 4/5 more recent than entry index 2/3. 1: Entry index 2/3 more recent than entry index 4/5.
6	ITLB_MRU6	**Most Recent Used 6.** 0: Entry index 6/7 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 6/7.
5	ITLB_MRU5	**Most Recent Used 5.** 0: Entry index 4/5 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 4/5.
4	ITLB_MRU4	**Most Recent Used 4.** 0: Entry index 2/3 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 2/3.
3	ITLB_MRU3	**Most Recent Used 3.** 0: Entry index 7 more recent than entry index 6. 1: Entry index 6 more recent than entry index 7.
2	ITLB_MRU2	**Most Recent Used 2.** 0: Entry index 5 more recent than entry index 4. 1: Entry index 4 more recent than entry index 5.
1	ITLB_MRU1	**Most Recent Used 1.** 0: Entry index 3 more recent than entry index 2. 1: Entry index 2 more recent than entry index 3.
0	ITLB_MRU0	**Most Recent Used 0.** 0: Entry index 0 more recent than entry index 1. 1: Entry index 1 more recent than entry index 0.

CPU Core Register Descriptions (Continued)

4.5.2.52 Instruction Memory TLB Entry Register

MSR Address 00001722h
Type R/W
Reset Value xxxxx000_xxxxx000h

Instruction Memory TLB Entry Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IM_TLB_LIN																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IM_TLB_PHY																				RSVD							IM_TLB_CD	RSVD	IM_TLB_US	RSVD	IM_TAG_V

Instruction Memory TLB Entry Bit Descriptions

Bit	Name	Description
63:44	IM_TLB_LIN	**TLB Linear Address.**
43:32	RSVD (RO)	**Reserved (Read Only).**
31:12	IM_TLB_PHY	**TLB Physical Address.**
11:5	RSVD (RO)	**Reserved (Read Only).**
4	IM_TLB_CD	**Cache Disable Flag.** A 1 in this bit indicates that the page is uncacheable.
3	RSVD (RO)	**Reserved (Read Only).**
2	IM_TLB_US	**User Access Privileges.** 0: Supervisor. 1: Non-supervisor.
1	RSVD (RO)	**Reserved (Read Only).**
0	IM_TAG_V	**Valid Bit.** A 1 in this bit indicates that the entry in the TLB is valid.

4.5.2.53 Instruction Memory TLB Entry w/INC Register

MSR Address 00001723h
Type R/W
Reset Value 00000000_00000000h

Instruction Memory TLB Entry w/INC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
IM_TLB_LIN																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IM_TLB_PHY																				RSVD							IM_TLB_CD	RSVD	IM_TLB_US	RSVD	IM_TAG_V

CPU Core Register Descriptions (Continued)

Instruction Memory TLB Entry w/INC Bit Descriptions

Bit	Name	Description
63:0	---	**Definition same as Instruction Memory TLB Entry Register (MSR 00001722h).** Except read/write of this register causes an auto-increment on the Instruction Memory TLB Index register.

4.5.2.54 Instruction Memory Tag BIST Register

MSR Address 00001730h
Type RO
Reset Value 00000000_00000000h

Instruction Memory Tag BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														IM_CMP_B	IM_TAG_B

Instruction Memory Tag BIST Bit Descriptions

Bit	Name	Description
63:2	RSVD (RO)	**Reserved (Read Only).**
1	IM_CMP_B (RO)	**Tag Compare Logic BIST (Read Only).** 0: Fail. 1: Pass.
0	IM_TAG_B (RO)	**Valid and Tag Array Logic BIST (Read Only).** 0: Fail. 1: Pass.

4.5.2.55 Instruction Memory Data BIST Register

MSR Address 00001731h
Type RO
Reset Value 00000000_00000000h

Instruction Memory Data BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														IM_LRU_B	IM_DATA_B

Instruction Memory Data BIST Register Bit Descriptions

Bit	Name	Description
63:2	RSVD (RO)	**Reserved (Read Only),**
1	IM_LRU_B (RO)	**LRU Array BIST (Read Only).** 0: Fail. 1: Pass.
0	IM_DATA_B (RO)	**Data Array BIST (Read Only).** 0: Fail. 1: Pass.

4.5.2.56 Data Memory Configuration Register

MSR Address 00001800h
Type R/W
Reset Value 00000000_00000000h

Table 4-15. Data Memory Configuration Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PFLOCKT2				PFLOCKT1				PFLOCKT0				PFLOCKNTA				RSVD	WSREQ			RSVD	WCTO			RSVD	WBTO			RSVD			WBDIS
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
RSVD												LSLOCK				RSVD		NOFTTBRES	DTCNINV	P4MDIS	DTCDIS	L2TLBDIS	DCDIS	SPCDEC	WTBRST	WBINVD	NOSMC	NOFWD	BLOCKC	MISSER	LDSER

Data Memory Configuration Bit Descriptions

Bit	Name	Description
63:60	PFLOCKT2	**Prefetch Lockout of PREFETCHT2.** Lock data cache ways (MSB = Way3, LSB = Way0) from allocating or replacing the data on a data prefetch miss from a PREFECTHT2 instruction. If all cache ways are locked then PREFECTHT2 is effectively disabled. Use this field to prevent data prefetch operations from thrashing too much of the cache.
59:56	PFLOCKT1	**Prefetch Lockout of PREFETCHT1.** Lock data cache ways (MSB = Way3, LSB = Way0) from allocating or replacing the data on a data prefetch miss from a PREFECTHT1 instruction. If all cache ways are locked then PREFECTHT1 is effectively disabled. Use this field to prevent data prefetch operations from thrashing too much of the cache.
55:52	PFLOCKT0	**Prefetch Lockout of PREFETCHT0.** Lock data cache ways (MSB = Way3, LSB = Way0) from allocating or replacing the data on a data prefetch miss from a PREFECTHT0 instruction. If all cache ways are locked then PREFECTHT0 is effectively disabled. Use this field to prevent data prefetch operations from thrashing too much of the cache.
51:48	PFLOCKNTA	**Prefetch Lockout of PREFETCHNTA.** Lock data cache ways (MSB = Way3, LSB = Way0) from allocating or replacing the data on a data prefetch miss from a PREFECTHNTA instruction. If all cache ways are locked then PREFECTHNTA is effectively disabled. Use this field to prevent data prefetch operations from thrashing too much of the cache.
47	RSVD	**Reserved.** Write as read.

CPU Core Register Descriptions (Continued)

Data Memory Configuration Bit Descriptions (Continued)

Bit	Name	Description
46:44	WSREQ	**Write-Serialize Request.** Number of outstanding write-serialize requests. 000: Unlimited. 001-111: Binary Value.
43	RSVD	**Reserved.** Write as read.
42:40	WCTO	**Write-Combine Timeout.** Flushes write-combinable entry from write buffer if it has not been written for the specified number of clocks. 000: Disable timeout. 001-111: Flush after 2^X clocks (where X = WCTO).
39	RSVD	**Reserved.** Write as read.
38:36	WBTO	**Write-Burst Timeout.** Flushes write-burstable entry from write buffer if it has not been written for the specified number of clocks. 000: Disable timeout. 001-111: Flush after 2^X clocks (where X = WBTO).
35:33	RSVD	**Reserved.** Write as read.
32	WBDIS	**Write Buffer Disable.** Disabling the write buffer forces stores to be sent directly from the output of the store queue to the BC. Enabling the write buffer allows memory stores to be buffered, with or without the combining based on region properties. 0: Enable write buffer. 1: Disable write buffer.
31:20	RSVD	**Reserved.** Write as read.
19:16	LSLOCK	**Load/Store Lockout.** Lock data cache ways (MSB = Way3, LSB = Way0) from being allocated or replaced on a load or store miss.
15:14	RSVD	**Reserved.** Write as read.
13	NOFTTBRES	**No Page Fault.** Do not page fault if any reserved bits are set in the DTE/PTE page table entries. 0: Take the page fault. 1: Do not take the page fault.
12	DTCNINV	**Do Not Invalidate DTE Cache Entry.** Do not invalidate DTE cache entry on INVLPG. Entire DTE cache is always flushed on a store into the directory page. 0: Invalidate DTE cache entry on INVLPG hit. 1: Do not invalidate DTE cache entry on INVLPG hit.
11	P4MDIS	**Disable 4M PTE Cache.** 0: Enable 4M PTEs to be cached. Normal operation. 1: Prevent 4M PTEs from being cached and flush any existing entries.
10	DTCDIS	**Disable DTE Cache.** 0: Enable DTE cache. Normal operation. 1: Disable DTE cache and flush any existing entries.
9	L2TLBDIS	**Disable L2 TLB.** Contents are not modified. 0: Enable L2 TLB. Normal operation. 1: Disable L2 TLB.
8	DCDIS	**Disable Data Memory Cache.** Contents are not modified. 0: Enable Data Memory Cache and use standard x86 cacheablility rules. Normal operation. 1: Disable Data Memory Cache. Data cache always generates a miss.

CPU Core Register Descriptions (Continued)

Data Memory Configuration Bit Descriptions (Continued)

Bit	Name	Description
7	SPCDEC	**Decrease Number of Speculative Reads of Data Cache.** 0: Actively resync cache tag and data arrays so that loads can be speculatively handled in one clock if the MRU way is hit. 1: Do not attempt to resync cache tag and data arrays. This is a performance optimization bit and the preferred value may have to be empirically determined. The cache tag and data arrays get “out of sync” when there is a miss to the MRU way or if the data array is busy with a store, line fill, or eviction. While the arrays are out of sync, all hits take two clocks. When they are in sync, hits to the MRU way take one clock, while hits to other ways take three.
6	WTBRST	**Write-Through Bursting.** 0: Writes are sent unmodified to the bus on write-through operations. 1: Writes may be combined using write-burstable semantics on write-through operations.
5	WBINVD	**Convert INVD to WBINVD.** 0: INVD invalidates cache without writeback. 1: INVD writes back any dirty cache lines.
4	NOSMC	**Snoop Detecting on Self-Modified Code.** Generates snoops on stores for detecting self-modified code. 0: Generate snoops. 1: Disable snoops.
3	NOFWD	**Forward Data from Bus Controller.** Enable forwarding of data directly from BC if a new request hits a line fill in progress. 0: Forward data from BC if possible. 1: Wait for valid data in cache, then read cache array.
2	BLOCKC	**Blocking Cache.** 0: New request overlapped with line fill. 1: Line fill must complete before starting new request.
1	MISSER	**Serialize Load Misses.** Stall everything but snoops on a load miss. If any part of the PCI space is marked as cacheable, set this bit. Data accesses are made from the cacheable space, and there is a PCI master device that must complete a master request before it completes a slave read. 0: Load misses are treated the same as load hits. 1: Load misses prevent non-snoop requests from being handled until the miss data is returned by the BC.
0	LDSER	**Serialize Loads vs Stores.** All loads are serialized versus stores in the store queue, but a load that hits the DCache completes without affecting any pending stores in the write buffers. 0: Loads can bypass stores based on region properties. 1: All loads and stores are executed in program order.

CPU Core Register Descriptions (Continued)

4.5.2.57 Default Region Configuration Properties Register

MSR Address 00001808h
Type R/W
Reset Value 01FFFFF0_10000001h
Warm Start Value 04xxxxx0_1xxxxx01h

Default Region Configuration Properties Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
ROMRP								ROMBASE																				DEVRP			
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DEVRP				SYSTOP																				SYSRP							

Default Region Configuration Properties Bit Descriptions

Bit	Name	Description
63:56	ROMRP	**ROM Region Properties.** Region properties for addresses greater than ROMBASE (bits 55:36]).
55:36	ROMBASE	**ROM Base Address.** Base address for boot ROM. This field represents A[32:12] of the memory address space, 4 kB granularity.
35:28	DEVRP	**SYSTOP to ROMBASE Region Properties.** Region properties for addresses less than ROMBASE (bits 55:36]) and addresses greater than or equal to SYSTOP (bits [27:8]).
27:8	SYSTOP	**Top of System Memory.** Top of system memory that is available for general processor use. The frame buffer and other private memory areas are located above SYSTOP.
7:0	SYSRP	**System Memory Region Properties.** Region properties for addresses less than SYSTOP (bits [27:8]). Note that Region Configuration 000A0000h-000FFFFFh takes precedence over SYSRP.

4.5.2.58 Region Configuration Bypass Register

MSR Address 0000180Ah
Type R/W
Reset Value 00000000_00000101h
Warm Start Value 00000000_00000219h

Region Configuration Bypass Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																RPSMHDR								RPTLB							

Region Configuration Bypass Bit Descriptions

Bit	Name	Description
63:16	RSVD (RO)	**Reserved (Read Only).**
15:8	RPSMHDR	**Region Properties during SMM/DMM.** Region configuration properties used during SMM/DMM header accesses.
7:0	RPTLB	**Region Properties during Tablewalks.**

CPU Core Register Descriptions (Continued)

4.5.2.59 Region Configuration A0000-BFFFF Register

MSR Address 0000180Bh
Type R/W
Reset Value 01010101_01010101h
Warm Start Value 19191919_19191919h

Region Configuration A0000-BFFFF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RPBC								RPB8								RPB4								RPB0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RPAC								RPA8								RPA4								RPA0							

Region Configuration A0000-BFFFF Bit Descriptions

Bit	Name	Description
63:56	RPBC	**Region Properties for 000BC000-000BFFFF.**
55:48	RPB8	**Region Properties for 000B8000-000BBFFF.**
47:40	RPB4	**Region Properties for 000B4000-000BAFFF.**
39:32	RPB0	**Region Properties for 000B0000-000B3FFF.**
31:24	RPAC	**Region Properties for 000AC000-000AFFFF.**
23:16	RPA8	**Region Properties for 000A8000-000ABFFF.**
15:8	RPA4	**Region Properties for 000A4000-000A7FFF.**
7:0	RPA0	**Region Properties for 000A0000-000A3FFF.**

4.5.2.60 Region Configuration C0000-DFFFF Register

MSR Address 0000180Ch
Type R/W
Reset Value 01010101_01010101h
Warm Start Value 19191919_19191919h

Region Configuration C0000-DFFFF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RPDC								RPD8								RPD4								RPD0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RPCC								RPC8								RPC4								RPC0							

Region Configuration C0000-DFFFF Bit Descriptions

Bit	Name	Description
63:56	RPDC	**Region Properties for 000DC000-000DFFFF.**
55:48	RPD8	**Region Properties for 000D8000-000DBFFF.**
47:40	RPD4	**Region Properties for 000D4000-000DAFFF.**
39:32	RPD0	**Region Properties for 000D0000-000D3FFF.**
31:24	RPCC	**Region Properties for 000CC000-000CFFFF.**
23:16	RPC8	**Region Properties for 000C8000-000CBFFF.**

CPU Core Register Descriptions (Continued)

Region Configuration C0000-DFFFF Bit Descriptions (Continued)

Bit	Name	Description
15:8	RPC4	**Region Properties for 000C4000-000C7FFF.**
7:0	RPC0	**Region Properties for 000C0000-000C3FFF.**

4.5.2.61 Region Configuration E0000-FFFFF Register

MSR Address 0000180Dh
Type R/W
Reset Value 01010101_01010101h
Warm Start Value 19191919_19191919h

Region Configuration E0000-FFFFF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RPFC								RPF8								RPF4								RPF0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RPEC								RPE8								RPE4								RPE0							

Region Configuration E0000-FFFFF Bit Descriptions

Bit	Name	Description
63:56	RPFC	**Region Properties for 000FC000-000FFFFF.**
55:48	RPF8	**Region Properties for 000F8000-000FBFFF.**
47:40	RPF4	**Region Properties for 000F4000-000FAFFF.**
39:32	RPF0	**Region Properties for 000F0000-000F3FFF.**
31:24	RPEC	**Region Properties for 000EC000-000EFFFF.**
23:16	RPE8	**Region Properties for 000E8000-000EBFFF.**
15:8	RPE4	**Region proPerties for 000E4000-000E7FFF.**
7:0	RPE0	**Region Properties for 000E0000-000E3FFF.**

4.5.2.62 Region Configuration SMM Register

MSR Address 0000180Eh
Type R/W
Reset Value 00000001_00000001h
Warm Start Value xxxxx001_xxxxx005h

Region Configuration SMM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
SMMTOP																				RSVD				RPSMM							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SMMBASE																				RSVD			RPSMM_EN	SMM_NORM						

CPU Core Register Descriptions (Continued)

Region Configuration SMM Bit Descriptions

Bit	Name	Description
63:44	SMMTOP	**Top of SMM.** Top of SMM region, 4 kB granularity inclusive.
43:40	RSVD (RO)	**Reserved (Read Only).**
39:32	RPSMM	**Region Properties in SMM Region when SMM Active.**
31:12	SMMBASE	**Start of SMM.** Start of SMM region, 4kB granularity inclusive
11:9	RSVD (RO)	**Reserved (Read Only).**
8	RPSMM_EN	**SMM Properties Region Enable.** 0: Disable. 1: Enable.
7:0	SMM_NORM	**Region Properties in SMM Region when SMM Inactive.**

4.5.2.63 Region Configuration DMM Register

MSR Address 0000180Fh
Type R/W
Reset Value 00000001_00000001h
Warm Start Value xxxxx001_xxxxx005h

Region Configuration DMM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DMMTOP																				RSVD				RPDMM							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DMMBASE																				RSVD			RPDMM_EN	DMM_NORM						

Region Configuration DMM Register Bit Descriptions

Bit	Name	Description
63:44	DMMTOP	**Top of DMM.** Top of DMM region, 4 kB granularity inclusive.
43:40	RSVD (RO)	**Reserved (Read Only).**
39:32	RPDMM	**Region Properties in DMM Region when DMM Active.**
31:12	DMMBASE	**Start of DMM.** Start of DMM region, 4kB granularity inclusive
11:9	RSVD (RO)	**Reserved (Read Only).**
8	RPDMM_EN	**DMM Properties Region Enable.** 0: Disable. 1: Enable.
7:0	DMM_NORM	**Region Properties in DMM Region when DMM Inactive.**

CPU Core Register Descriptions (Continued)

4.5.2.64 Region Configuration Range Registers

Region Configuration Range 0 Register
MSR Address 00001810h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 1 Register
MSR Address 00001811h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 2 Register
MSR Address 00001812h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 3 Register
MSR Address 00001813h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 4 Register
MSR Address 00001814h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 5 Register
MSR Address 00001815h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 6 Register
MSR Address 00001816h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range 7 Register
MSR Address 00001817h
Type R/W
Reset Value 00000000_00000000h
Warm Start Value xxxxx000_xxxxx0xxh

Region Configuration Range[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RPTOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RPBASE																				RSVD			RPEN	RP							

Region Configuration Range[x] Bit Descriptions

Bit	Name	Description
63:44	RPTOP	**Top of Range.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:12	RPBASE	**Start of Range.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
8	RPEN	**Enable Range.** 0: Disable range. 1: Enable range.
7:0	RP	**Range Properties.**

CPU Core Register Descriptions (Continued)

4.5.2.65 CR[x] Copy Registers

CR1 Copy Register
MSR Address 00001881h
Type R/W
Reset Value 00000000_xxxxxxxxh

CR2 Copy Register
MSR Address 00001882h
Type R/W
Reset Value 00000000_xxxxxxxxh

CR3 Copy Register
MSR Address 00001883h
Type R/W
Reset Value 00000000_xxxxxxxxh

CR4 Copy Register
MSR Address 00001884h
Type R/W
Reset Value 00000000_xxxxxxxxh

CR[x] Copy Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CR[x]_COPY																															

CR[x] Copy Register

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:0	CR[x]_COPY	**Copy of CR1.** Refer to Table 4-10 "CR0 Bit Descriptions" on page 98 (Reserved). **Copy of CR2.** Refer to Table 4-9 "CR2 Bit Descriptions" on page 98. **Copy of CR3.** Refer to Table 4-8 "CR3 Bit Descriptions" on page 98. **Copy of CR4.** Refer to Table 4-7 "CR4 Bit Descriptions" on page 97.

4.5.2.66 Data Cache Index Register

MSR Address 00001890h
Type R/W
Reset Value 00000000_00000000h

Data Cache Index Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														DC_DSEL		RSVD							DC_LINE							DC_WAY	

Data Cache Index Bit Descriptions

Bit	Name	Description
63:18	RSVD (RO)	**Reserved (Read Only).**
17:16	DC_DSEL	**Data QWORD Select.** Determines which QWORD in a cache line is accessed by a read or a write to DC_DATA (MSR 00001891h). DC_DSEL increments on accesses to DC_DATA and resets to 0 on accesses to the Data Cache Read/Write Tag register (MSR 00001892h) or the Data Cache Read/Write Tag w/INC register (MSR 00001893h).
15:9	RSVD (RO)	**Reserved (Read Only).**

CPU Core Register Descriptions (Continued)

Data Cache Index Bit Descriptions (Continued)

Bit	Name	Description
8:2	DC_LINE	**Cache Line Select.** Forms the high 7 bits of a 9-bit counter. The DC_WAY field (bits [1:0]) forms the low 2 bits of the counter. This field increments when DC_WAY overflows on an access to the Data Cache Read/Write Tag w/INC register (MSR 00001893h).
1:0	DC_WAY	**Cache Way Select.** Forms the low 2 bits of a 9-bit counter. The DC_LINE field (bits [8:2]) forms the high 7 bits of the counter. This field post-increments on accesses to the Data Cache Read/Write Tag w/INC register (MSR 00001893h).

4.5.2.67 Data Cache Data Register

MSR Address 00001891h
Type R/W
Reset Value 00000000_00000000h

Data Cache Data Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DC_DATA																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DC_DATA																															

Data Cache Data Bit Descriptions

Bit	Name	Description
63:0	DC_DATA	**Data Cache Data.** QWORD data to read from or write to the cache line buffer. The buffer is filled from the cache data array on a read to Data Cache Read/Write Tag register (MSR 00001892h) or Data Cache Read/Write Tag w/INC register (MSR 00001893h), and the buffer is written to the cache data array on a write to the Data Cache Read/Write Tag or Data Cache Read/Write Tag w/INC registers. The DC_DSEL field in the Data Cache Index register (MSR 00001890h[17:16]) selects which QWORD in the buffer is accessed by DC_DATA, and each access to DC_DATA increments DC_DSEL.

4.5.2.68 Data Cache Read/Write Tag Register

MSR Address 00001892h
Type R/W
Reset Value 00000000_00000000h

Data Cache Read/Write Tag Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DC_TAG																				RSVD					DC_LRU			RSVD		DC_DIRTY	DC_V

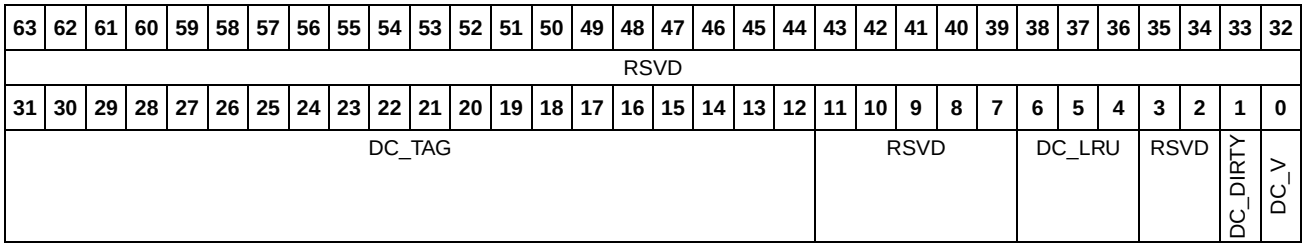
Data Cache Read/Write Tag Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).**
31:12	DC_TAG	**Data Cache Tag.** Tag value for the way/line selected by DC_WAY and DC_LINE of the Data Cache Index register (MSR 00001890h bits [1:0] and [8:2], respectively).
11:7	RSVD (RO)	**Reserved (Read Only).**
6:4	DC_LRU	**Data Cache LRU.** LRU value for the way/line selected by DC_WAY and DC_LINE of the Data Cache Index register (MSR 00001890h bits [1:0] and [8:2], respectively). 0xx: Way[1:0] more recent than Way[3:2]. 1xx: Way[3:2] more recent than Way[1:0]. x0x: Way2 more recent than Way3. x1x: Way3 more recent than Way2. xx0: Way0 more recent than Way1. xx1: Way1 more recent than Way0.
3:2	RSVD (RO)	**Reserved (Read Only).**
1	DC_DIRTY	**Data Cache Dirty Bit.** Dirty value for the line/way selected by DC_LINE and DC_WAY of the Data Cache Index register (MSR 00001890h bits [1:0] and [8:2], respectively). **Note:** Operation is undefined if the DIRTY bit is set to 1 and the VALID bit is 0.
0	DC_V	**Data Cache Valid Bit.** Valid value for the way/line selected by DC_WAY and DC_LINE of the Data Cache Index register (MSR 00001890h bits [1:0] and [8:2], respectively). **Note:** Operation is undefined if the DIRTY bit is set to 1 and the VALID bit is 0.

4.5.2.69 Data Cache Read/Write Tag w/INC Register

MSR Address 00001893h
Type R/W
Reset Value 00000000_00000000h

Data Cache Read/Write Tag w/INC Register Map



Data Cache Read/Write Tag w/INC Register

Bit	Name	Description
63:0	---	**Definition same as Data Cache Read/Write Tag Register (MSR 00001892h).** Except read/write of this register causes an auto-increment on the Data Cache Index register.

CPU Core Register Descriptions (Continued)

4.5.2.70 Data/Instruction Cache Snoop Register

MSR Address 00001894h
Type WO
Reset Value 00000000_xxxxxxxxh

Data/Instruction Cache Snoop Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SNOOP_ADD																															

Data/Instruction Cache Snoop Bit Descriptions

Bit	Name	Description
63:32	RSVD (WO)	**Reserved (Write Only).** Write as read.
31:0	SNOOP_ADD (WO)	**Cache Snoop Address (Write Only).** Physical address to snoop in the caches. A hit to a dirty line results in a writeback followed by an invalidation. A hit to a clean line results in an invalidation only. Both the data and instruction caches are snooped.

4.5.2.71 L1 Data TLB Index Register

MSR Address 00001898h
Type R/W
Reset Value 00000000_00000000h

L1 Data TLB Index Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													L1TLB_ INDX		

L1 Data TLB Index Bit Descriptions

Bit	Name	Description
63:3	RSVD (RO)	**Reserved (Read Only).**
2:0	L1TLB_INDX	**L1 TLB Index.** Index of L1 TLB entry to access. Post increments on each access to L1 Data TLB Entry w/INC (MSR 0000189Bh).

CPU Core Register Descriptions (Continued)

4.5.2.72 L1 Data TLB LRU Register

MSR Address 00001899h
Type R/W
Reset Value 00000000_00000000h

L1 Data TLB LRU Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						L1DTLB_MR9	L1DTLB_MR8	L1DTLB_MR7	L1DTLB_MR6	L1DTLB_MR5	L1DTLB_MR4	L1DTLB_MR3	L1DTLB_MR2	L1DTLB_MR1	L1DTLB_MR0

L1 Data TLB LRU Bit Descriptions

Bit	Name	Description
63:10	RSVD (RO)	**Reserved (Read Only).**
9	L1DTLB_MRU9	**Most Recent Used 9.** 0: Entry index 6/7 more recent than entry index 4/5. 1: Entry index 4/5 more recent than entry index 6/7
8	L1DTLB_MRU8	**Most Recent Used 8.** 0: Entry index 6/7 more recent than entry index 2/3. 1: Entry index 2/3 more recent than entry index 6/7
7	L1DTLB_MRU7	**Most Recent Used 7.** 0: Entry index 4/5 more recent than entry index 2/3. 1: Entry index 2/3 more recent than entry index 4/5
6	L1DTLB_MRU6	**Most Recent Used 6.** 0: Entry index 6/7 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 6/7
5	L1DTLB_MRU5	**Most Recent Used 5.** 0: Entry index 4/5 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 4/5
4	L1DTLB_MRU4	**Most Recent Used 4.** 0: Entry index 2/3 more recent than entry index 0/1. 1: Entry index 0/1 more recent than entry index 2/3
3	L1DTLB_MRU3	**Most Recent Used 3.** 0: Entry index 7 more recent than entry index 6. 1: Entry index 6 more recent than entry index 7
2	L1DTLB_MRU2	**Most Recent Used 2.** 0: Entry index 5 more recent than entry index 4. 1: Entry index 4 more recent than entry index 5
1	L1DTLB_MRU1	**Most Recent Used 1.** 0: Entry index 3 more recent than entry index 2. 1: Entry index 2 more recent than entry index 3
0	L1DTLB_MRU0	**Most Recent Used 0.** 0: Entry index 0 more recent than entry index 1. 1: Entry index 1 more recent than entry index 0

CPU Core Register Descriptions (Continued)

4.5.2.73 L1 Data TLB Entry Register

MSR Address 0000189Ah
Type R/W
Reset Value 00000000_00000020h

L1 Data TLB Entry Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
L1DTLB_LADD																				RSVD									L1DTLB_WP	L1DTLB_WA_WS	L1DTLB_WC
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L1DTLB_PADD																				RSVD					L1DTLB_D	L1DTLB_ACC	L1DTLB_CD	L1DTLB_WT_BR	L1DTLB_US	L1DTLB_WR	L1DTLB_V

L1 Data TLB Entry Bit Descriptions

Bit	Name	Description
63:44	L1DTLB_LADD	**Linear Address.** Address [32:12]
43:35	RSVD (RO)	**Reserved (Read Only).**
34	L1DTLB_WP	**Write Protect Flag.** 0: Page can be written. 1: Page is write protected.
33	L1DTLB_WA_WS	**Write Allocate / Write Serialize Flag.** If the page is cacheable, a 1 indicates the Write Allocate flag. If the page is non-cacheable, a 1 indicates the Write Serialize flag.
32	L1DTLB_WC	**Write Combine Flag.** When this page marked as non-cacheable, a 1indicates that writes may be combined before being sent to the bus.
31:12	L1DTLB_PADD	**Physical Address.** Address [32:12]
11:7	RSVD (RO)	**Reserved (Read Only).**
6	L1DTLB_D	**Dirty Flag.** A 1 indicates that the page has been written to.
5	L1DTLB_ACC	**Accessed Flag.** A 1 indicates an entry in the TLB.
4	L1DTLB_CD	**Cache Disable Flag.** A 1 indicates that the page is uncacheable.
3	L1DTLB_WT_BR	**Write-Through / Write Burst Flag.** When the page is cacheable, a 1 indicates that the page is write-through. When the page is non-cacheable, a 1 indicates that the page allows write bursting.
2	L1DTLB_US	**User Access Privileges.** 0: Supervisor. 1: Non-supervisor.
1	L1DTLB_WR	**Writable Flag.** 0: Page can not be written. 1: Page can be written.
0	L1DTLB_V	**Valid Bit.** A 1 indicates that the entry in the TLB is valid.

CPU Core Register Descriptions (Continued)

4.5.2.74 L1 Data TLB Entry w/INC Register

MSR Address 0000189Bh
Type R/W
Reset Value 00000000_00000000h

L1 Data TLB Entry w/INC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
L1DTLB_LADD																				RSVD									L1DTLB_WP	L1DTLB_WA_WS	L1DTLB_WC
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L1DTLB_PADD																				RSVD					L1DTLB_D	L1DTLB_ACC	L1DTLB_CD	L1DTLB_WT_BR	L1DTLB_US	L1DTLB_WR	L1DTLB_V

L1 Data TLB Entry w/INC Bit Descriptions

Bit	Name	Description
63:0	---	**Definition same as L1 Data TLB Entry Register (MSR 0000189Ah).** Except read/write of this register causes an auto increment on the L1 TLB Index register.

4.5.2.75 L2 TLB/DTE Index Register

MSR Address 0000189Ch
Type R/W
Reset Value 00000000_00000000h

L2 TLB/DTE Index Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														L2TLB_SEL		RSVD										L2TLB_INDX					L2TLB_WAY
																										RSVD				D_P_TE_INDX	

L2 TLB/DTE Index Bit Descriptions

Bit	Name	Description
63:18	RSVD (RO)	**Reserved (Read Only).**
17:16	L2TLB_SEL	**Cache Array Select.** 0x: Select L2 TLB. 10: Select DTE cache. 11: Select 4M PTE cache.
15:6	RSVD (RO)	**Reserved (Read Only).**
If L2TLB_SEL (bits [17:16]) = 0x:		
5:1	L2TLB_INDX	**L2 TLB Index.** Post increments on an access to L2 TLB/DTE Entry w/INC register (MSR 0000189Bh) when L2TLB_WAY (bit 0) = 1.
0	L2TLB_WAY	**Way Access.** Toggles of each access to L2 TLB/DTE Entry w/INC register (MSR 0000189Bh).
If L2TLB_SEL (bits [17:16]) = 1x:		
5:2	RSVD	**Reserved.** Write as read.
1:0	D_P_TE_INDX	**DTE/PTE Index.** Post increments on access to L2 TLB/DTE Entry w/INC register (MSR 0000189Bh).

4.5.2.76 L2 TLB/DTE LRU Register

MSR Address 0000189Dh
Type R/W
Reset Value 00000000_00000000h

L1 TLB/DTE LRU Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										L2PTE_MRU0	L2PTE_MRU1	L2PTE_MRU2	L2PTE_MRU3	L2PTE_MRU4	L2PTE_MRU5	RSVD		L2DTE_MRU0	L2PTE_MRU1	L2PTE_MRU2	L2PTE_MRU3	L2PTE_MRU4	L2PTE_MRU5	RSVD							L2NWR

L2 TLB/DTE LRU Bit Descriptions

Bit	Name	Description
63:22	RSVD (RO)	**Reserved (Read Only).**
21	L2PTE_MRU0	**Most Recent Used 0.** 0: Entry 4MPTE index 1 more recent than entry index 0. 1: Entry 4MPTE index 0 more recent than entry index 1
20	L2PTE_MRU1	**Most Recent Used 1.** 0: Entry 4MPTE index 2 more recent than entry index 0. 1: Entry 4MPTE index 0 more recent than entry index 2
19	L2PTE_MRU2	**Most Recent Used 2.** 0: Entry 4MPTE index 3 more recent than entry index 0. 1: Entry 4MPTE index 0 more recent than entry index 3

CPU Core Register Descriptions (Continued)

L2 TLB/DTE LRU Bit Descriptions (Continued)

Bit	Name	Description
18	L2PTE_MRU3	**Most Recent Used 3.** 0: Entry 4MPTE index 2 more recent than entry index 1. 1: Entry 4MPTE index 1 more recent than entry index 2
17	L2PTE_MRU4	**Most Recent Used 4.** 0: Entry 4MPTE index 3 more recent than entry index 1. 1: Entry 4MPTE index 1 more recent than entry index 3
16	L2PTE_MRU5	**Most Recent Used 5.** 0: Entry 4MPTE index 3 more recent than entry index 2. 1: Entry 4MPTE index 2 more recent than entry index 3.
15:14	RSVD (RO)	**Reserved (Read Only).**
13	L2DTE_MRU0	**Most Recent Used 0.** 0: Entry 4MDTE index 1 more recent than entry index 0. 1: Entry 4MDTE index 0 more recent than entry index 1.
12	L2DTE_MRU1	**Most Recent Used 1.** 0: Entry 4MDTE index 2 more recent than entry index 0. 1: Entry 4MDTE index 0 more recent than entry index 2.
11	L2DTE_MRU2	**Most Recent Used 2.** 0: Entry 4MDTE index 3 more recent than entry index 0. 1: Entry 4MDTE index 0 more recent than entry index 3.
10	L2DTE_MRU3	**Most Recent Used 3.** 0: Entry 4MDTE index 2 more recent than entry index 1. 1: Entry 4MDTE index 1 more recent than entry index 2.
9	L2DTE_MRU4	**Most Recent Used 4.** 0: Entry 4MDTE index 3 more recent than entry index 1. 1: Entry 4MDTE index 1 more recent than entry index 3.
8	L2DTE_MRU5	**Most Recent Used 5.** 0: Entry 4MDTE index 3 more recent than entry index 2. 1: Entry 4MDTE index 2 more recent than entry index 3.
7:1	RSVD (RO)	**Reserved (Read Only).**
0	L2NWR	**L2 TLB Next Write.** Next L2 TLB Way to write to if both Ways are valid. 0: Next write to Way0. 1: Next write to Way1.

CPU Core Register Descriptions (Continued)

4.5.2.77 L2 TLB/DTE Entry Register

MSR Address 0000189Eh
Type R/W
Reset Value 00000000_00000020h

L2 TLB/DTE Entry Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
L2TLB_LADD																				RSVD									L2TLB_WP	L2TLB_WA_WS	L2TLB_WC
L2DP_LADD										RSVD																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L2TLB_PADD										RSVD													L2TLB_GBL	RSVD	L2TLB_D	L2TLB_ACC	L2TLB_CD	L2TLB_WT_BR	L2TLB_US	L2TLB_WR	L2TLB_V
L2DP_PADD																															

L2 TLB/DTE Entry Bit Descriptions

Bit	Name	Description
If L2TLB_SEL (MSR 0000189Ch[17:16]) = 0x:		
63:44	L2TLB_LADD	**Linear Address.** Address [31:12]
43:35	RSVD	**Reserved.** Write as read.
34	L2TLB_WP	**Write Protect Flag.** 0: Page can be written. 1: Page is write protected.
33	L2TLB_WA_WS	**Write Allocate / Write Serialize Flag.** If the page is cacheable, a 1 indicates the Write Allocate flag. If the page is non-cacheable, a 1 indicates the Write Serialize flag.
32	L2TLB_WC	**Write Combine Flag.** When this page marked as non-cacheable, a 1 indicates that writes may be combined before being sent to the bus.
31:12	L2TLB_PADD	**Physical Address**. Address [31:12]
If L2TLB_SEL (MSR 0000189Ch[17:16]) = 1x:		
63:54	L2DP_LADD	**Linear Address.** Address [31:22]
53:32	RSVD	**Reserved.** Write as read.
31:12	L2DP_PADD	**Physical Address.** If L2TLB_SEL = 10: Pointer to the page containing the PTE If L2TLB_SEL = 11: Bits [31:22] of this register equal 4MPTE physical address [31:22] and bits [21:12] are always 0.
If L2TLB_SEL (MSR 0000189Ch[17:16]) = xx:		
11:9	RSVD	**Reserved.** Write as read.
8	L2TLB_GBL	**Global Page Flag.** A 1indicates that the OS will treat the page as a global page instead of a local application page.
7	RSVD	**Reserved.** Write as read.
6	L2TLB_D	**Dirty Flag.** A 1 indicates that a page has been written to.
5	L2TLB_ACC	**Accessed Flag.** A 1 indicates an entry in the TLB.

CPU Core Register Descriptions (Continued)

L2 TLB/DTE Entry Bit Descriptions (Continued)

Bit	Name	Description
4	L2TLB_CD	**Cache Disable Flag.** A 1 indicates that the page is non-cacheable.
3	L2TLB_WT_BR	**Write-Through / Write Burst Flag.** When the page is cacheable, a 1indicates that the page is write-through. When the page is non-cacheable, a 1 indicates that the page allows write bursting.
2	L2TLB_US	**User Access Privileges.** 0: Supervisor. 1: Non-supervisor.
1	L2TLB_WR	**Writable Flag.** 0: Page can not be written. 1: Page can be written.
0	L2TLB_V	**Valid Bit.** A 1indicates that the entry in the TLB is valid.

4.5.2.78 L2 TLB/DTE Entry w/INC Register

MSR Address 0000189Fh
Type R/W
Reset Value 00000000_00000000h

L2 TLB/DTE Entry w/INC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
L2TLB_LADD																				RSVD									L2TLB_WP	L2TLB_WA_WS	L2TLB_WC
L2DP_LADD										RSVD																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L2TLB_PADD																				RSVD			L2TLB_GBL	RSVD	L2TLB_D	L2TLB_ACC	L2TLB_CD	L2TLB_WT_BR	L2TLB_US	L2TLB_WR	L2TLB_V
L2DP_PADD																															

L2 TLB/DTE Entry w/INC Bit Descriptions

Bit	Name	Description
63:0	---	**Definition same as L2 TLB/DTE Entry Register (MSR 0000189Eh).** Except read/write of this register causes an auto-increment on the L2 TLB/DTE Index register.

CPU Core Register Descriptions (Continued)

4.5.2.79 Data Memory BIST Register

MSR Address 000018C0h
Type R/W
Reset Value 00000000_00000000h

Data Memory BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L2TLBCMP1	L2TLBCMP0	L2TLBDAT1	L2TLBDAT0	RSVD		DC_DATA_LRU	DC_DATA	DC_TAGCMP3	DC_TAGCMP2	DC_TAGCMP1	DC_TAGCMP0	DC_DAT3	DC_DAT2	DC_DAT1	DC_DAT0	RSVD										L2TLB_RETEN	L2TLB_RUN	DC_RETEN	DC_RUN	DCTAG_RETEN	DCTAG_RUN

Data Memory BIST Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).**
31	L2TLBCMP1 (RO)	**BIST Results - L2 TLB Comparators for Way1 (Read Only).** 0: Fail. 1: Pass.
30	L2TLBCMP0 (RO)	**BIST Results - L2 TLB Comparators for Way0 (Read Only)**. 0: Fail. 1: Pass.
29	L2TLBDAT1 (RO)	**BIST Results - L2 TLB Data Integrity for Way1 (Read Only).** 0: Fail. 1: Pass.
28	L2TLBDAT0 (RO)	**BIST Results - L2 TLB Data Integrity for Way0 (Read Only).** 0: Fail. 1: Pass.
27:26	RSVD (RO)	**Reserved (Read Only).**
25	DC_DATA_LRU (RO)	**BIST Results for LRU Bits of Cache Data Array (Read Only).** 0: Fail. 1: Pass
24	DC_DATA (RO)	**BIST Results - Data of Cache Data Array (Read Only).** 0: Fail. 1: Pass. **Note:** A DATA_LRU failure can easily lead to a DATA failure, even if the actual data bits are functioning properly. This is because the DATA accesses use the READ_MRU_WAY functionality of the array that can be affected by an LRU bit failure.
23	DC_TAGCMP3 (RO)	**BIST Results - Data Cache Comparators for Way3 (Read Only).** 0: Fail. 1: Pass.
22	DC_TAGCMP2 (RO)	**BIST Results - Data Cache Comparators for Way2 (Read Only).** 0: Fail 1: Pass

CPU Core Register Descriptions (Continued)

Data Memory BIST Bit Descriptions (Continued)

Bit	Name	Description
21	DC_TAGCMP1 (RO)	**BIST Results - Data Cache Comparators for Way1 (Read Only).** 0: Fail 1: Pass
20	DC_TAGCMP0 (RO)	**BIST Results - Data Cache Comparators for Way0 (Read Only).** 0: Fail 1: Pass
19	DC_DAT3 (RO)	**BIST Results - Data Cache Data Integrity for Way3 (Read Only).** 0: Fail 1: Pass
18	DC_DAT2 (RO)	**BIST Results - Data Cache Data Integrity for Way2 (Read Only).** 0: Fail 1: Pass
17	DC_DAT1 (RO)	**BIST Results - Data Cache Data Integrity for Way1 (Read Only).** 0: Fail 1: Pass
16	DC_DAT0 (RO)	**BIST Results - Data Cache Data Integrity for Way0 (Read Only).** 0: Fail 1: Pass
15:6	RSVD (RO)	**Reserved (Read Only).**
5	L2TLB_RETEN	**Enable L2 TLB BIST Retention Timer.** 0: Disable. 1: Enable.
4	L2TLB_RUN	**Start BIST on Data Cache.** Should always read a 0. 0: Do not start BIST. 1: Start BIST.
3	DC_RETEN	**Enable Data Cache Data BIST Retention Timer.** 0: Disable. 1: Enable.
2	DC_RUN	**Start BIST on Data Cache.** Should always read a 0. 0: Do not start BIST. 1: Start BIST.
1	DCTAG_RETEN	**Enable Data Cache Tag BIST Retention Timer.** 0: Disable. 1: Enable.
0	DCTAG_RUN	**Start BIST on Data Cache Tag.** Should always read a 0. 0: Do not start BIST. 1: Start BIST.

CPU Core Register Descriptions (Continued)

4.5.2.80 Bus Controller Configuration 0 Register

MSR Address 00001900h
Type R/W
Reset Value 00000000_00000111h

Bus Controller Configuration 0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD											GPF_X	RSVD		BC_PRI_TO		RSVD	FPUON	CLK_ONS	SUSP	RSVD		RTSC_SUSP	RSVD	TSC_DMM	TSC_SUSP	TSC_SMM	RSVD		ISNINV	SNOOP

Bus Controller Configuration 0 Bit Descriptions

Bit	Name	Description
63:21	RSVD	**Reserved.** Write as read.
20	GPF_X	**General Protection Faults on EXCEPT Flags.** Enable General Protection Faults on MSR accesses whose response packets have the EXCEPT flag set. 0: Disable. 1: Enable.
19:18	RSVD	**Reserved.** Write as read.
17:16	BC_PRI_TO	**Priority Timeout.** When the CPU Core makes a request to a GLIU, it starts a timer. If the maximum count is reached before a response is received, the CPU Core elevates the priority of the request by sending a NULL packet to the GLIU with a new priority level. The feature is intended to ensure that the CPU Core gets requests serviced during heavy traffic from other devices. 00: No reprioritization done, priority timeout disabled. 01: Priority timeout after 256 clocks. 10: Priority timeout after 512 clocks. 11: Priority timeout after 1024 clocks.
15	RSVD	**Reserved.** Write as read.
14	FPUON	**FPU Clocks on with IPIPE Clocks.** Allow FPU clock gating to be enabled except during Suspend. 0: FPU clock off when FPU not active. 1: FPU clock always on except during Suspend.
13	CLK_ONS	**CPU Core Clocks On during Suspend.** 0: All CPU Core clocks off during Suspend. 1: All CPU Core clocks on during Suspend.
12	SUSP	**SUSP# Active.** Enable SUSP# input. 0: Ignore SUSP# input. 1: Enable SUSP# input.
11:9	RSVD	**Reserved.** Write as read.
8	RTSC_SUSP	**Real Time Stamp Counter Counts during Suspend.** 0: Disable. 1: Enable.
7	RSVD	**Reserved.** Write as read.

CPU Core Register Descriptions (Continued)

Bus Controller Configuration 0 Bit Descriptions (Continued)

Bit	Name	Description
6	TSC_DMM	**Time Stamp Counter Counts during DMM.** 0: Disable. 1: Enable.
5	TSC_SUSP	**Time Stamp Counter Counts during Suspend.** 0: Disable. 1: Enable.
4	TSC_SMM	**Time Stamp Counter Counts during SMM.** 0: Disable. 1: Enable.
3:2	RSVD	**Reserved.** Write as read.
1	ISNINV	**Ignore Snoop Invalidate.** Allow the CPU Coreto ignore the INVALIDATE bit in the GLIU snoop packet. When a snoop hits to a dirty cache line it is evicted, regardless of the state of INVALIDATE bit in the GLIU packet. 0: Process snoop packet. 1: Ignore snoop packet.
0	SNOOP	**Instruction Memory (IM) to Data Memory (DM) Snooping.** Allow code fetch snoops from the IM to the DM cache. 0: Disable. 1: Enable.

4.5.2.81 Bus Controller Configuration 1 Register

MSR Address 00001901h
Type R/W
Reset Value 00000000_00000000h

This register is reserved. Write as read.

4.5.2.82 Reserved Status Register

MSR Address 00001904h
Type RO
Reset Value 00000000_00000000h

Reserved Status Register

Bit	Name	Description
63:0	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

CPU Core Register Descriptions (Continued)

4.5.2.83 MSR Lock Register

MSR Address 00001908h
Type R/W
Reset Value 00000000_00000000h

MSR Lock Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															MSR_LOCK

MSR Lock Bit Descriptions

Bit	Name	Description
63:1	RSVD	**Reserved.** Write as read
0	MSR_LOCK	**Lock MSRs.** The CPU CoreMSRs above 0xFFF (with the exception of the MSR_LOCK register itself) are locked when this bit reads back as 1. To unlock these MSRs, write the value 45524F434C494156h to this register (the byte string “VAILCORE”). Writing any other value locks the MSRs. The lock only affects software access via the WRMSR and RDMSR instructions when the processor is NOT in SMM or DMM mode. MSRs are always writable and readable from the GLBus and when the processor is in SMM or DMM mode regardless of the state of the LOCK bit. Note that a write or read to a locked MSR register causes a protection exception in the pipeline. When MSRs are locked, no GLBus MSR transactions are generated (GLBus MSR addresses are above 0x3FFF).

4.5.2.84 Real Time Stamp Counter Register

MSR Address 00001910h
Type R/W
Reset Value 00000000_00000000h

Real Time Stamp Counter Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RTSC																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RTSC																															

Real Time Stamp Counter Bit Descriptions

Bit	Name	Description
63:0	RTSC	**Real Time Stamp Counter.** This register is the 64-bit secondary, or “real” time stamp counter. This counter allows software to configure the TSC not to include SMM or DMM time, and yet still have an accurate real time measurement that includes these times. Bus Controller Configuration 0 Register (MSR 00001900h) contains configuration bits that determine if the RTSC counts during Suspend mode. It always counts during SMM and DMM modes. All bits in this register are writable, unlike the TSC that clears the upper DWORD to 0 on writes.

4.5.2.85 TSC and RTSC Low DWORDs Register

MSR Address 00001911h
Type RO
Reset Value 00000000_00000000h

TSC and RTSC Low DWORDs Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RTSC_LOW																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TSC_LOW																															

TSC and RTSC Low DWORDs Bit Descriptions

Bit	Name	Description
63:32	RTSC_LOW (RO)	**Real Time Stamp Counter Low DWORD (Read Only).** This field provides a synchronized snapshot of the low DWORD of the RTSC register (MSR 00001910h).
31:0	TSC_LOW (RO)	**Time Stamp Counter Low DWORD (Read Only).** This field provides a synchronized snapshot of the low DWORD of the TSC register (MSR 00000010h).

4.5.2.86 Memory Subsystem Array Control Register

MSR Address 00001980h
Type R/W
Reset Value 00000000_00000000h

Memory Subsystem Array Control Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD							EN	RSVD																							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

Memory Subsystem Array Control Bit Descriptions

Bit	Name	Description
63:57	RSVD	**Reserved.** Write as read.
56	EN	**Enable.** This bit provides alternate array delay control values for the MSS (Memory Subsystem) arrays. After a reset, the MSS clock modules provide JTAG-accessible control values. This MSR can be used by software to override these values. Enable the array control values in this register to be used instead of those provided by the clock modules. 0: Disable. 1: Enable.
55:0	RSVD	**Reserved.** Write as read.

4.5.2.87 FPU Operation Modes Register

MSR Address 00001A00h
Type R/W
Reset Value 00000000_00000000h

FPU Operation Modes Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													FPU_HCM	FPU_SP	FPU_IPE

FPU Operation Modes Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.
2	FPU_HCM	**Half Clock Mode.** EX pipeline runs at 1/2 the clock frequency. This may save power for certain applications, specifically x87 single precision streaming operations. 0: Disable. 1: Enable.

FPU Operation Modes Bit Descriptions (Continued)

Bit	Name	Description
1	FPU_SP	**Limit Results to Single Precision.** The FPU datapath is only single-precision width. Operations on single precision numbers can generally be completed in one cycle, but double or extended precision numbers takes many cycles. This bit overrides the precision control bits in the x87 Mode Control register (of the FPU Instruction Set, see Table 7-30 on page 436), and causes the FPU to operate as if the precision control is set to single precision (00). 0: Disable. 1: Enable limit to single precision.
0	FPU_IPE	**Enable Force of Imprecise Exceptions.** For precise exceptions, the FPU allows only one instruction to be in the pipeline at a time when any FPU exceptions are unmasked. This results in a huge performance penalty. To run the FPU at full speed, it is necessary to mask all exceptions in the FPU Control Word register (MSR 00001A10h[11:0]). When this bit is set, the FPU is allowed to run at full speed even if there are unmasked exceptions in the FPU Control Word. With this bit set, exceptions will be generated, however, there is no guarantee that the exception will occur on any particular instruction boundary. It is known that setting this bit will cause some diagnostic software to fail. It is recommended to be set only when the FPU exception handler does not need to handle exceptions on the specific instruction boundary. 0: Disable. 1: Enable.

4.5.2.88 FPU BIST Register

MSR Address 00001A03h
Type R/W
Reset Value 00000000_00000000h

FPU BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																				BIST_DONE	SQBIST_PASS	SEEDBIST_PASS	SSBIST_EN	ABIST_DONE	ABIST_PASS	ARET_EN	ABIST_EN	RSVD	UBIST_DONE	UBIST_PASS	UBIST_EN

FPU BIST Bit Descriptions

Bit	Name	Description
63:12	RSVD	**Reserved.** Write as read.
11	BIST_DONE (RO)	**Seed/Square ROM BIST Done (Read Only).** Indicates that the seed and square ROM BIST tests have completed. 0: Not Completed. 1: Completed.
10	SQBIST_PASS (RO)	**Square ROM BIST Pass (Read Only).** Indicates pass/fail for the square ROM. 0: Fail. 1: Pass.

CPU Core Register Descriptions (Continued)

FPU BIST Bit Descriptions (Continued)

Bit	Name	Description
9	SEEDBIST_ PASS (RO)	**Seed ROM BIST Pass (Read Only).** Indicates pass/fail for the seed ROM. 0: Fail. 1: Pass.
8	SSBIST_EN	**Seed/Square BIST Enable.** Start BIST test for both the seed and square ROMs. 0: Disable. 1: Enable.
7	ABIST_DONE (RO)	**Array BIST Done (Read Only).** Indicates that the array BIST test has completed. 0: Not Completed. 1: Completed.
6	ABIST_PASS (RO)	**Array BIST Pass (Read Only).** Indicates pass/fail for the array BIST tests. 0: Fail. 1: Pass.
5	ARET_EN	**Array Retention Enable.** Start BIST data retention test on the register array. 0: Disable. 1: Enable.
4	ABIST_EN	**Array BIST Enable.** Start BIST test on the register array. 0: Disable. 1: Enable.
3	RSVD	**Reserved.** Write as read.
2	UBIST_DONE (RO)	**UROM BIST Done (Read Only).** Indicates that the UROM BIST test has completed. 0: Not Completed. 1: Completed.
1	UBIST_PASS (RO)	**UROM BIST Pass (Read Only).** Indicates pass/fail for the UROM BIST. 0: Fail. 1: Pass.
0	UBIST_EN	**UROM BIST Enable.** Start BIST ROM test on the microcode ROM. 0: Disable. 1: Enable.

4.5.2.89 FPU x87 Control Word Register

MSR Address 00001A10h
Type R/W
Reset Value 00000000_00000040h

FPU x87 Control Word Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																				FPU_CW											

FPU x87 Control Word Bit Descriptions

Bit	Name	Description
63:12	RSVD	**Reserved.** Write as read.
11:0	FPU_CW	**FPU Control Word.**

CPU Core Register Descriptions (Continued)

4.5.2.90 FPU x87 Status Word Register

MSR Address 00001A11h
Type R/W
Reset Value 00000000_00000000h

FPU x87 Status Word Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																FPU_SW															

Table 4-16. FPU x87 Status Word Register

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:0	FPU_SW	**FPU Status Word.**

4.5.2.91 FPU x87 Tag Word Register

MSR Address 00001A12h
Type R/W
Reset Value 00000000_00000000h

FPU x87 Tag Word Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																FPU_TW															

FPU x87 Tag Word Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:0	FPU_TW	**FPU Tag Word.**

4.5.2.92 FPU Busy Register

MSR Address 00001A13h
Type RO
Reset Value 00000000_00000000h

FPU Busy Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															FPU_BUSY

CPU Core Register Descriptions (Continued)

FPU Busy Bit Descriptions

Bit	Name	Description
63:1	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
0	FPU_BUSY (RO)	**FPU Busy (Read Only).** Software must check that the FPU is Idle before accessing MSRs 00001A10h-00001A12h, 00001A40h-00001A6Fh 0: FPU Idle. 1: FPU Busy.

4.5.2.93 FPU Register Map Register

MSR Address 00001A14h
Type RO
Reset Value 00000000_76543210h

FPU Register Map Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPU_REG_MAP																															

FPU Register Map Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).**
31:0	FPU_REG_MAP (RO)	**FPU Register Map (Read Only).** Internal mapping of architectural registers to physical registers in the register array.

CPU Core Register Descriptions (Continued)

4.5.2.94 Mantissa of R[x] Registers

Mantissa of R0 Register
MSR Address 00001A40h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R1 Register
MSR Address 00001A42h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R2 Register
MSR Address 00001A44h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R3 Register
MSR Address 00001A46h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R4 Register
MSR Address 00001A48h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R5 Register
MSR Address 00001A4Ah
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R6 Register
MSR Address 00001A4Ch
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R7 Register
MSR Address 00001A4Eh
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R8 Register
MSR Address 00001A50h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R9 Register
MSR Address 00001A52h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R10 Register
MSR Address 00001A54h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R11 Register
MSR Address 00001A56h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R12 Register
MSR Address 00001A58h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R13 Register
MSR Address 00001A5Ah
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R14 Register
MSR Address 00001A5Ch
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R15 Register
MSR Address 00001A5Eh
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of R[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
FPU_MR[x]																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPU_MR[x]																															

Mantissa of R[x] Bit Descriptions

Bit	Name	Description
63:0	FPU_MR[x]	**Mantissa of FPU Register R[x.]**

CPU Core Register Descriptions (Continued)

4.5.2.95 Exponent of R[x] Registers

Exponent of R0 Register
MSR Address 00001A41h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R1 Register
MSR Address 00001A43h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R2 Register
MSR Address 00001A45h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R3 Register
MSR Address 00001A47h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R4 Register
MSR Address 00001A49h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R5 Register
MSR Address 00001A4Bh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R6 Register
MSR Address 00001A4Dh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R7 Register
MSR Address 00001A4Fh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R8 Register
MSR Address 00001A51h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R9 Register
MSR Address 00001A53h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R10 Register
MSR Address 00001A55h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R11 Register
MSR Address 00001A57h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R12 Register
MSR Address 00001A59h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R13 Register
MSR Address 00001A5Bh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R14 Register
MSR Address 00001A5Dh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R15 Register
MSR Address 00001A5Fh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of R[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPU_ER[x]																															

Exponent of R[x] Register

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:0	FPU_ER[x]	**Exponent of FPU Register R[x].**

CPU Core Register Descriptions (Continued)

4.5.2.96 Mantissa of M[x] Registers

Mantissa of M0 Register
MSR Address 00001A60h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M1 Register
MSR Address 00001A62h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M2 Register
MSR Address 00001A64h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M3 Register
MSR Address 00001A66h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M4 Register
MSR Address 00001A68h
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M5 Register
MSR Address 00001A6Ah
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M6 Register
MSR Address 00001A6Ch
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M7 Register
MSR Address 00001A6Eh
Type R/W
Reset Value xxxxxxxx_xxxxxxxxh

Mantissa of M[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
FPU_MM[x]																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FPU_MM[x]																															

Mantissa of M[x] Register

Bit	Name	Description
63:0	FPU_MM[x]	**Mantissa of FPU Register M[x].**

CPU Core Register Descriptions (Continued)

4.5.2.97 Exponent of M[x] Registers

Exponent of M0 Register
MSR Address 00001A61h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M1 Register
MSR Address 00001A63h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M2 Register
MSR Address 00001A65h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M3 Register
MSR Address 00001A67h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M4 Register
MSR Address 00001A69h
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M5 Register
MSR Address 00001A6Bh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M6 Register
MSR Address 00001A6Dh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M7 Register
MSR Address 00001A6Fh
Type R/W
Reset Value 00000000_0000xxxxh

Exponent of M[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																FPU_EM[x]															

Exponent of M[x] Register

Bit	Name	Description
63:16	RSVD	**Reserved.** Write as read.
15:0	FPU_EM[x]	**Exponent of FPU Register M[x].**

CPU Core Register Descriptions (Continued)

4.5.2.98 CPU ID MSRs

CPUID0 Register (Standard Levels and Vendor ID String 1)
MSR Address 00003000h
Type Write Once
Reset Value 646F6547_00000001h

CPUID1 Register (Vendor ID Strings 2 and 3)
MSR Address 00003001h
Type Write Once
Reset Value 79622065_43534E20h

CPUID2 Register (Type/Family/Model/Step)
MSR Address 00003002h
Type Write Once
Reset Value 00000000_0000055xh

CPUID3 Register (Feature Flags)
MSR Address 00003003h
Type Write Once
Reset Value 0080A93D_00000000h

CPUID4 Register (N/A)
MSR Address 00003004h
Type Write Once
Reset Value 00000000_00000000h

CPUID5 Register (N/A)
MSR Address 00003005h
Type Write Once
Reset Value 00000000_00000000h

CPUID6 Register (Max Extended Levels 1)
MSR Address 00003006h
Type Write Once
Reset Value 646F6547_80000006h

CPUID7 Register (Max Extended Levels 2)
MSR Address 00003007h
Type Write Once
Reset Value 79622065_43534E20h

CPUID8 Register (Extended Type/Family/Model/Stepping)
MSR Address 00003008h
Type Write Once
Reset Value 00000000_0000055xh

CPUID9 Register (Extended Feature Flags)
MSR Address 00003009h
Type Write Once
Reset Value C0C0A13D_00000000h

CPUIDA Register (CPU Marketing Name 1)
MSR Address 0000300Ah
Type Write Once
Reset Value 4D542865_646F6547h

CPUIDB Register (CPU Marketing Name 2)
MSR Address 0000300Bh
Type Write Once
Reset Value 72676574_6E492029h

CPUIDC Register (CPU Marketing Name 3)
MSR Address 0000300Ch
Type Write Once
Reset Value 6F725020_64657461h

CPUIDD Register (CPU Marketing Name 4)
MSR Address 0000300Dh
Type Write Once
Reset Value 6220726F_73736563h

CPUIDE Register (CPU Marketing Name 5)
MSR Address 0000300Eh
Type Write Once
Reset Value 6E6F6974_614E2079h

CPUIDF Register (CPU Marketing Name 6)
MSR Address 0000300Fh
Type Write Once
Reset Value 00696D65_53206C61h

CPUID10 Register (L1 TLB Information)
MSR Address 00003010h
Type Write Once
Reset Value FF08FF08_00000000h

CPUID11 Register (L1 Cache Information)
MSR Address 00003011h
Type Write Once
Reset Value 10040120_10040120h

CPUID12 Register (L2 TLB Information)
MSR Address 00003012h
Type Write Once
Reset Value 00002040_0000F004h

CPUID13 Register (L2 Cache Information)
MSR Address 00003013h
Type Write Once
Reset Value 00000000_00000000h

CPUID[x] Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
CPUID[x]																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CPUID[x]																															

CPU Core Register Descriptions (Continued)

CPUID[x] Bit Descriptions

Bit	Name	Description
63:0	CPUID0	**Standard Levels and Vendor ID String 1.** Same data as CPUID instruction [00000000] EBX/EAX. Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID1	**Vendor ID Strings 2 and 3.** Same data as CPUID instruction [00000000] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID2	**Type/Family/Model/Step.** Same data as CPUID instruction [00000001] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID3	**Feature Flags.** Same data as CPUID instruction [00000001] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID4	**Reserved.** This register is not used in the CPU Core module.
63:0	CPUID5	**Reserved.** This register is not used in the CPU Core module.
63:0	CPUID6	**CPUID Max Extended Levels.** Same data as CPUID instruction [80000000] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID7	**CPUID Max Extended Levels.** Same data as CPUID instruction [80000000] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID8	**Extended Type/Family/Model/Stepping.** Same data as CPUID instruction [80000001] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUID9	**Extended Feature Flags.** Same data as CPUID instruction [80000001] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUIDA	**CPU Marketing Name 1.** Same data as CPUID instruction [80000002] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUIDB	**CPU Marketing Name 2.** Same data as CPUID instruction [80000002] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details.
63:0	CPUIDC	**CPU Marketing Name 3.** Same data as CPUID instruction [80000003] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUIDD	**CPU Marketing Name 4.** Same data as CPUID instruction [80000003] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUIDE	**CPU Marketing Name 5.** Same data as CPUID instruction [80000004] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUIDF	**CPU Marketing Name 6.** Same data as CPUID instruction [80000004] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUID10	**L1 TLB Information.** Same data as CPUID instruction [80000005] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUID11	**L1 Cache Information.** Same data as CPUID instruction [80000005] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUID12	**L2 TLB Information.** Same data as CPUID instruction [80000006] EBX/EAX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details
63:0	CPUID13	**L2 Cache Information.** Same data as CPUID instruction [80000006] EDX/ECX. See Section 7.2 "CPUID Instruction Set" on page 409 for more details

5.0 Integrated Functions

The integrated functions (shown in gray in Figure 5-1) of the Geode GX2 processor are:

- GeodeLink Memory Controller (GLMC)
- Graphics Processor (GP)
- Display Controller (DC)
- Video Processor (VP)
- GeodeLink Control Processor (GLCP)
- GeodeLink PCI Bridge (GLPCI)
- Geode I/O Companion

These functions are GLIU clients. This section provides a functional description of each client and their respective registers.

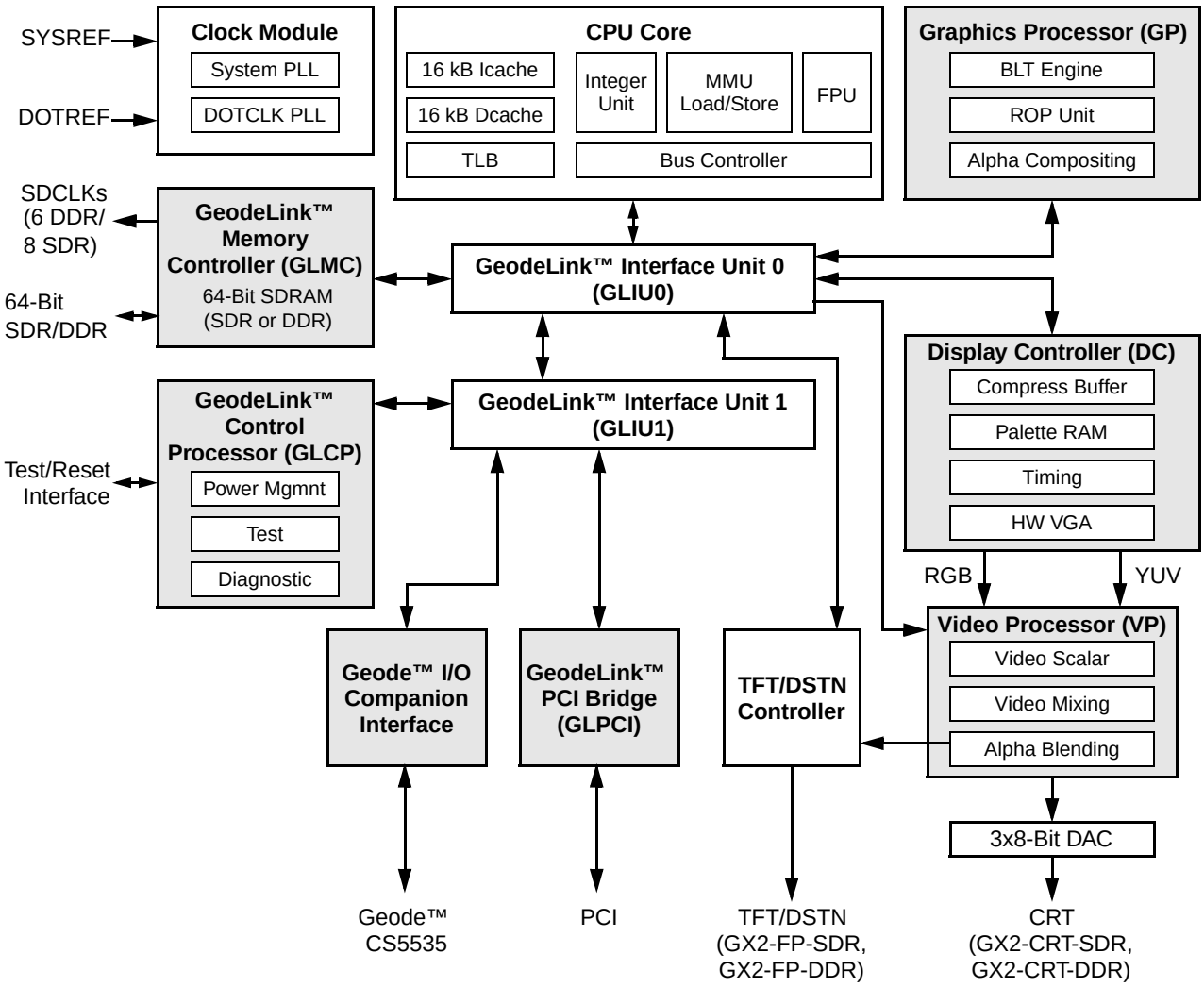


Figure 5-1. Integrated Functions in the GX2 Block Diagram

5.1 GEODELINK MEMORY CONTROLLER REGISTER DESCRIPTIONS

All GeodeLink Memory Controller (GLMC) registers are Model Specific Registers (MSRs) and are accessed via the RDMSR and WRMSR instructions.

The registers associated with the GLMC are the Standard GeodeLink Device MSRs and GLMC Specific MSRs. Table 5-1 and Table 5-2 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: MSR addresses are documented using the CPU Core as the source; refer to Table 3-1 "MSR Addressing" on page 55 for further details.

Table 5-1. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
20002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_000200xxh	Page 178
4C002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG) - Not used.	00000000_00000000h	Page 178
20002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000000h	Page 178
20002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 179
20002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 179
20002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 181

Table 5-2. GLMC Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
20000010h	RO	Row Addresses Bank0 DIMM0, Bank1 DIMM0 (MC_CF_BANK01)	xxxxxxxx_xxxxxxxxh	Page 181
20000011h	RO	Row Addresses Bank2 DIMM0, Bank3 DIMM0 (MC_CF_BANK23)	xxxxxxxx_xxxxxxxxh	Page 181
20000012h	RO	Row Addresses Bank4 DIMM0, Bank5 DIMM0 (MC_CF_BANK45)	xxxxxxxx_xxxxxxxxh	Page 182
20000013h	RO	Row Addresses Bank6 DIMM0, Bank7 DIMM0 (MC_CF_BANK67)	xxxxxxxx_xxxxxxxxh	Page 182
20000014h	RO	Row Addresses Bank0 DIMM1, Bank1 DIMM0 (MC_CF_BANK89)	xxxxxxxx_xxxxxxxxh	Page 183
20000015h	RO	Row Addresses Bank2 DIMM1, Bank3 DIMM1 (MC_CF_BANKAB)	xxxxxxxx_xxxxxxxxh	Page 183
20000016h	RO	Row Addresses Bank4 DIMM1, Bank5 DIMM1 (MC_CF_BANKCD)	xxxxxxxx_xxxxxxxxh	Page 184
20000017h	RO	Row Addresses Bank6 DIMM1, Bank7 DIMM1 (MC_CF_BANKEF)	xxxxxxxx_xxxxxxxxh	Page 184
20000018h	R/W	Refresh and SDRAM Program (MC_CF07_DATA)	10071007_00000040h	Page 185
20000019h	R/W	Timing and Mode Program (MC_CF8F_DATA)	18000008_287337A3h	Page 187
2000001Ah	R/W	Feature Enables (MC_CF1017_DATA)	00000000_00000000h	Page 190
2000001Bh	RO	Performance and Counters 1 (MC_CFPERF_CNT1)	00000000_00000000h	Page 191
2000001Ch	R/W	Performance and Counters 2 (MC_PERF_CNT2)	00000000_00FF00FFh	Page 191

GLMC Register Descriptions (Continued)

Table 5-2. GLMC Specific MSRs Summary (Continued)

MSR Address	Type	Register	Reset Value	Reference
2000001Dh	R/W	Clocking and Debug (MC_CFCLK_DBUG)	00000000_00000000h	Page 193
2000001Eh	RO	Page Open Status (MC_CFPG_OPEN)	00000000_0000FFFFh	Page 194
2000001Fh	RW	Read Sync Control (MC_CF_RDSYNC)	00000000_00000000h	Page 195
20000020h	R/W	PM Sensitivity Counters (MC_CF_PMCTR)	00000000_00000006h	Page 195

5.1.1 Standard GeodeLink Device MSRs

5.1.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 20002000h
Type RO
Reset Value 00000000_000200xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.**
23:8	DEV_ID	**Device ID.** Identifies device (0200h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

5.1.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address 4C002001h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the GLMC module.

5.1.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 20002002h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the GLMC module.

GLMC Register Descriptions (Continued)

5.1.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 20002003h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD															UNEXP_TYPE_ERR_FLAG	RSVD															UNEXP_TYPE_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as read.
31:17	RSVD	**Reserved.** Write as read.
16	UNEXP_TYPE_ ERR_FLAG	**Unexpected Type Error Flag.** If high, records that an ERR was generated due to an unexpected type event (GLIU's request type field is either an I/O type or snoop type.) Write 1 to clear; writing 0 has no effect. UNEXP_TYPE_ERR_EN (bit 0) must be low to generate ERR and set flag.
15:1	RSVD	**Reserved.** Write as read.
0	UNEXP_TYPE_ ERR_EN	**Unexpected Type Error Enable.** Write 0 to enable UNEXP_TYPE_ERR_FLAG (bit 16) and to allow the unexpected type event to generate an ERR and set flag.

5.1.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 20002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																												PMODE1		PMODE0	

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:34	RSVD	**Reserved.** Write as read.
33:32	RSVD	**Reserved.** Write as 0.

GLMC Register Descriptions (Continued)

GLD_MSR_PM Bit Descriptions (Continued)

Bit	Name	Description
31:4	RSVD	**Reserved.** Write as read.
3:2	PMODE1	**Power Mode 1 (GLIU and GLMC Clocks).** Clock gating for clock domains 0 (GLIU clock) and 1 (GLMC clock). Once the GLMC becomes idle, it enters PMODE1 by: — Closing all banks with a 'precharge all' command to the DIMMs. — Issuing a self-refresh command. — Bringing CKE[1:0] signals low and placing the address and control signals into TRI-STATE mode. — It then shuts off its GLIU and GLMC clocks on the next clock after the self-refresh. The GLMC resumes to full power after any activity is detected (e.g., a GLIU request). 00: Disable clock gating. Clocks are always on. (Default) 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
1:0	PMODE0	**Power Mode 0 (GLIU Clock).** Clock gating for clock domain 0 (GLIU clock). Once the GLMC becomes idle, it enters PMODE0 by: — Bringing CKE[1:0] signals low and placing the address and control signals into TRI-STATE mode. — It then shuts off its GLIU clock on the next cycle. The GLMC clock remains on to maintain the refresh counters, as do the SDRAM clocks. The GLMC resumes to full power either after any activity is detected, or when it needs to perform a refresh. The CKE[1:0] signals are brought back high one cycle before the GLIU clock is turned back on. 00: Disable clock gating. Clocks are always on. (Default) 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

GLMC Register Descriptions (Continued)

5.1.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address 20002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

5.1.2 GLMC Specific MSRs

5.1.2.1 Row Addresses Bank0 DIMM0, Bank1 DIMM0 (MC_CF_BANK01)

MSR Address 20000010h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANK01 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANK1																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANK0																					

MC_CF_BANK01 Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANK1	**Memory Configuration Bank1.** Open row address (addr[31:10]) for Bank1, DIMM0.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANK0	**Memory Configuration Bank0.** Open row address (addr[31:10]) for Bank0, DIMM0.

5.1.2.2 Row Addresses Bank2 DIMM0, Bank3 DIMM0 (MC_CF_BANK23)

MSR Address 20000011h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANK23 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANK3																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANK2																					

GLMC_CF_BANK23 Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANK3	**Memory Controller Configuration Bank3.** Open row address (addr[31:10]) for Bank3, DIMM0.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANK2	**Memory Controller Configuration Bank2.** Open row address (addr[31:10]) for Bank2, DIMM0.

GLMC Register Descriptions (Continued)

5.1.2.3 Row Addresses Bank4 DIMM0, Bank5 DIMM0 (MC_CF_BANK45)

MSR Address 20000012h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANK45 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANK5																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANK4																					

MC_CF_BANK45 Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANK5	**Memory Controller Configuration Bank5.** Open row address (addr[31:10]) for Bank5, DIMM0.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANK4	**Memory Controller Configuration Bank4.** Open row address (addr[31:10]) for Bank4, DIMM0.

5.1.2.4 Row Addresses Bank6 DIMM0, Bank7 DIMM0 (MC_CF_BANK67)

MSR Address 20000013h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANK67 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANK7																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANK6																					

MC_CF_BANK67 Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANK7	**Memory Controller Configuration Bank7.** Open row address (addr[31:10]) for Bank7, DIMM0.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANK6	**Memory Controller Configuration Bank6.** Open row address (addr[31:10]) for Bank6, DIMM0.

GLMC Register Descriptions (Continued)

5.1.2.5 Row Addresses Bank0 DIMM1, Bank1 DIMM0 (MC_CF_BANK89)

MSR Address 20000014h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANK89 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANK9																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANK8																					

MC_CF_BANK89 Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANK9	**Memory Controller Configuration Bank9.** Open row address (addr[31:10]) for Bank1, DIMM0.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANK8	**Memory Controller Configuration Bank8.** Open row address (addr[31:10]) for Bank0, DIMM1.

5.1.2.6 Row Addresses Bank2 DIMM1, Bank3 DIMM1 (MC_CF_BANKAB)

MSR Address 20000015h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANKAB Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANKB																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANKA																					

MC_CF_BANKAB Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANKB	**Memory Controller Configuration BankB.** Open row address (addr[31:10]) for Bank3, DIMM1.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANKA	**Memory Controller Configuration BankA.** Open row address (addr[31:10]) for Bank2, DIMM1.

GLMC Register Descriptions (Continued)

5.1.2.7 Row Addresses Bank4 DIMM1, Bank5 DIMM1 (MC_CF_BANKCD)

MSR Address 20000016h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANKCD Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANKD																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANKC																					

MC_CF_BANKCD Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANKD	**Memory Controller Configuration BankC.** Open row address (addr[31:10]) for Bank5, DIMM1.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANKC	**Memory Controller Configuration BankB.** Open row address (addr[31:10]) for Bank4, DIMM1.

5.1.2.8 Row Addresses Bank6 DIMM1, Bank7 DIMM1 (MC_CF_BANKEF)

MSR Address 20000017h
Type RO
Reset Value xxxxxxxx_xxxxxxxxh

MC_CF_BANKEF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD										MC_CF_BANKF																					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										MC_CF_BANKE																					

MC_CF_BANKEF Bit Descriptions

Bit	Name	Description
63:54	RSVD	**Reserved.** Reads as 0.
53:32	MC_CF_BANKF	**Memory Controller Configuration BankF.** Open row address (addr[31:10]) for Bank7, DIMM1.
31:22	RSVD	**Reserved.** Reads as 0.
21:0	MC_CF_BANKE	**Memory Controller Configuration BankE.** Open row address (addr[31:10]) for Bank6, DIMM1.

GLMC Register Descriptions (Continued)

5.1.2.9 Refresh and SDRAM Program (MC_CF07_DATA)

MSR Address 20000018h
Type R/W
Reset Value 10071007_00000040h

MC_CF07_DATA Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
D1_SZ				RSVD			D1_MB	RSVD			D1_CB	RSVD	D1_PSZ			D0_SZ				RSVD			D0_MB	RSVD			D0_CB	RSVD	D0_PSZ		
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD		EMR_BA1	EMR_BA0	RSVD	EMR_QFC	EMR_DRV	EMR_DLL	REF_INT																REF_STAG		RSVD		REF_TST	RSVD	SOFT_RST	PROG_DRAM

MC_CF07_DATA Bit Descriptions

Bit	Name	Description
63:60	D1_SZ	**DIMM1 Size.** 0000: Reserved 0001: 8 MB (Default) 0010: 16 MB 0011: 32 MB 0100: 64 MB 0101: 128 MB 0110: 256 MB 0111: 512 MB 1xxx: Reserved
59:57	RSVD	**Reserved.** Write as read.
56	D1_MB	**DIMM1 Module Banks.** Number of module banks for DIMM1. 0: One module bank. (Default) 1: Two module banks.
55:53	RSVD	**Reserved.** Write as read.
52	D1_CB	**DIMM1 Component Banks.** Number of component banks per module bank for DIMM1. 0: Two component banks. (Default) 1: Four component banks.
51	RSVD	**Reserved.** Write as read.
50:48	D1_PSZ	**DIMM1 Page Size.** 000: 1 kB 001: 2 kB 010: 4 kB 011: 8 kB 100: 16 kB 101: Reserved 110: Reserved 111: DIMM 1 Not Installed (Default)
47:44	D0_SZ	**DIMM0 Size.** 0000: Reserved 0001: 8 MB (Default) 0010: 16 MB 0011: 32 MB 0100: 64 MB 0101: 128 MB 0110: 256 MB 0111: 512 MB 1xxxx: Reserved
43:41	RSVD	**Reserved.** Write as read.
40	D0_MB	**DIMM0 Module Banks.** Number of module banks for DIMM0. 0: One module bank. (Default) 1: Two module banks.
39:37	RSVD	**Reserved.** Write as read.

GLMC Register Descriptions (Continued)

MC_CF07_DATA Bit Descriptions (Continued)

Bit	Name	Description
36	D0_CB	**DIMM0 Component Banks.** Number of component banks per module bank for DIMM0. 0: Two component banks. (Default) 1: Four component banks.
35	RSVD	**Reserved.** Write as read.
34:32	D0_PSZ	**DIMM0 Page Size.** 000: 1 kB 001: 2 kB 010: 4 kB 011: 8 kB 100: 16 kB 101: Reserved 110: Reserved 111: DIMM0 not installed (Default)
31:30	RSVD	**Reserved.** Write as read.
29:28	EMR_BA[1:0]	**Mode Register Set Bank Address.** These are the bank select bits used in DDR mode only for programming the DDR DIMM's Extended Mode Register. These bits select whether the GLMC is programming the Mode Register or the Extended Mode Register. 00: Program the DIMM Mode Register. (Default) 01: Program the DIMM Extended Mode Register. Bits [26:24] determine the program data.
27	RSVD	**Reserved.** Write as read.
26	EMR_QFC	**Extended Mode Register FET Control.** This bit programs the DIMMs QFC# signal that provides control for FET switches that are used to isolate module loads from the system memory busy at times when the given module is not being accessed. Only pertains to x4 configurations. 0: Enable. (Default) 1: Disable.
25	EMR_DRV	**Extended Mode Register Drive Strength Control.** This bit selects either normal or reduced drive strength. 0: Normal. (Default) 1: Reduced.
24	EMR_DLL	**Extended Mode Register DLL.** This bit disables/enables the DLL. 0: Enable. (Default) 1: Disable.
23:8	REF_INT	**Refresh Interval.** This field determines the number of SDRAM clocks between refresh. This value multiplied by 16 is the average number of clocks between refresh. The value 0000h disables refresh. (Default: 0000h.)
7:6	REF_STAG	**Refresh Staggering.** This field controls the number of clocks between REF commands to different banks during refresh cycles. Staggering is used to help reduce power spikes during refresh. Do not program 01 in two clock setup mode. 00: Four SDRAM clocks. 01: One SDRAM clock. (Default) 10: Two SDRAM clocks. 11: Three SDRAM clocks.
5:4	RSVD	**Reserved.** Write as read.
3	REF_TST	**Test Refresh.** When set high, generates one refresh request that the GLMC queues in its refresh request queue. When read this bit always returns a 0. It is not necessary to clear this bit between each refresh request. Since the refresh queue is 8-deep, 8 sets/clears of this bit queues 8 refresh requests, thus forcing a refresh request out to DRAM. This bit should only be used for initialization and test. 0: Do not generate refresh request. (Default) 1: Generate refresh request.
2	RSVD	**Reserved.** Write as read.

GLMC Register Descriptions (Continued)

MC_CF07_DATA Bit Descriptions (Continued)

Bit	Name	Description
1	SOFT_RST	**Software Reset**. Puts the GLMC in a known state. Does not change configuration registers. The recommended sequence to use is: 1) Make sure SDRAM interface has “been idle for a while”. 2) Set software reset, then clear software reset. 3) Do a refresh cycle. Accesses to memory may resume as normal following this. Note that configuration registers are not scannable. To reproduce a problem in simulation requires saving the configuration registers with software in silicon and reprogramming the values in simulation. (Default: 0.)
0	PROG_DRAM	**Program Mode Register in SDRAM.** When this bit is set, the GLMC issues one Load Mode Register command to the DRAMs. It either programs the Mode Register (if EMR_BA[1:0] = 00, MSR 20000018h[29:28]), or the Extended Mode Register (if EMR_BA[1:0] = 01). The Mode Register is programmed with CAS latency (see MSR 20000019h[30:28]), wrap type sequential, and a burst length of 4 for 64-bit data path, or a burst length of 8 for 32-bit wide data path. The Extended Mode Register, applies only to DDR DIMMs, is programmed with the QFC#, drive strength and DLL disable bits per bits [26:24] (bits EMR_QFC, EMR_DRV, EMR_DLL). In DDR mode, the Extended Mode Register must be programmed first to enable the DLLs, then the Mode Register. This bit must be set and cleared for each Load Mode Register command. (Default: 0.)

5.1.2.10 Timing and Mode Program (MC_CF8F_DATA)

MSR Address 20000019h
Type R/W
Reset Value 18000008_287337A3h

MC_CF8F_DATA Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
STALE_REQ								RSVD			XOR_BIT_SEL		XOR_MB0	XOR_BA1	XOR_BA0	RSVD								AP_B2B	AP_EN	RSVD	RSVD	DDR_MODE	RSVD	HOI_LOI	RSVD
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
THZ_DLY	CAS_LAT			REF2ACT				ACT2PRE				RSVD	PRE2ACT			RSVD	ACT2CMD			ACT2ACT				DPLWR		DPLRD		RSVD	DAL		

MC_CF8F_DATA Bit Descriptions

Bit	Name	Description
63:56	STALE_REQ	**GLIU Max Stale Request Count.** Non-high priority requests (PRI = 0) are made high priority requests when the request is not serviced within max stale request count clocks. (Default: 18h.)
55:53	RSVD	**Reserved.** Write as read.

GLMC Register Descriptions (Continued)

MC_CF8F_DATA Bit Descriptions (Continued)

Bit	Name	Description
52:51	XOR_BIT_SEL	**XOR Bit Select.** Selects which upper GLIU address bit to XOR with MB0, BA1 or BA0 (see LOI address interleaving). Only applies to LOI mode. 00: Addr[18] (Default) 10: Addr[20] 01: Addr[19] 11: Addr[21]
50	XOR_MB0	**XOR MB0.** Allows XORing of module bank select MB0 with upper GLIU address bit selected by XOR_BIT_SEL (bits [52:51]). 0: Disable. (Default) 1: Enable.
49	XOR_BA1	**XOR BA1.** Allows XORing of component bank select BA1 with upper GLIU address bit selected by XOR_BIT_SEL (bits [52:51]). 0: Disable. (Default) 1: Enable.
48	XOR_BA0	**XOR BA0.** Allows XORing of component bank select BA0 with upper GLIU address bit selected by XOR_BIT_SEL (bits [52:51]). 0: Disable. (Default) 1: Enable.
47:40	RSVD	**Reserved.** Write as read.
39	AP_B2B	**Autoprecharge Back-to-Back Command.** Used with autoprecharge mode only. Enables back-to-back commands. For enabling back-to-back commands in all other modes including MTEST debug mode, see MC_CFCLK_DBUG[34] (MSR 2000001Dh). 0: Enable. (Default) 1: Disable.
38	AP_EN	**Autoprecharge.** 0: Enable. (Default) 1: Disable.
37:36	RSVD	**Reserved.** Write as 0.
35	SDR_DDR (RO)	**Double Data Rate SDRAM Mode (Read Only).** Selects whether DDR (double-data rate) or SDR (single data rate) DIMMs are installed in the system. This bit is a registered version of the GLCP's SDRMODE bit (MSR 4C000014h[10]). 0: SDR SDRAMs installed in system. 1: DDR SDRAMS installed in system. (Default)
34	RSVD	**Reserved.** Write as read.
33	HOI_LOI	**High / Low Order Interleave Select (HOI / LOI).** Selects the address interleaving mode. HOI uses fixed upper address bits to map the GLIU address to a component bank. LOI uses variable lower address bits depending on page size, number of module banks, and number of component banks of the DIMMs, plus an option to XOR with upper address bits. 0: LOI. (Default) 1: HOI.
32	RSVD	**Reserved.** Write as read.
31	THZ_DLY	**t_{HZ} Delay.** Add one extra clock on read-to-write turnarounds to satisfy DRAM parameter t_{HZ} for higher frequencies. 0: No delay. (Default) 1: Add one clock.

GLMC Register Descriptions (Continued)

MC_CF8F_DATA Bit Descriptions (Continued)

Bit	Name	Description
30:28	CAS_LAT	**Read CAS Latency.** Number of clocks delayed between READ command and Data Valid. Note: In registered DIMM mode, add one more clock to latencies listed below. **SDR Mode:** 000: RSVD 010: 2 Clks (Default) 100: 4 Clks 110: 6 Clks 001: RSVD 011: 3 Clks 101: 5 Clks 111: RSVD **DDR Mode:** 000: RSVD 010: 2 Clks (Default) 100: RSVD 110: 2.5 Clks 001: RSVD 011: RSVD 101: 1.5 Clks 111: RSVD
27:24	REF2ACT	**REF to REF/ACT Period (t_{RC}).** Minimum number of SDRAM clocks between REF and REF/ACT commands. Default: 8h. 0000: RSVD 0100: 5 Clks 1000: 9 Clks (Default) 1100: 13 Clks 0001: 2 Clks 0101: 6 Clks 1001: 10 Clks 1101: 14 Clks 0010: 3 Clks 0110: 7 Clks 1010: 11 Clks 1110: 15 Clks 0011: 4 Clks 0111: 8 Clks 1011: 12 Clks 1111: 16 Clks
23:20	ACT2PRE	**ACT to PRE Period (t_{RAS}).** Minimum number of clocks from ACT to PRE commands on the same component bank. 0000: RSVD 0100: 5 Clks 1000: 9 Clks 1100: 13 Clks 0001: 2 Clks 0101: 6 Clks 1001: 10 Clks 1101: 14 Clks 0010: 3 Clks 0110: 7 Clks 1010: 11 Clks 1110: 15 Clks 0011: 4 Clks 0111: 8 Clks (Default) 1011: 12 Clks 1111: 16 Clks
19	RSVD	**Reserved.** Write as read.
18:16	PRE2ACT	**PRE to ACT Period (t_{RP}).** Minimum number of SDRAM clocks between PRE and ACT commands. 000: RSVD 010: 2 Clks 100: 4 Clks 110: 6 Clks 001: 1 Clk 011: 3 Clks (Default) 101: 5 Clks 111: 7 Clks
15	RSVD	**Reserved.** Write as read.
14:12	ACT2CMD	**Delay Time from ACT to READ/WRITE (t_{RCD}).** Minimum number of SDRAM clocks between ACT and READ/WRITE commands. 000: RSVD 010: 2 Clks 100: 4 Clks 110: 6 Clks 001: 1 Clks 011: 3 Clks (Default) 101: 5 Clks 111: RSVD
11:8	ACT2ACT	**ACT(0) to ACT(1) Period (t_{RRD}).** Minimum number of SDRAM clocks between ACT and ACT command to two different component banks within the same module bank. 000: RSVD 010: 2 Clks 100: 4 Clks 110: 6 Clks 001: 1 Clks 011: 3 Clks 101: 5 Clks 111: 7 Clks (Default)
7:6	DPLWR	**Data-in to PRE Period (t_{DPLW}).** Minimum number of clocks from last write data to precharge command on the same component bank. This value is not pertinent for autoprecharge mode. 00: RSVD 01: 1 Clks 10: 2 Clks (Default) 11: 3 Clks
5:4	DPLRD	**Data-in to PRE Period (t_{DPLR}).** Minimum number of clocks from last read data to precharge command on the same component bank (3..1 valid). The count starts on the same clock that the last data would have been if the command was a write. This value is not pertinent for autoprecharge mode. 00: RSVD 01: 1 Clk 10: 2 Clks (Default) 11: 3 Clks
3	RSVD	**Reserved.** Write as read.

GLMC Register Descriptions (Continued)

MC_CF8F_DATA Bit Descriptions (Continued)

Bit	Name	Description
2:0	DAL	**Data-in to ACT (REF) Period (t_{DAL}).** Minimum number of clocks from last write data to activate command on the same component bank. This value is only pertinent for autoprecharge mode and otherwise should be left at the default value. 000: RSVD 010: 2 Clks 100: 4 Clks 110: 6 Clks 001: 1 Clk 011: 3 Clks (Default) 101: 5 Clks 111: 7 Clks

5.1.2.11 Feature Enables (MC_CF1017_DATA)

MSR Address 2000001Ah
Type R/W
Reset Value 00000000_00000000h

MC_CF1017_DATA Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																							PM1_DLY	RSVD					WR2DAT		

MC_CF1017_DATA Bit Descriptions

Bit	Name	Description
63:9	RSVD	**Reserved.** Write as read.
8	PM1_UP_DLY	**PMode1 Up Delay.** Enables a delay of 200 clocks upon exit from power mode 1 (PMODE1), that involves a self-refresh command to DRAM. This is to satisfy a 200-clock delay from self-refresh exit to first read command (although this bit delays all commands, read and write). 0: No delay. (Default) 1: Enable delay.
7:3	RSVD	Reserved
2:0	WR2DAT	**Write Command to Data Latency.** Used only in registered mode and DDR mode, where there is a write latency between the write command and the first data beat. Valid values are: [2,1,0] and must correspond to the installed DIMMs as follows: 00: Value when unbuffered SDR SDRAMs are used. (Default) 01: Value when registered SDR SDRAMs or unbuffered DDR SDRAMs are used. 10: Value when registered DDR SDRAMs are used. 11: Reserved.

GLMC Register Descriptions (Continued)

5.1.2.12 Performance and Counters 1 (MC_CFPERF_CNT1)

MSR Address 2000001Bh
Type RO
Reset Value 00000000_00000000h

MC_CFPERF_CNT1 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
CNT0																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CNT1																															

MC_CFPERF_CNT1 Bit Descriptions

Bit	Name	Description
63:32	CNT0	**Counter 0.** Performance Counter 0 counts the occurrence of events at the GLIU interface. Events are specified in CNT0_DATA field (MSR 2000001Ch[7:0]). Reset and stop control on this counter is via the STOP_CNT0 and RST_CNT0 BITS (MSR 2000001Ch[33:32]). (Default: 0h.)
31:0	CNT1	**Counter 1.** Performance Counter 1 counts the occurrence of events at the GLIU interface. Events are specified in CNT1_DATA field (MSR 2000001Ch[23:16]). Reset and stop control on this counter is via the STOP_CNT1 and RST_CNT1 bits (MSR 2000001Ch[35:34]. (Default: 0h.)

5.1.2.13 Performance and Counters 2 (MC_PERF_CNT2)

MSR Address 2000001Ch
Type R/W
Reset Value 00000000_00FF00FFh

MC_PERF_CNT2 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																												STOP_CNT1	RST_CNT1	STOP_CNT0	RST_CNT0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CNT1_MASK								CNT1_DATA								CNT0_MASK								CNT0_DATA							

MC_PERF_CNT2 Bit Descriptions

Bit	Name	Description
63:36	RSVD	**Reserved.** Write as read.
35	STOP_CNT1	**Stop Counter 1.** 0: Counter 1 counts. (Default) 1: Stop Counter 1.
34	RST_CNT1	**Reset Counter 1.** 0: Do nothing. (Default) 1: Reset Counter 1.

GLMC Register Descriptions (Continued)

MC_PERF_CNT2 Bit Descriptions (Continued)

Bit	Name	Description
33	STOP_CNT0	**Stop Counter 0.** 0: Counter 0 counts. (Default) 1: Stop Counter 0.
32	RST_CNT0	**Reset Counter 0.** 0: Do nothing. (Default) 1: Reset Counter 0.
31:24	CNT1_MASK	**Counter 1 Mask**. Bits in the data fields in CNT1_DATA (bits [23:16]) to mask. These bits are not used in the comparisons. Used with Counter 1. (Default: 00h - i.e., no masking.)
23:16	CNT1_DATA	**Counter 1 Data.** The data value to compare with the GLMC's requests. Used with Counter 1. (Default: FFh.)
15:8	CNT0_MASK	**Counter 0 Mask**. Bits in the data fields in CNT0_DATA (bits 7:0) to mask. These bits are not used in the comparisons. Used with Counter 0. (Default: 00h - i.e., no masking.)
7:0	CNT0_DATA	**Counter 0 Data.** The data value to compare with the GLMC's requests. Used with Counter 0. (Default: FFh.) Note that the above four bit fields control the incrementing of the two 32-bit performance counters CNT0 and CNT1 (MSR 2000001Bh[63:32] and [31:0], respectively). Specifically, CNT0_DATA, CNT0_MASK control the CNT0 counter, and CNT1_DATA, CNT1_MASK control the CNT1 counter. The GLMC's GLIU request port is compared with each of the mask/data compare register sets listed above. If the request matches, the counter is incremented by one. The 8-bit data field compared at the GLMC request interface is: {SRC, REQ, PRI, PGHT, Burst, Read}. • SRC is any valid SRC ID from 000..111b. • REQ is a request accepted by the GLMC. • PRI is high priority (i.e., PRI > 1). • PGHT is page hit. • Burst is burst - not single. • Read is read - not write. Any of the above data bits can be masked off via CNT0_MASK/CNT1_MASK to exclude them from the comparison.

GLMC Register Descriptions (Continued)

5.1.2.14 Clocking and Debug (MC_CFCLK_DBUG)

MSR Address 2000001Dh
Type R/W
Reset Value 00000000_00000000h

MC_CFCLK_DBUG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																													B2B_DIS	MSTEST_SDR_DQS_EN	MTEST_EN
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						MASK_CKE1	MASK_CKE0	CNTL_MSK1	CNTL_MSK0	ADRS_MSK	RSVD				

MC_CFCLK_DBUG Bit Descriptions

Bit	Name	Description
63:35	RSVD	**Reserved.** Write as read.
34	B2B_EN	**Back-to-back Command Enable.** This bit enables/disables the issuing of DRAM commands within back-to-back cycles in both MTEST and normal functional mode. To maximize performance, this feature should only be disabled in MTEST mode, where the cycle following the command cycle should be idle for the logic analyzer to be able to properly capture and interpret the MTEST data. 0: Enable. (Default) 1: Disable.
33	MTST_SDR_ DQS_EN	**MTEST SDR DQS EN**. If in SDR mode and MTEST_EN (bit 32) is set, this bit enables the routing of the GLMC's internal 'read data valid' signal out onto the eight DQS balls to indicate when SDR read data is valid at the memory bus during MTEST mode. 0: Disable. (Default) 1: Enable.
32	MTEST_EN	**MTEST Enable.** Enables MTEST debug mode, that multiplexes debug data onto the 13 DRAM address output balls one cycle after the command cycle. 0: Disable. (Default) 1: Enable.
31:10	RSVD	**Reserved.** Write as read.
9:8	MASK_CKE[1:0]	**CKE Mask.** Mask output enables for CKE[1:0]. After power-up or warm reset, software can complete all necessary initialization tasks before clearing this mask to allow communication with the DRAM. These bits can also be used to selectively mask off the CKE signal of a DIMM that is not installed 00: CKE1 and CKE0 unmasked. 01: CKE1 unmasked, CKE0 masked. 10: CKE1 masked, CKE0 unmasked. 11: CKE1 and CKE0 masked. (Default)

GLMC Register Descriptions (Continued)

MC_CFCLK_DBUG Bit Descriptions (Continued)

Bit	Name	Description
7	CNTL_MSK1	**Control Mask 1**. Mask output enable bit for DIMM1's CAS1#, RAS1#, WE1#, and CS[3:2]#. 0: Unmasked. (Default) 1: Masked.
6	CNTL_MSK0	**Control Mask 0**. Mask output enable bit for DIMM0's CAS0#, RAS0#, WE0#, and CS[1:0]#. 0: Unmasked. (Default) 1: Masked.
5	ADRS_MSK	**Address Mask**. Mask output enable bit for MA, BA. 0: Unmasked. (Default) 1: Masked.
4:0	RSVD	**Reserved.** Write as read.

5.1.2.15 Page Open Status (MC_CFPG_OPEN)

MSR Address 2000001Eh
Type RO
Reset Value 00000000_0000FFFFh

MC_CF_PG_OPEN Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																PGOPEN1								PGOPEN0							

MC_CF_PG_OPEN Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** Reads as 0.
15:8	PGOPEN1	**Page Open DIMM1.** Page open indication of the second DIMM. Each bit position represents a page and a 1 indicates an open page. All pages are initialized 'open'. After reset, a 'precharge all' command closes all the banks.
7:0	PGOPEN0	**Page Open DIMM0.** Page open indication of the first DIMM. Each bit position represents a page and a 1 indicates an open page. All pages are initialized 'open'. After reset, a 'precharge all' command closes all the banks.

GLMC Register Descriptions (Continued)

5.1.2.16 Read Sync Control (MC_CF_RDSYNC)

MSR Address 2000001Fh
Type RW
Reset Value 00000000_00000000h

MC_CF_RDSYNC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD				RDSYNC_OLD								RDSYNC_PASS								RSVD		RDSYNC_RLATE	RDSYNC_LATE	RSVD			RDSYNC_OVRD	RSVD			TST_DUM
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RDSYNC_CNT																															

MC_CF_RDSYNC Bit Descriptions

Bit	Name	Description
63:60	RSVD	**Reserved.** Write as read.
59:52	RDSYNC_OLD	**RDSYNC Old.** Overrides the eight ‘old’ signals that are normally computed by the GLMC’s read sync logic for each byte of read data. A value of 1 indicates to the GLMC to use registered data for that byte. (Default: 00h)
51:44	RDSYNC_PASS	**RDSYNC Pass.** Overrides the eight ‘pass’ signals that are normally computed by the GLMC’s read sync logic for each byte of read data. A value of 1 indicates to the GLMC to use unregistered data for that byte. (Default: 00h)
43:42	RSVD	**Reserved.** Write as read.
41	RDSYNC_RLATE	**RDSYNC RLate.** Overrides the ‘DQ_REALLY_LATE’ signal that is normally computed by the GLMC’s read sync logic. 0: Normal. (Default) 1: Indicates to the GLMC that the read data arrives after the positive edge of the GLIU clock, and will require two extra GLIU clocks to sync.
40	RDSYNC_LATE	**RDSYNC Late.** Overrides the ‘DQ_LATE signal’ that is normally computed by the GLMC’s read sync logic. 0: Normal. (Default) 1: If RDSYNC_RLATE = 0, indicates to the GLMC that the read data arrives too close to the next positive edge of the GLIU clock, and will require an extra GLIU clocks to sync.
39:37	RSVD	**Reserved.** Write as read.
36	RDSYNC_OVRD	**RDSYNC Override.** Overrides the calibration of the read sync logic through either the dummy read method or the normal sync method. This allows user-definable override values to the following calibration signals internal to the GLMC: DQ_LATE, DQ_REALLY_LATE, pass, and old. These override values are user-defined via RDSYNC_LATE, RDSYNC_RLATE, RDSYNC_PASS, and RDSYNC_OLD bits. If RDSYNC_LATE and RDSYNC_RLATE are both set to 0, it indicates to the GLMC that the read data arrives early enough that it can by synchronized on the next GLIU clock edge. 0: Do not override. (Default) 1: Override.
35:33	RSVD	**Reserved.** Write as read.

GLMC Register Descriptions (Continued)

MC_CF_RDSYNC Bit Descriptions (Continued)

Bit	Name	Description
32	TST_DUM	**Dummy Read Test.** Triggers one dummy read immediately, without waiting for idle or refresh cycles. This should only be used in debug, as it may disrupt the normal flow of requests through the GLMC if the GLMC is non-idle at the time of setting this bit. 0: Normal. (Default) 1: Perform dummy read.
31:0	RDSYNC_CNT	**RDSYNC Counter.** Counter that counts intervals between read commands. Used mainly in DDR mode if optional dummy reads are used to calibrate the read capture/sync logic. A non-zero counter value enables the dummy read method of calibrating the read sync logic (a zero counter value disables dummy reads). With the dummy read method, a timer timeout triggers a dummy read on the next refresh, using the address of the last read/write request. This toggles the DQS pins that come with the read data, and the GLMC's read sync logic recalibrates data skews from byte by byte for the next read. If a memory read request arrives at the GLMC before the timer times out, the timer is reset to the max count without triggering a dummy read. (Default: 0000h - i.e., sync data without using dummy reads.)

5.1.2.17 PM Sensitivity Counters (MC_CF_PMCTR)

MSR Address 20000020h
Type R/W
Reset Value 00000000_00000006h

MC_CF_PMCTR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
PM1_SENS																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PM0_SENS																															

MC_CF_PMCTR Bit Descriptions

Bit	Name	Description
63:32	PM1_SENS	**PMODE1 Sensitivity Counter.** Counter that controls the GLMC's sensitivity to entering PMODE1 power down mode. If PMODE1 is enabled, PM1_SENS starts counting down from its loaded value whenever the GLMC becomes idle. If it times out and the GLMC is still idle, the GLMC goes into PMODE1. If, however, the GLMC resumes activity before timeout, the counter is reset to its loaded value and PMODE1 is not entered. (Default: 00000000h.)
31:0	PM0_SENS	**PMODE0 Sensitivity Counter.** Counter that controls the GLMC's sensitivity to entering PMODE0 power down mode. If PMODE0 is enabled, PM0_SENS starts counting down from its loaded value whenever the GLMC becomes idle. If it times out and the GLMC is still idle, the GLMC goes into PMODE0. If, however, the GLMC resumes activity before timeout, the counter is reset to its loaded value and PMODE0 is not entered. (Default: 00000006h - i.e., to allow 32-bit bursts to finish.)

5.2 GRAPHICS PROCESSOR REGISTER DESCRIPTIONS

The registers associated with the Graphics Processor (GP) are the Standard GeodeLink Device MSRs and GP Configuration registers. Table 5-3 and Table 5-4 are register summary tables that include reset values and page references where the bit descriptions are provided.

The Standard GeodeLink Device MSRs (accessed via the RDMSR and WRMSR instructions) control the GP's behavior as a GLIU client. These registers should be programmed at configuration time and left alone thereafter. They do not need to be modified by software to set up any of the graphics primitives. The MSRs are 64 bits wide, although not all bits are used in each register. Unused bits marked as "write as read" return the value that was last written to them. All other unused bits return 0.

The GP Configuration registers are accessible by the CPU through memory mapped reads and writes on the GLIU. Note that due to the pipelining operation of the GP, the value returned during a read is the value stored in the slave register, while the value in the master register is the actual value being used by an ongoing BLT or vector operation. Reserved bits that are marked as "write as read," indicate that there is a real register backing those bits, that may be used in some future implementation of the GP. Reserved register bits that do not have a register backing them always return a 0, regardless of what value software decides to write into them.

The GP register space occupies 4 kB of the memory map. Only the first 80 bytes are defined. Read accesses of GP space outside of the 80-byte range always returns the GP_BLT_STATUS register (GP Memory Offset 44h[0]). Write accesses outside of the 80-byte range go into the bit bucket.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

For memory offset mapping details, see Section 3.1.3 "Memory and I/O Mapping" on page 55.

Table 5-3. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
A0002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_0003D0xxh	Page 198
A0002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)	00000000_00000010h	Page 198
A0002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000000h	Page 199
A0002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 200
A0002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 201
A0002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 202

Table 5-4. GP Configuration Registers Summary

GP Memory Offset	Type	Config. Group	Register Name	Reset Value	Reference
00h	R/W	Address	Destination Offset (GP_DST_OFFSET)	00000000h	Page 202
04h	R/W	Address	Source Offset (GP_SRC_OFFSET)	00000000h	Page 203
	R/W	Vector	Vector Error (GP_VEC_ERR)	00000000h	Page 203
08h	R/W	Address	Stride (GP_STRIDE)	00000000h	Page 204
0Ch	R/W	BLT	BLT Width/Height (GP_WID_HEIGHT)	00000000h	Page 204
		Vector	Vector Length (GP_VEC_LEN)	00000000h	Page 205
10h	R/W	Color	Source Color Foreground (GP_SRC_COLOR_FG)	00000000h	Page 205
14h	R/W	Color	Source Color Background (GP_SRC_COLOR_BG)	00000000h	Page 206

GP Register Descriptions (Continued)

Table 5-4. GP Configuration Registers Summary (Continued)

GP Memory Offset	Type	Config. Group	Register Name	Reset Value	Reference
18h	R/W	Pattern	Pattern Color 0 (GP_PAT_COLOR_0)	00000000h	Page 206
1Ch	R/W	Pattern	Pattern Color 1 (GP_PAT_COLOR_1)	00000000h	
20h	R/W	Pattern	Pattern Color 2 (GP_PAT_COLOR_2)	00000000h	
24h	R/W	Pattern	Pattern Color 3 (GP_PAT_COLOR_3)	00000000h	
28h	R/W	Pattern	Pattern Color 4 (GP_PAT_COLOR_4)	00000000h	
2Ch	R/W	Pattern	Pattern Color 5 (GP_PAT_COLOR_5)	00000000h	
30h	R/W	Pattern	Pattern Data 0 (GP_PAT_DATA_0)	00000000h	Page 207
34h	R/W	Pattern	Pattern Data 0 (GP_PAT_DATA_1)	00000000h	
38h	R/W	BLT	Raster Mode (GP_RASTER_MODE)	00000000h	Page 208
3Ch	WO	Vector	Vector Mode (GP_VECTOR_MODE)	00000000h	Page 210
40h	WO	BLT	BLT Mode (GP_BLT_MODE)	00000000h	Page 210
44h	R/W	BLT/Reset	Status and Reset (GP_BLT_STATUS, GP_RESET)	00000008h	Page 211
48h	WO	BLT Data	Host Source (GP_HST_SRC)	xxxxxxxxh	Page 212
4Ch	R/W	Address	Base Offset (GP_BASE_OFFSET)	01000000h	Page 213

5.2.1 Standard GeodeLink Device MSRs

5.2.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address A0002000h
Type RO
Reset Value 00000000_0003D0xxh

This MSR contains the revision and device IDs for the particular implementation of the GP. This register is read-only.

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.** Reads as 0.
23:8	DEV_ID	**Device ID.** Identifies device (03D0h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

GP Register Descriptions (Continued)

5.2.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address A0002001h
Type R/W
Reset Value 00000000_00000010h

This MSR contains the GLIU priority domain bits and priority level bits that are sent to the GLIU on every GLIU transaction.

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																									PRI0			RSVD	PID		

Table 5-5. GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:7	RSVD	**Reserved.** Write as read.
6:4	PRI0	**Priority Level.** GP requests this priority for every GLIU transaction.
3	RSVD	**Reserved.** Write as read.
2:0	PID	**Priority Domain.** GLBus assigned priority ID value to be used for GP GLIU requests.

5.2.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address A0002002h
Type R/W
Reset Value 00000000_00000000h

This MSR contains the SMIs and SMI Enable bits for the GP. An SMI is asserted whenever an illegal address or an illegal type is detected on the GLIU and the MASK bit is not set. This also causes the internal GP_P_ASMI output to be asserted. This signal remains asserted until the SMI is cleared or the EN bit is set. An illegal address is defined as a memory mapped access to an address offset greater than 07Fh or an MSR access to an address greater than A0002007h. An illegal type is flagged if the GP receives a transaction whose type is not one of the following: NCOH_READ, NCOH_WRITE, NCOH_READ_BEX, MSR_READ, MSR_WRITE, BEX, NULL.

GP Register Descriptions (Continued)

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															UNEXP_ADDR_TYPE_SSMI_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															UNEXP_ADDR_TYPE_SSMI_EN

GLD_MSR_SMI Bit Descriptions

Bit	Name	Description
63:33	RSVD	**Reserved.** Read returns 0.
32	UNEXP_ADDR_TYPE_SSMI_FLAG	**Unexpected Address or Type Synchronous SMI Flag.** If high, records that an SSMI was generated due to an unexpected address or type event. Write 1 to clear; writing 0 has no effect. UNEXP_ADDR_TYPE_SSMI_EN (bit 0) must be low to generate SSMI and set flag.
31:1	RSVD	**Reserved.** Read returns 0.
0	UNEXP_ADDR_TYPE_SSMI_EN	**Unexpected Address or Type Synchronous SMI Enable.** Write 0 to enable UNEXP_ADDR_TYPE_SSMI_FLAG (bit 32) and to allow the unexpected address or type event to generate an SSMI.

5.2.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address A0002003h
Type R/W
Reset Value 00000000_00000000h

This MSR contains the Error and Error Enable bits for the GP. An ERR is asserted whenever an illegal address or an illegal type is detected on the GLIU and the Enable bit is not set. This also causes the GP_P_ASMI output to be asserted if the EN bit is not set. The ERR bits remain asserted until they are cleared. An illegal address is defined as a memory mapped access to an address offset greater than 07Fh or an MSR access to an address greater than A0002007h. An illegal type is flagged if the GP receives a transaction whose type is not one of the following: NCOH_READ, NCOH_WRITE, NCOH_READ_BEX, MSR_READ, MSR_WRITE, BEX, NULL.

GP Register Descriptions (Continued)

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														UNEXP_ADDR_ERR_FLAG	UNEXP_TYPE_ERR_FLAG	RSVD														UNEXP_ADDR_ERR_EN	UNEXP_TYPE_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:18	RSVD	**Reserved.** Read returns 0.
17	UNEXP_ADDR_ERR_FLAG	**Unexpected Address Error Flag.** If high, records that an ERR was generated due to an unexpected address event. Write 1 to clear; writing 0 has no effect. UNEXP_ADDR_ERR_EN (bit 1) must be low to generate ERR and set flag.
16	UNEXP_TYPE_ERR_FLAG	**Unexpected Type Error.** If high, records that an ERR was generated due to an unexpected type event. Write 1 to clear; writing 0 has no effect. UNEXP_TYPE_ERR_EN (bit 0) must be low to generate ERR and set flag.
15:2	RSVD	**Reserved.** Read returns 0.
1	UNEXP_ADDR_ERR_EN	**Unexpected Address Error Enable.** Write 0 to enable UNEXP_ADDR_ERR_FLAG (bit 17) and to allow the unexpected address event to generate an ERR.
0	UNEXP_TYPE_ERR_EN	**Unexpected Type Error Enable.** Write 0 to enable UNEXP_TYPE_ERR_FLAG (bit 16) and to allow the unexpected type event to generate an ERR.

5.2.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address A0002004h
Type R/W
Reset Value 00000000_00000000h

This MSR contains the power management controls for the GP. Since there is only one clock domain within the GP, most bits in this register are unused.This register allows the GP to be switched off by disabling the clocks to this block. If hardware clock gating is enabled (bits [1:0] = 01), the GP turns off its clocks whenever there is no BLT Busy or Pending and no GLIU transactions destined for the GP. A register or MSR write causes the GP to wakeup temporarily to service the request, then return to power down. A write to the GP_BLT_MODE (GP Memory Offset 40h) or GP_VECTOR_MODE (GP Memory Offset 3Ch) registers causes the GP to wakeup for the duration of the requested operation.

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														PMODE0	

GP Register Descriptions (Continued)

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:33	RSVD	**Reserved.** Write as read.
32	RSVD	**Reserved.** Write as 0.
31:2	RSVD	**Reserved.** Write as read.
1:0	PMODE0	**Power Mode 0.** Clock control mode. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

5.2.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address A0002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

5.2.2 GP Configuration Registers

5.2.2.1 Destination Offset (GP_DST_OFFSET)

GP Memory Offset 00h
Type R/W
Reset Value 00000000h

GP_DST_OFFSET is used to give a starting location for the destination of a BLT or vector in the frame buffer space. It consists of three fields: the DST_OFFSET, DST_XLSBS, and DST_YLSBS. DST_OFFSET is a pointer, that when added to the frame buffer base address, gives the memory address of the first byte of the BLT or vector. For a left-to-right direction BLT or a vector, the address should be aligned to the least significant byte of the first pixel, since this is the leftmost byte. For a right-to-left direction BLT, the address should be aligned to the most significant byte of the first pixel, since this is the rightmost byte of the BLT. The address alignment must also be correct with respect to the pixel depth. In 32 BPP mode, the address specified must be aligned to the least significant or most significant byte of a DWORD, depending upon BLT direction. Pixels may not straddle a DWORD boundary. In 16 BPP mode, the address specified must be aligned to a 16-bit boundary. DST_XLSBS and DST_YLSBS are used to inform the hardware of the location of the pixel within the pattern memory for pattern alignment.

GP_DST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DST_YLSBS			DST_XLSBS			RSVD		DST_OFFSET																							

GP_DST_OFFSET Bit Descriptions

Bit	Name	Description
31:29	DST_YLSBS	**Destination Y LSBs.** Indicates Y coordinate of starting pixel within pattern memory.
28:26	DST_XLSBS	**Destination X LSBs.** Indicates X coordinate of starting pixel within pattern memory.
25:24	RSVD	**Reserved.** Write as read.
23:0	DST_OFFSET	**Destination Offset.** Offset from the frame buffer base address to the first destination pixel.

GP Register Descriptions (Continued)

5.2.2.2 Source Offset (GP_SRC_OFFSET)

GP Memory Offset 04h
Type R/W
Reset Value 00000000h

The GP_SRC_OFFSET is used during a BLT to give a starting location for the source in the frame buffer space. In this mode, the register consists of two fields: SRC_OFFSET and SRC_XLSBS. SRC_OFFSET is a pointer, that when added to the frame buffer base address, gives the memory location of the byte containing the first pixel of the BLT. As in the destination offset (GP_DST_OFFSET), this value must be aligned correctly for BLT direction and pixel depth. When host source data is used, the two LSBs of SRC_OFFSET must still be initialized with the byte location of the first source pixel in the host source data stream. XLSBS is used when the source is monochrome to give an offset within the specified byte to the bit representing the starting pixel. In byte-packed mode, SRC_XLSBS is used to index into the first byte of every new line of source data. In unpacked mode, both SRC_OFFSET and SRC_XLSBS are used to index into the first DWORD of every new line of source data.

GP_SCR_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			SCR_ XLSBS			RSVD		SCR_OFFSET																							

GP_SCR_OFFSET Bit Descriptions

Bit	Name	Description
31:29	RSVD	**Reserved.** Write as read.
28:26	SCR_XLSBS	**Source X LSBs.** Offset within byte to first monochrome pixel.
25:24	RSVD	**Reserved.** Write as read.
23:0	SCR_OFFSET	**Source Offset.** Offset from the frame buffer base address to the first destination pixel.

5.2.2.3 Vector Error (GP_VEC_ERR)

GP Memory Offset 04h
Type R/W
Reset Value 00000000h

This register specifies the axial and diagonal error terms used by the Bresenham vector algorithm. GP_VEC_ERR shares the same storage space as GP_SRC_OFFSET and thus a write to one of these registers is reflected in both, since they both have the same offset. The name change is only for documentation purposes.

GP_VEC_ERR Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
A_ERR																D_ERR															

GP_VEC_ERR Bit Descriptions

Bit	Name	Description
31:16	A_ERR	**Axial Error Term.** 2s complement format.
15:0	D_ERR	**Diagonal Error Term.** 2s complement format.

GP Register Descriptions (Continued)

5.2.2.4 Stride (GP_STRIDE)

GP Memory Offset 08h
Type R/W
Reset Value 00000000h

The GP_ STRIDE register is used to indicate the byte width of the destination and source images. Whenever the Y coordinate is incremented, this value is added to the previous start address to generate the start address for the next line. Stride values up to 64 kB minus one are supported. Adding the GP_STRIDE to the OFFSET gives the byte address for the first pixel of the next line of a BLT. In the case of monochrome source, SRC_XLSBS specified in the GP_SRC_OFFSET (GP Memory Offset 04h) register is used to index into the first byte of every line to extract the first pixel.

Note that the Display Controller (DC) module may not support variable strides for on-screen space, especially when compression is enabled. Refer to Section 5.3 “Display Controller Register Descriptions” on page 214 for stride limitations. DC restrictions do not apply to source stride.

When copying from on-screen frame buffer space (e.g., window move), the values of S_STRIDE and D_STRIDE should match. When copying from off-screen space, S_STRIDE should be the number of bytes to add to get from one line in the source bitmap to the next. This allows software to linearly pack a bitmap into off-screen space (e.g., for an 800x600 monochrome bitmap packed linearly into off-screen space, bytes per line is 100, so S_STRIDE should be written with 100).

GP_STRIDE Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S_STRIDE																D_STRIDE															

GP_STRIDE Bit Descriptions

Bit	Name	Description
31:16	S_STRIDE	**Source Stride.** Width of the source bitmap (in bytes).
15:0	D_STRIDE	**Destination Stride.** Width of the destination scan line (in bytes).

5.2.2.5 BLT Width/Height (GP_WID_HEIGHT)

GP Memory Offset 0Ch
Type R/W
Reset Value 00000000h

This register is used to specify the width and the height of the BLT in pixels. Note that operations that extend beyond the bounds of the frame buffer space “wrap” into the other end of the frame buffer.

GP_WID_HEIGHT Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				WID												RSVD				HI											

GP_WID_HEIGHT Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.
27:16	WID	**Width.** Width in pixels of the BLT operation.
15:12	RSVD	**Reserved.** Write as read.
11:0	HI	**Height.** Height in pixels of the BLT operation.

GP Register Descriptions (Continued)

5.2.2.6 Vector Length (GP_VEC_LEN)

GP Memory Offset 0Ch
Type R/W
Reset Value 00000000h

This register is used to specify the length of the vector in pixels and the initial error term. Note that this is the same register as GP_WID_HEIGHT, and that writing to one overwrites the other. They are just separated for documentation purposes. As with BLT operations, vectors that extend below or above the frame buffer space wrap to the other end of the frame buffer.

GP_VEC_LEN Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				LEN												I_ERR															

GP_VEC_LEN Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.
27:16	LEN	**Length.** Length of the vector in pixels.
15:0	I_ERR	**Initial Error.** Initial error for rendering a vector (2s complement format).

5.2.2.7 Source Color Foreground (GP_SRC_COLOR_FG)

GP Memory Offset 10h
Type R/W
Reset Value 00000000h

When source data is monochrome, the contents of this register are used for expanding pixels that are set in the monochrome bitmap, thus replacing the monochrome bit with a color that is appropriately sized for the destination.

When source data is color, this register contains the color key for transparency. The value(s) in this register is XORed with the color source data, after which the GP_SRC_COLOR_BG register (GP Memory Offset 14h[31:0]) is used to mask out bits that are don't cares. If all bits of a pixel that are not masked off compare and source transparency is enabled, then the write of that pixel is inhibited and the frame buffer data remains unchanged. Otherwise, the frame buffer is written with the color data resulting from the raster operation.

If no source is required for a given BLT, the value of this register is used as the default source data into the raster operation.

This register should only be written after setting the BPP field in the GP_RASTER_MODE register (GP Memory Offset 38h[31:30]), since the value written is replicated as necessary to fill the register. Thus a write to this register in 8 BPP mode takes the least significant data byte and replicates it in the four bytes of the register. In 16 BPP mode, the least significant two bytes are replicated in the upper half of the register. A read returns the replicated data.

GP_SRC_COLOR_FG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SCR_FG																															

GP_SRC_COLOR_FG Bit Descriptions

Bit	Name	Description
31:0	SCR_FG	**Source Foreground.** Mono source mode - Foreground source color. Color source mode - Color key for transparency.

GP Register Descriptions (Continued)

5.2.2.8 Source Color Background (GP_SRC_COLOR_BG)

GP Memory Offset 14h
Type R/W
Reset Value 00000000h

When source data is monochrome, the content of this register is used for expanding pixels that are clear in the monochrome bitmap, thus replacing the monochrome bit with a color that is appropriately sized for the destination.

When source data is color, this register contains the color key mask for transparency. The value(s) in this register is inverted and ORed with the result of the compare of the source data and the GP_SRC_COLOR_FG register (GP Memory Offset 10h[31:0]). Thus, a bit that is clear implies that bit position is a don't care for transparency and a bit that is set implies that bit position must match in both the source data and GP_SRC_COLOR_FG register. If the result of the OR produces all ones for an entire pixel and transparency is enabled, then the write of that pixel is inhibited and the destination data is unchanged.

This register should only be written after setting the BPP field in the GP_RASTER_MODE register (GP Memory Offset 38h[31:30]), since the value written is replicated as necessary to fill the register. Thus a write to this register in 8 BPP mode takes the least significant data byte and replicates it in all four bytes of the register. In 16 BPP mode, the least significant two bytes are replicated in the upper half of the register. A read returns the replicated data.

GP_SRC_COLOR_BG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SCR_BG																															

GP_SRC_COLOR_BG Bit Descriptions

Bit	Name	Description
31:0	SCR_BG	**Source Background.** Mono source mode – Background source color. Color source mode - Color key mask for transparency.

5.2.2.9 Pattern Color (GP_PAT_COLOR_x)

GP Memory Offset 18h GP_PAT_COLOR_0
1Ch GP_PAT_COLOR_1
20h GP_PAT_COLOR_2
24h GP_PAT_COLOR_3
28h GP_PAT_COLOR_4
2Ch GP_PAT_COLOR_5
Type R/W
Reset Value 00000000h

In solid pattern mode, the pattern hardware is disabled and GP_PAT_COLOR_0 is selected as the input to the raster operation.

In monochrome pattern mode, GP_PAT_COLOR_0 and GP_PAT_COLOR_1 are used for expanding the monochrome pattern into color. A clear bit in the pattern is replaced with the color stored in GP_PAT_COLOR_0 and a set bit in the pattern is replaced with the color stored in GP_PAT_COLOR_1.

GP Register Descriptions (Continued)

In color pattern mode, these registers each hold part of the pattern according to the Table 5-6.

Table 5-6. PAT_COLOR Usage for Color Patterns

Register	8 BPP Mode	16 BPP Mode	32 BPP Mode
GP_PAT_COLOR_0	Line 1, pixels 3-0	Line 0, pixels 5-4	Line 0, pixel 2
GP_PAT_COLOR_1	Line 1, pixels 7-4	Line 0, pixels 7-6	Line 0, pixel 3
GP_PAT_COLOR_2	Line 2, pixels 3-0	Line 1, pixels 1-0	Line 0, pixel 4
GP_PAT_COLOR_3	Line 2, pixels 7-4	Line 1, pixels 3-2	Line 0, pixel 5
GP_PAT_COLOR_4	Line 3, pixels 3-0	Line 1, pixels 5-4	Line 0, pixel 6
GP_PAT_COLOR_5	Line 3, pixels 7-4	Line 1, pixels 7-6	Line 0, pixel 7

These registers should only be written after setting the BPP (bits [31:30]) and PM (bits in [9:8]) GP_RASTER_MODE (GP Memory Offset 38h), since the value written may be replicated if necessary to fill the register. If the pattern is color, no replication is performed and the data is written to the registers exactly as it is received. If the pattern is monochrome, the write data is expanded if the color depth is less than 32 BPP. Thus a write to these registers in 8 BPP monochrome pattern mode takes the least significant data byte and replicates it in the four bytes of the register. In 16 BPP monochrome pattern mode, the least significant two bytes are replicated in the upper half of the register. A read returns the replicated data.

GP_PAT_COLOR_x Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PAT_COLOR_x																															

GP_PAT_COLOR_x Bit Descriptions

Bit	Name	Description
31:0	PAT_COLOR_x	**Pattern Color x.** Mono pattern mode – Pattern color for expansion. Color pattern mode – Color pattern.
Note: Registers GP_PAT_COLOR_2 - GP_PAT_COLOR_5 are not pipelined. They should not be written to when the "BLT Busy" bit is set in the GP_BLT_STATUS register (GP Memory Offset 44h[0]), which indicates that a BLT is in progress. Writing to these registers when a BLT is active or pending can corrupt that operation.		

5.2.2.10 Pattern Data (GP_PAT_DATA_x)

GP Memory Offset 30h GP_PAT_DATA_0
34h GP_PAT_DATA_1
Type R/W
Reset Value 00000000h

In solid pattern mode, these registers are not used.

In monochrome pattern mode, GP_PAT_DATA_0 and GP_PAT_DATA_1 combine to hold the entire 8x8 pattern (64 bits). GP_PAT_DATA_0[7:0] is the first line of the pattern, with bit 7 corresponding to the leftmost pixel on the screen. GP_PAT_DATA_1[31:24] is the last line of the pattern.

GP Register Descriptions (Continued)

In color pattern mode, these registers each hold part of the pattern according to Table 5-7.

Table 5-7. PAT_DATA Usage for Color Patterns

Register	8 BPP Mode	16 BPP Mode	32 BPP Mode
GP_PAT_DATA_0	Line 0, pixels 3-0	Line 0, pixels 1-0	Line 0, pixel 0
GP_PAT_DATA_1	Line 0, pixels 7-4	Line 0, pixels 3-2	Line 0, pixel 1

GP_PAT_DATA_x Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PAT_DATA_x																															

GP_PAT_DATA_x Bit Descriptions

Bit	Name	Description
31:0	PAT_DATA_x	**Pattern Color x.** Mono pattern mode – Pattern data. Color pattern mode – Color pattern.

5.2.2.11 Raster Mode (GP_RASTER_MODE)

GP Memory Offset 38h
Type R/W
Reset Value 00000000h

This register controls the manipulation of the pixel data through the graphics pipeline. This register is byte writable to allow modification of the ROP and other control bits without having to rewrite the BPP and FMT every time.

GP_RASTER_MODE Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BPP		FMT		RSVD				EN		OS		AS			CS	RSVD				ST	PT	PM		ROP/α_R							

GP_RASTER_MODE Bit Descriptions

Bit	Name	Description
31:28	BPP/FMT	**Color Depth and Format.** 0000: 8 BPP, 3:3:2 format. 0100: 16 BPP, 4:4:4:4 format. 0101: 16 BPP, 1:5:5:5 format. 0110: 16 BPP, 0:5:6:5 format. 1000: 32 BPP, 8:8:8:8 format. All Others: Undefined.
27:24	RSVD	**Reserved.** Write as read

GP Register Descriptions (Continued)

GP_RASTER_MODE Bit Descriptions (Continued)

Bit	Name	Description
23:22	EN	**Alpha Enable Bits.** Also used to select how to apply the specified operation. 00: Alpha disabled / ROP enabled. 01: Alpha operation applies to only the RGB values of the pixel. Output alpha is from channel B if the OS is 01; otherwise from channel A. 10: Alpha operation applies to only the alpha of the pixel. Output RGB is from channel B if the OS is 01; otherwise from channel A. 11: Alpha operation applies to all channels of the pixel (ARGB).
21:20	OS	**Alpha Operation Select.** Determines the alpha operation to be performed if enabled. 00: α*A. 01: (1-α)*B. 10: A + (1-α)*B. 11: α*A + (1-α)*B. * Channel A is added in this case only if the selected α is also from channel A.
19:17	AS	**Alpha Select.** Chooses which alpha value to use for the multiplication. 000: α_A 100: $Color_A$ 001: α_B 101: $Color_B$ 010: α_R 110: α_R 011: Constant 1 111: Constant 1
16	CS	**Channel Select.** Determines which data stream gets put on which channel. 0: A is source, B is destination. 1: A is destination, B is source.
15:13	RSVD	**Reserved.** Write as read.
11	ST	**Source Transparency.** Enables transparency for monochrome source data and color keying for color source data. 0: Disable. 1: Enable.
10	PT	**Pattern Transparency.** Enables transparency for monochrome pattern data. 0: Disable. 1: Enable.
9:8	PM	**Pattern Mode.** Specifies the format of the pattern data. 00: Solid pattern. Pattern data always sourced from GP_PAT_COLOR_0 (GP Memory Offset 18h). 01: Mono pattern. 10: Color pattern. 11: Undefined.
7:0	ROP/α_R	**Raster Operations (ROP).** Combination rule for source, pattern and destination when performing raster operations. **Alpha Value (α_R).** Alpha value that can be used for some of the alpha compositing operations.

GP Register Descriptions (Continued)

5.2.2.12 Vector Mode (GP_VECTOR_MODE)

GP Memory Offset 3Ch
Type WO
Reset Value 00000000h

Writing to this register configures the vector mode and initiates the rendering of the vector. If a BLT or vector operation is already in progress when this register is written, the BLT pending bit in the GP_BLT_STATUS register (GP Memory Offset 44h[2]) is set and the vector is queued to begin when the current operation is complete. Software should not write to any register (other than GP_HST_SRC (GP Memory Offset 48h) if required) while the BLT pending bit is set since it corrupts the pending vector operation. Setting the TH bit causes the vector operation to wait until the next VBLANK before beginning rendering. Software may still queue another operation behind a throttled vector as long as the BLT pending bit is clear.

GP_VECTOR_MODE Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																											TH	DR	DN	DJ	YJ

GP_VECTOR_MODE Bit Descriptions

Bit	Name	Description
31:5	RSVD	**Reserved.** Read returns 0.
4	TH	**Throttle.** 0: Operation begins immediately. 1: Operation waits until next VBLANK before beginning.
3	DR	**Destination Required.** 0: Destination data is not needed for operation. 1: Destination data is needed from frame buffer.
2	DN	**Minor Direction.** 0: Negative minor axis step. 1: Positive minor axis step.
1	DJ	**Major Direction.** 0: Negative major axis step. 1: Positive major axis step
0	YJ	**Y Major.** 0: X major vector. 1: Y major vector.

5.2.2.13 BLT Mode (GP_BLT_MODE)

GP Memory Offset 40h
Type WO
Reset Value 00000000h

Writing to this register configures the BLT mode and initiates the rendering of the BLT. If a BLT or vector operation is already in progress when this register is written, the BLT pending bit in the GP_BLT_STATUS register (GP Memory Offset 44h[2]) is set and the BLT is queued to begin when the current operation is complete. Software should not write to any register (other than GP_HST_SRC, GP Memory Offset 48h, if required) while the BLT pending bit is set since it corrupts the pending BLT. Setting the TH bit (bit 10) causes the BLT operation to wait until the next VBLANK before beginning. Software may still queue another operation behind a throttled BLT as long as the BLT pending bit is clear.

GP Register Descriptions (Continued)

GP_BLT_MODE Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																					TH	X	Y	SM		RSVD			DR	SR	

GP_BLT_MODE Bit Descriptions

Bit	Name	Description
31:11	RSVD	**Reserved.** Write 0.
10	TH	**Throttle.** BLT does not begin until next VBLANK. 0: Disable. 1: Enable.
9	X	**X Direction.** 0: Indicates a positive increment for the X position. 1: Indicates a negative increment for the X position.
8	Y	**Y Direction.** 0: Indicates a positive increment for the Y position. 1: Indicates a negative increment for the Y position.
7:6	SM	**Source Mode.** Specifies the format of the source data. 00: Source is color bitmap. 01: Source is unpacked monochrome. 10: Source is byte-packed monochrome. 11: Undefined.
5:3	RSVD	**Reserved.** Write as read.
2	DR	**Destination Required.** 0: No destination data is required. 1: Indicates that destination data is needed from frame buffer
1:0	SR	**Source Required.** 00: No source data. 01: Source from frame buffer. 10: Source from GP_HST_SRC register (GP Memory Offset 48h). 11: Undefined.

5.2.2.14 Status and Reset (GP_BLT_STATUS, GP_RESET)

GP Memory Offset 44h
Type R/W
Reset Value 00000008h

This register is used to provide software with the current status of the GP in regards to operations pending and currently executing. A write to this register has no effect unless byte 3 is 69h, which causes a reset of the GP, losing all state information and discarding any active or pending BLT or vector. This is only intended to be used during debug to restore the GP in the event of a hang. It is not required as part of the initialization or power on sequence for GP.

GP_BLT_STATUS, GP_RESET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GP_RESET								RSVD																				HE	BP	RSVD	BB

GP Register Descriptions (Continued)

GP_BLT_STATUS, GP_RESET Bit Descriptions

Bit	Name	Description
31:24	GP_RESET	**Graphics Pipeline Reset.** If a value of 69h is written, the GP resets. Debug feature.
23:4	RSVD (RO)	**Reserved. (Read Only).**
3	HE (RO)	**Half Empty (Read Only).** Source FIFO can accept another cache line of host source data. 0: Source can not accept another cache line. 1: Source can accept another cache line.
2	BP (RO)	**BLT Pending (Read Only).** A second BLT or vector is in the queue behind currently executing operation. 0: BLT not pending. 1: BLT pending.
1	R (RO)	**Reserved (Read Only).** Read returns 0.
0	BB (RO)	**BLT Busy (Read Only).** An operation is currently executing in the GP. 0: BLT not busy. 1: BLT busy.

5.2.2.15 Host Source (GP_HST_SRC)

GP Memory Offset 48h
Type WO
Reset Value xxxxxxxxh

This register is used by software to load source data that is not originated in the frame buffer memory region. When performing a BLT that requires host source data, software should first set up all of the configuration registers that are required and initiate the BLT by writing to the GP_BLT_MODE register (GP Memory Offset 40h). This initiates the BLT in hardware, which then wait for writes to the GP_HST_SRC register. Software should then perform enough writes to this register to complete the BLT operation. Writes to this register are moved immediately into the source FIFO, allowing the CPU to perform successive writes. The HE bit in the GP_BLT_STATUS register (GP Memory Offset 44h[3]) indicates that the GP can accept another cache line (32 bytes) of data. The BB bit in the GP_BLT_STATUS register (GP Memory Offset 44h[0]) does not clear until sufficient writes to this register have been received, which leaves the GP in a pending state. This register is write only.

GP_HST_SRC Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HST_SRC																															

GP_HST_SRC Bit Descriptions

Bit	Name	Description
31:0	HST_SRC	**Host Source Data.** Data written into this register is used by BLT engine during BLT in host source mode

GP Register Descriptions (Continued)

5.2.2.16 Base Offset (GP_BASE_OFFSET)

GP Memory Offset 4Ch
Type R/W
Reset Value 01000000h

This register is used to define the physical base address of the frame buffer that is used for all subsequent GP operations. The frame buffer is required to reside on a 16 MB boundary so only the top byte of the address is used. The other bytes of this register are RSVD and always returns 0.

GP_BASE_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GP_BSE								RSVD																							

GP_BASE_OFFSET Bit Descriptions

Bit	Name	Description
31:24	GP_BASE	**Base Address.** Base address of 16 MB frame buffer in physical memory.
23:0	RSVD	**Reserved.** Write 0, read 0.

5.3 DISPLAY CONTROLLER REGISTER DESCRIPTIONS

This section provides information on the registers associated with the Display Controller (DC) (i.e., GUI and VGA units), including the Standard GeodeLink Device MSRs and the DC Specific MSRs (accessed via the RDMSR and WRMSR instructions). Table 5-8 through Table 5-12 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

For memory offset mapping details, see Section 3.1.3 "Memory and I/O Mapping" on page 55.

Table 5-8. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
80002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_0003E0xxh	Page 217
80002001h	R/W	GeodeLink Device Configuration MSR (GLD_MSR_CONFIG)	00000000_00000000h	Page 217
80002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000000h	Page 218
80002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 219
80002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 220
80002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 221

Table 5-9. DC Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
80002010h	R/W	BIST MSR (MSR_BIST)	00000000_00000000h	Page 222
80002011h	R/W	Reserved (RSVD)	00000000_00000000h	---
80002012h	R/W	RAM Control MSR (MSR_RAM_CTL)	00000000_02020202h	Page 222

Table 5-10. DC Registers Summary

DC Memory Offset	Type	Register	Reset Value	Reference
Configuration and Status Registers				
00h	R/W	DC Unlock (DC_UNLOCK)	00000000h	Page 223
04h	R/W	DC General Configuration (DC_GENERAL_CFG)	00000000h	Page 224
08h	R/W	DC Display Configuration (DC_DISPLAY_CFG)	Cxxx00000h	Page 227
0Ch	R/W	DC Graphics Scale (DC_GFX_SCL)	xxxxxxxxh	Page 228
Memory Organization Registers				
10h	R/W	DC Frame Buffer Start Address (DC_FB_ST_OFFSET)	xxxxxxxxh	Page 229
14h	R/W	DC Compression Buffer Start Address (DC_CB_ST_OFFSET)	xxxxxxxxh	Page 230
18h	R/W	DC Cursor Buffer Start Address (DC_CURS_ST_OFFSET)	xxxxxxxxh	Page 230
1Ch	R/W	DC Icon Buffer Start Address (DC_ICON_ST_OFFSET)	xxxxxxxxh	Page 231

DC Register Descriptions (Continued)

Table 5-10. DC Registers Summary (Continued)

DC Memory Offset	Type	Register	Reset Value	Reference
20h	R/W	DC Video Y Buffer Start Address Offset (DC_VID_Y_ST_OFFSET)	00000000h	Page 231
24h	R/W	DC Video U Buffer Start Address Offset (DC_VID_U_ST_OFFSET)	00000000h	Page 232
28h	R/W	DC Video V Buffer Start Address Offset (DC_VID_V_ST_OFFSET)	00000000h	Page 232
30h	R/W	DC Line Size (DC_LINE_SIZE)	00000000h	Page 233
34h	R/W	DC Graphics Pitch (DC_GFX_PITCH)	00000000h	Page 233
38h	R/W	DC Video YUV Pitch (DC_VID_YUV_PITCH)	00000000h	Page 234
Timing Registers				
40h	R/W	DC Horizontal and Total Timing (DC_H_ACTIVE_TIMING)	xxxxxxxxh	Page 234
44h	R/W	DC CRT Horizontal Blanking Timing (DC_H_BLANK_TIMING)	xxxxxxxxh	Page 235
48h	R/W	DC CRT Horizontal Sync Timing (DC_H_SYNC_TIMING)	xxxxxxxxh	Page 236
4Ch	--	Reserved	--	--
50h	R/W	DC Vertical and Total Timing (DC_V_ACTIVE_TIMING)	xxxxxxxxh	Page 236
54h	R/W	DC CRT Vertical Blank Timing (DC_V_BLANK_TIMING)	xxxxxxxxh	Page 237
58h	R/W	DC CRT Vertical Sync Timing (DC_V_SYNC_TIMING)	xxxxxxxxh	Page 237
5Ch	--	Reserved	--	--
Cursor Position and Line Compare Registers				
60h	R/W	DC Cursor X Position (DC_CURSOR_X)	xxxxxxxxh	Page 238
64h	R/W	DC Cursor Y Position (DC_CURSOR_Y)	xxxxxxxxh	Page 239
68h	R/W	DC Icon X Position (DC_ICON_X)	xxxxxxxxh	Page 239
6Ch	R	DC Line Count/Status (DC_LINE_CNT/STATUS)	xxxxxxxxh	Page 240
Palette Access and RAM Diagnostic Registers				
70h	R/W	DC Palette Address (DC_PAL_ADDRESS)	xxxxxxxxh	Page 241
74h	R/W	DC Palette Data (DC_PAL_DATA)	xxxxxxxxh	Page 241
78h	R/W	DC Display FIFO Diagnostic (DC_DFIFO_DIAG)	xxxxxxxxh	Page 242
7Ch	R/W	DC Compression FIFO Diagnostic (DC_CFIFO_DIAG)	xxxxxxxxh	Page 242
Video Downscaling				
80h	R/W	DC Video Downscaling Delta (DC_VID_DS_DELTA)	xxxxxxxxh	Page 243
GLIU Control Registers				
84h	R/W	GLIU0 Memory Offset Register (GLIU_MEM_OFFSET)	00000000h	Page 244
8Ch	R/W	Dirty/Valid RAM Access Register (DV_ACC)	xxxxxxxxh	Page 244
VGA Unit Configuration Registers				
100h	R/W	VGA Configuration Register (VGA_CONFIG)	00000000h	Page 245

DC Register Descriptions (Continued)

Table 5-10. DC Registers Summary (Continued)

DC Memory Offset	Type	Register	Reset Value	Reference
104h	RO	Reserved (RSVD)	00000000h	Page 245

Table 5-11. VGA Unit Standard Register Summary

I/O Read Address	I/O Write Address	Register/ Group	Reference
3CCh	3C2h (W)	Miscellaneous Output Register	Page 246
3C2h	--	Input Status Register 0	Page 246
3BAh or 3DAh (Note1)	--	Input Status Register 1	Page 247
3CAh	3BAh or 3DAh (Note 1)	Feature Control Register	Page 247
3C4h		Sequencer Index	Page 248
3C5h		Sequencer Data	Page 248
3B4h or 3D4h (Note 1)		CRTC Index Register	Page 254
3B5h or 3D5h (Note 1)		CRTC Data Register	Page 254
3CEh		Graphics Controller Index	Page 265
3CFh		Graphics Controller Data	Page 265
3C0h		Attribute Controller Index/Data	Page 271
3C1h (R)	3C0h (W)		
3C8h	3C7h (Palette Read Mode)	Video DAC Palette Address	Page 275
	3C8h (Palette Write Mode)		
3C7h	--	Video DAC State	Page 276
3C9h		Video DAC Palette Data	Page 276
3C6h		Video DAC Palette Mask	Page 276

Note 1. The I/O addresses are determined by bit 0 of the Miscellaneous Output Register. See Section 5.3.10.1 on page 246 for more information.

Table 5-12. VGA Unit Extended Register Summary

VGA CRTC Index	Register	Reference
30h	ExtendedRegisterLock - Unlock code is 4Ch	Page 277
43h	ExtendedModeControl	Page 277
44h	ExtendedStartAddress	Page 278
47h	WriteMemoryAperture	Page 278
48h	ReadMemoryAperture	Page 279
60h	BlinkCounterCtl	Page 279
61h	BlinkCounter	Page 279
70h	VGALatchSavRes	Page 280
71h	DACIFSavRes	Page 280

DC Register Descriptions (Continued)

5.3.1 Standard GeodeLink Device MSRs

5.3.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 80002000h
Type RO
Reset Value 00000000_0003E0xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.**
23:8	DEV_ID	**Device ID.** Identifies device (03E0h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

5.3.1.2 GeodeLink Device Configuration MSR (GLD_MSR_CONFIG)

MSR Address 80002001h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																					PRI1			RSVD	PRI0			RSVD	PID		

GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:11	RSVD	**Reserved.** Write as 0.
10:8	PRI1	**Secondary Priority Level.** This value is the priority level the DC uses when performing “high priority” GLIU accesses. This is the case when the FIFOs are nearly empty.
7	RSVD	**Reserved.** Write as 0.
6:4	PRI0	**Primary Priority Level.** This value is the priority level the DC uses for most accesses (i.e., when the display FIFO is not in danger of being emptied).
3	RSVD	**Reserved.** Write as 0.
2:0	PID	**Priority ID.** This value is the Priority ID (PID) value used when the DC initiates GLIU transactions.

DC Register Descriptions (Continued)

5.3.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 80002002h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																											CRTCIO_SSMI_FLAG	VGA_BL_ASMI_FLAG	ISR0_SSMI_FLAG	MISC_SSMI_FLAG	DC_BL_ASMI_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																											CRTCIO_SSMI_EN	VGA_BL_ASMI_EN	ISR0_SSMI_EN	MISC_SSMI_EN	DC_BL_ASMI_EN

GLD_MSR_SMI Bit Descriptions

Bit	Name	Description
63:37	RSVD	**Reserved.** Write as 0.
36	CRTCIO_SSMI_ FLAG	**CRTC Invalid Register I/O Synchronous SMI Flag.** If high, records that an SSMI was generated due to a read or write of a non-implemented VGA CRT Controller register (see Table 5-17 "CRTC Register Settings" on page 252 for a register list). Write 1 to clear; writing 0 has no effect. CRTCIO_SSMI_EN (bit 4) must be low to generate SSMI and set flag.
35	VGA_BL_ASMI_ FLAG	**VGA Vertical Blank Asynchronous SMI Flag.** If high, records that the ASMI corresponding to VGA Vertical Blank has been triggered. Write 1 to clear (and deactivate the ASMI signal); writing 0 has no effect. VGA_BL_ASMI_EN (bit 3) must be low to generate ASMI and set flag.
34	ISR0_SSMI_FLAG	**Input Status Register 0 Synchronous SMI Flag.** If high, records that an SSMI was generated due to a read of the VGA Input Status Register 0 (Read Address 3C2h). Write 1 to clear; writing 0 has no effect. IRS0_SSMI_EN (bit 2) must be low to generate SSMI and set flag.
33	MISC_SSMI_FLAG	**Miscellaneous Output Register Synchronous SMI Flag.** If high, records that an SSMI was generated due to a write to the Miscellaneous Output Register (Read Address 3CCh, Write Address 3C2h). Write 1 to clear; writing 0 has no effect. MISC_SSMI_EN (bit 1) must be low to generate SSMI and set flag.
32	DC_BL_ASMI_ FLAG	**DC Vertical Blank Asynchronous SMI Flag.** If high, records that the ASMI corresponding to DC Vertical Blank has been triggered. Write 1 to clear (and deactivate ASMI signal); writing a 0 has no effect. DC_BL_ASMI_EN (bit 0) must be low to generate ASMI and set flag.
31:5	RSVD	**Reserved.** Write as 0.
4	CRTCIO_SSMI_EN	**CRTC Invalid Register I/O Synchronous SMI Enable.** Write 0 to enable generation of an SSMI when a non-implemented VGA CRT Controller register is read or written and set flag (bit 36).
3	VGA_BL_ASMI_EN	**VGA Vertical Blank Asynchronous SMI Enable.** Write 0 to enable generation an ASMI due to a VGA Vertical Blank and set flag (bit 35).

DC Register Descriptions (Continued)

GLD_MSR_SMI Bit Descriptions (Continued)

Bit	Name	Description
2	ISR0_SSMI_EN	**Input Status Register 0 Synchronous SMI Enable.** Write 0 to enable generation an SSMI due to a read of the VGA Input Status Register 0 and set flag (bit 34).
1	MISC_SSMI_EN	**Miscellaneous Output Register Synchronous SMI Enable.** Write 0 to enable generation an SSMI due to a write of the Miscellaneous Output Register and set flag (bit 33).
0	DC_BL_ASMI_EN	**DC Vertical Blank Asynchronous SMI Enable.** Write 0 to enable generation of an ASMI due to a DC Vertical Blank and set flag (bit 32).

5.3.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 80002003h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																												DFIFO_ERR_FLAG	SMI_ERR_FLAG	UNEXP_ADDR_ERR_FLAG	UNEXP_TYPE_ERR_FLAG
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
RSVD																												DFIFO_ERR_EN	SMI_ERR_EN	UNEXP_ADDR_ERR_EN	UNEXP_TYPE_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:36	RSVD	**Reserved.** Write as 0.
35	DFIFO_ERR_ FLAG	**Display FIFO Underrun Error Flag.** If high, records that the ERR signal is being driven because the display FIFO has “run dry”. This implies that at least one frame of the display was corrupted. Write 1 to clear; writing 0 has no effect.
34	SMI_ERR_FLAG	**Uncleared SMI Error Flag.** If high, records that the ERR signal is being driven because a second SMI occurred while the first SMI went unserviced. Write 1 to clear; writing 0 has no effect.
33	UNEXP_ADDR_ ERR_FLAG	**Unexpected Address Error Flag.** If high, records that an ERR has occurred because the DC received a GLIU transaction with the exception flag was set. Write 1 to clear; writing 0 has no effect.

DC Register Descriptions (Continued)

GLD_MSR_ERROR Bit Descriptions (Continued)

Bit	Name	Description
32	UNEXP_TYPE_ ERR_FLAG	**Unexpected Type Error Flag.** If high, records that an ERR has occurred because the DC received a GLIU transaction with an undefined or unexpected type. Write 1 to clear; writing 0 has no effect.
31:4	RSVD	**Reserved.** Write as 0.
3	DFIFO_ERR_EN	**Display FIFO Underrun Error Enable.** Write 0 to enable generation of the ERR signal if the display FIFO runs dry and set flag (bit 35).
2	SMI_ERR_EN	**Uncleared SMI Error Enable.** Write 0 to enable generation of the ERR signal if a second SMI occurs before the first SMI is serviced and set flag (bit 34).
1	UNEXP_ADDR_ ERR_EN	**Unexpected Address Error Enable.** Write 0 to enable generation of the ERR signal if the DC receives a GLIU transaction with the exception flag set and set flag (bit 33).
0	UNEXP_TYPE_ ERR_EN	**Unexpected Type Error Enable.** Write 0 to enable generation of the ERR signal if the DC receives a GLIU transaction with an undefined or unexpected type and set flag (bit 32).

5.3.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 80002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								PMODE3		PMODE2		PMODE1		PMODE0	

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved.** Write as 0.
31:8	RSVD	**Reserved.** Write as 0.
7:6	PMODE3	**Power Mode 3 (VGA DOTCLK).** This field controls the internal clock gating for the DOTCLK to the VGA unit. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
5:4	PMODE2	**Power Mode 2 (VGA GLIU Clock).** This field controls the internal clock gating for the GLIU clock to the VGA unit. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

DC Register Descriptions (Continued)

GLD_MSR_PM Bit Descriptions (Continued)

Bit	Name	Description
3:2	PMODE1	**Power Mode 1 (DOTCLK).** This field controls the internal clock gating for the DOTCLK to all logic other than the VGA unit. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
1:0	PMODE0	**Power Mode 0 (GLIU Clock).** This field controls the internal clock gating for the GLIU clock to all logic other than the VGA unit. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

5.3.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address 80002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

DC Register Descriptions (Continued)

5.3.2 DC Specific MSRs

5.3.2.1 BIST MSR (MSR_BIST)

MSR Address 80002010h
Type R/W
Reset Value 00000000_00000000h

MSR_BIST Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						MBIST_EN	MBIST_DRT_EN	RSVD					MBIST_DONE	MBIST_CMP_STAT	MBIST_GO

MSR_BIST Bit Descriptions

Bit	Name	Description
63:10	RSVD	**Reserved.** Write as 0.
9	MBIST_EN	**Memory Built-In Self Test Enable.** Memory BIST enable (FIFO not available for other features during BIST testing). This bit is read/write.
8	MBIST_DRT_EN	**MBIST DRT Enable.** Dynamic refresh pauses feature for memory BIST. This bit is read/write.
7:3	RSVD	**Reserved.** Write as 0.
2	MBIST_DONE (RO)	**MBIST Done Status Indicator (Read Only).** High when GLCP FIFO BIST is done. Read-only, low during normal operation.
1	MBIST_CMP_STAT (RO)	**MBIST Completion Status Indicator (Read Only).** Low during compare failure of GLCP FIFO BIST. Under normal operation, this bit is set high.
0	MBIST_GO (RO)	**MBIST Error Indicator (Read Only).** High when GLCP FIFO found no errors; low during normal operation.

5.3.2.2 RAM Control MSR (MSR_RAM_CTL)

MSR Address 80002012h
Type R/W
Reset Value 00000000_02020202h

MSR_RAM_CTL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					DFIFO_CTL1			RSVD					DFIFO_CTL0			RSVD					CFIFO_CTL		RSVD					DV_RAM_CTL		

DC Register Descriptions (Continued)

MSR_RAM_CTL Bit Descriptions

Bit	Name	Description
63:27	RSVD	**Reserved.** Write as read.
26:24	DFIFO_CTL1	**DFIFO RAM 1 Delay Control.** This bit determines the precharge delay for the DFIFO1 DFIFO0, CFIFO, or DV] RAM cell.
23:19	RSVD	**Reserved.** Write as read.
18:16	DFIFO_CTL0	**DFIFO RAM 0 Delay Control.** This bit determines the precharge delay for the DFIFO0 RAM cell.
15:11	RSVD	**Reserved.** Write as read.
10:8	CFIFO_CTL	**CFIFO RAM Delay Control.** This bit determines the precharge delay for the CFIFO RAM cell.
7:3	RSVD	**Reserved.** Write as read.
2:0	DV_RAM_CTL	**DV RAM Delay Control.** This bit determines the precharge delay for the DV RAM cell.

5.3.3 GUI Unit Configuration and Status Registers

5.3.3.1 DC Unlock (DC_UNLOCK)

DC Memory Offset 00h
Type R/W
Reset Value 00000000h

This register is provided to lock the most critical memory-mapped DC registers to prevent unwanted modification (write operations). Read operations are always allowed.

DC_UNLOCK Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																DC_UNLOCK															

DC_UNLOCK Bit Descriptions

Bit	Name	Description
31:16	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

DC_UNLOCK Bit Descriptions (Continued)

Bit	Name	Description
15:0	DC_UNLOCK	**Unlock Code.** This register must be written with the value 4758h in order to write to the protected registers. The following registers are protected by the locking mechanism. DC_GENERAL_CFG (DC Memory Offset 04h) DC_DISPLAY_CFG (DC Memory Offset 08h) DC_FB_ST_OFFSET (DC Memory Offset 10h) DC_CB_ST_OFFSET (DC Memory Offset 14h) DC_CURS_ST_OFFSET (DC Memory Offset 18h) DC_ICON_ST_OFFSET (DC Memory Offset 1Ch) DC_VID_Y_ST_OFFSET (DC Memory Offset 20h) DC_VID_U_ST_OFFSET (DC Memory Offset 24h) DC_VID_V_ST_OFFSET (DC Memory Offset 28h) DC_LINE_SIZE (DC Memory Offset 30h) DC_GFX_PITCH (DC Memory Offset 34h) DC_VID_YUV_PITCH (DC Memory Offset 38h) DC_H_ACTIVE_TIMING (DC Memory Offset 40h) DC_H_BLANK_TIMING (DC Memory Offset 44h) DC_H_SYNC_TIMING (DC Memory Offset 48h) DC_V_ACTIVE_TIMING (DC Memory Offset 50h) DC_V_BLANK_TIMING (DC Memory Offset 54h) DC_V_SYNC_TIMING (DC Memory Offset 58h) GLIU_MEM_OFFSET (DC Memory Offset 84h) DV_CTL (DC Memory Offset 88h)

5.3.3.2 DC General Configuration (DC_GENERAL_CFG)

DC Memory Offset 04h
Type R/W
Reset Value 00000000h

This register contains general control bits for the DC.

DC_GENERAL_CFG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	CFRW	DIAG	CRC_MODE	SGFR	SGRE	SIGE	VFSL	RSVD		YUVM	VDSE	VGAFT	FDTY	STFM	DFHPEL				DFHPSL				VGAE	DECE	CMPE	RSVD	VIDE	ICNE	CURE	DFLE

DC_GENERAL_CFG Bit Descriptions

Bit	Name	Description
31	RSVD	**Reserved.**
30	RSVD	**Reserved.**
29	CFRW	**Compressed Line Buffer (CLB) Read/Write Select.** Only has effect if in RAM diagnostic mode (bit 28 = 1). 0: Write address enabled to CLB in diagnostic mode. 1: Read address enabled to CLB in diagnostic mode.
28	DIAG	**RAM Diagnostic Mode.** Allows testability of the on-chip display FIFO and compressed line buffer via the diagnostic access registers. A low-to-high transition resets the display FIFO and compressed line buffer read and write pointers. 0: Normal operation. 1: RAM diagnostic mode enabled.

DC Register Descriptions (Continued)

DC_GENERAL_CFG Bit Descriptions (Continued)

Bit	Name	Description
27	CRC_MODE	**CRC Mode.** When cleared, the CRC algorithm used to compute the signature is the same as in GX1 and in Rev 1.0.: nxt_crc[23:0] <= {crc[22:0], (crc[23], crc[3], crc[2])} ^ data[23:0]; When set to 1, a different 32-bit CRC algorithm is used: NXT_CRC = (reset) ? 32'h0 : {crc[30:0], 1'b0} ^ ((crc[31]) ? 32'h04c11db7 : 0) ^ data;
26	SGFR	**Signature Free Run.** When this bit is cleared, the signature accumulation stops at the end of the current frame. 0: Capture display signature for one frame. 1: Capture display signature continuously for multiple frames.
25	SGRE	**Signature Read Enable.** The palette address register contents are ignored in this case. Note that the automatic palette address increment mechanism continues to operate even though the address is ignored. 0: Reads to DC_PAL_DATA (DC Memory Offset 74h[23:0]) return palette data. 1: Reads to DC_PAL_DATA (DC Memory Offset 74h[23:0]) return signature data.
24	SIGE	**Signature Enable.** CRC logic captures the pixel data signature with each pixel clock beginning with the next leading edge of vertical blank. Note that the CRC logic treats each 24-bit pixel value as an autonomous 24-bit value (RGB color components are not captured separately in 8-bit signature registers). 0: CRC signature is reset to 000001h and held (no capture). 1: CRC logic capture enabled.
23	VFSL	**Video Fifo Select.** This bit determines how the DC's memory interface behaves when fetching video data. When 0, the DC attempts to fetch video data whenever there is room for 32 bytes (one cacheline) of video data in the DFIFO. When set to 1, the DC waits until 64 bytes of space is available.
22:21	RSVD	**Reserved.**
20	YUVM	**YUV Mode.** Selects YUV display mode. 0: YUV 4:2:2 display mode. 1: YUV 4:2:0 display mode.
19	VDSE	**Video Downscale Enable.** 0: Send all video lines to the display filter. 1: Use DC_VID_DS_DELTA (DC Memory Offset 80h[31:18]) as a DDA delta value to skip certain video lines to support downscaling in the display filter.
18	VGAFT	**VGA Fixed Timing.** When in VGA mode (VGAE, bit 7 = 1), this bit indicates that the GUI unit (DC) timing generator should provide the display timings. The VGA slaves its display activity to the regular DC sync and displays enable signals. The VGA can be made to center or scale its pixel output depending on a control bit in the VGA ExtendedModeControl register (CRTC Index 43h[3]). This is a writable bit. 0: VGA uses its own timer when it is enabled. 1: The DC's "default" timing generator is used to control the display of the screen image.
17	FDTY	**Frame Dirty Mode.** 0: Frame buffer writes mark associated scan line dirty. Used when DC_GFX_PITCH (DC Memory Offset 34h[15:0]) is equal to 1 kB, 2 kB, or 4 kB. 1: Frame buffer writes mark entire frame as dirty. Used when DC_GFX_PITCH (DC Memory Offset 34h[15:0]) is not equal to 1 kB, 2 kB, or 4 kB.

DC Register Descriptions (Continued)

DC_GENERAL_CFG Bit Descriptions (Continued)

Bit	Name	Description
16	STFM	**Static Frame Mode.** If compression is enabled (CMPE, bit 5 = 1), this bit selects when to update dirty scan lines. 0: Update any dirty scan lines every frame when compression is enabled. 1: Update any dirty scan lines every other frame when compression is enabled.
15:12	DFHPEL	**Display FIFO High Priority End Level.** This field specifies the depth of the display FIFO (in 64-bit entries x 4) at which a high-priority request previously issued to the memory controller ends. The value is dependent upon display mode. This field should always be non-zero and should be larger than the start level.
11:8	DFHPSL	**Display FIFO High Priority Start Level.** This field specifies the depth of the display FIFO (in 64-bit entries x 4) at which a high-priority request is sent to the memory controller to fill up the FIFO. The value is dependent upon display mode. This field should always be non-zero and should be less than the high-priority end level.
7	VGAE	**VGA Enable.** 0: Normal DC operation. 1: Allow the hardware VGA unit use of the display FIFO and the memory request interface. The VGA hsync, vsync, blank, and pixel outputs are routed through the back end of the DC pixel and sync pipeline and then to the I/O pads. When changing the state of this bit, both DC and VGA (which is part of the DC) should be stopped, and not actively fetching and displaying data. No other DC features operate with the VGA pass-through feature enabled, with the exception of the CRC/signature feature and the timing generator (when VGA fixed timings are enabled, bit 18 = 0). All other features should be turned off to prevent interference with VGA operation.
6	DECE	**Decompression Enable.** Synchronized to start of next frame. 0: Disable display refresh decompression. 1: Enable display refresh decompression.
5	CMPE	**Compression Enable.** Effective immediately. 0: Disable display refresh compression. 1: Enable display refresh compression.
4	RSVD	**Reserved.**
3	VIDE	**Video Enable.** Synchronized to start of next frame. 0: Disable video port/overlay. 1: Enable video port/overlay.
2	ICNE	**Icon Enable.** Synchronized to start of next frame. 0: Disable icon overlay. 1: Enable icon overlay.
1	CURE	**Cursor Enable.** Synchronized to start of next frame. 0: Disable hardware cursor. 1: Enable hardware cursor.
0	DFLE	**Display-FIFO Load Enable.** Setting this bit high initiates display refresh requests to the memory controller at the trailing edge of vertical sync. 0: Disable display FIFO. 1: Enable display FIFO.

DC Register Descriptions (Continued)

5.3.3.3 DC Display Configuration (DC_DISPLAY_CFG)

DC Memory Offset 08h
Type R/W
Reset Value Cxxx00000h

This register contains configuration bits for controlling the various display functions of the DC.

DC_DISPLAY_CFG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
A20M	A18M	FRSL	RSVD	VISL	FRLK	PALB	RSVD					DCEN	RSVD							16BPP_MODE		DISP_MODE		SCLE	TRUP	RSVD	VDEN	GDEN	RSVD		TGEN

DC_DISPLAY_CFG Bit Descriptions

Bit	Name	Description
31	A20M	**Address Bit 20 Unmask.** When this bit is set, Address bit 20 operates normally. When this bit is cleared, Address bit 20 is set to 0 for all outgoing memory requests.
30	A18M	**Address Bit 18 Unmask.** When this bit is set, Address bit 18 operates normally. When this bit is cleared, Address bit 18 is set to 0 for all outgoing memory requests.
29	FRSL	**Frame Dither Select.** Setting this bit to 1 disables frame-based (temporal) dithering for 32 BPP modes. It has no effect in other modes.
28	RSVD	**Reserved.** Write as read.
27	VISL	**Vertical Interrupt Select.** 0: SMI generated at start of vertical blank when VIEN is enabled (bit 5 = 1). 1: SMI generated at end of vertical sync when VIEN is enabled (bit 5 = 1).
26	FRLK	**Frame Lock Mode.** 0: Disable frame locking. 1: Enable frame lock display timing generator to VIP vertical blank signal.
25	PALB	**PAL Bypass.** (Only applicable in 24 BPP mode.) 0: Graphics data is routed through palette RAM in 24 BPP display mode (bits [9:8] = 10). 1: Graphics data bypasses palette RAM in 24 BPP display mode (bits [9:8] = 10).
24:20	RSVD	**Reserved.** Write as read.
19	DCEN	**Display Center.** 0: Normal active portion of scan line is qualified with DISP_ENA. 1: Border and active portions of scan line are qualified with DISP_ENA. This enables centering the display for flat panels. This signal can be used in CRT or flat panel, but is most useful in flat panel.
18:12	RSVD	**Reserved.** Write as read.
11:10	16BPP_MODE	**16-Bit Per Pixel Mode.** 16 BPP display format. 00: 16 BPP (RGB 5:6:5). 01: 15 BPP (RGB 5:5:5). 10: XRGB (RGB 4:4:4). 11: Reserved.

DC Register Descriptions (Continued)

DC_DISPLAY_CFG Bit Descriptions (Continued)

Bit	Name	Description
9:8	DISP_MODE	**Display Mode.** Bits per pixel. 00: 8 BPP (also used in VGA emulation; Display Mode bits must be set to 00 (8 BPP) while in VGA mode.) 01: 16 BPP. 10: 24 BPP (RGB 8:8:8). 11: Reserved.
7	SCLE	**Scale Enable.** 0: Disable graphics scaling. 1: Enable graphics scaling. (Scaling is controlled via the DC_GFX_SCL register (DC Memory Offset 0Ch).
6	TRUP	**Timing Register Update.** 0: Prevent update of working timing registers. This bit should be set low when a new timing set is being programmed, but the display is still running with the previously programmed timing set. 1: Update working timing registers on next active edge of vertical sync.
5	RSVD	**Reserved.** Write as read.
4	VDEN	**Video Data Enable.** Set this bit to 1 to allow transfer of video data to the display filter.
3	GDEN	**Graphics Data Enable.** Set this bit to 1 to allow transfer of graphics data through the display pipe.
2:1	RSVD	**Reserved.** Write as read.
0	TGEN	**Timing Generator Enable.** 0: Disable timing generator. 1: Enable timing generator.

5.3.3.4 DC Graphics Scale (DC_GFX_SCL)

DC Memory Offset 0Ch
Type R/W
Reset Value xxxxxxxxh

This register specifies the scale factors to scale the graphics display (source) buffer to the desired screen (destination) resolution. It is used primarily for stretching a VGA display to fill the screen for a flat panel display.

DC_GFX_SCL Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
YP2				YP1				YP0				YCNT				XP2				XP1				XP0				XCNT			

DC_GFX_SCL Bit Descriptions

Bit	Name	Description
31:28	YP2	**Vertical Position 2.** This value represents the line count within the current line group for which the corresponding source line should be replicated.
27:24	YP1	**Vertical Position 1.** This value represents the line count within the current line group for which the corresponding source line should be replicated.
23:20	YP0	**Vertical Position 0.** This value represents the line count within the current line group for which the corresponding source line should be replicated.

DC Register Descriptions (Continued)

DC_GFX_SCL Bit Descriptions (Continued)

Bit	Name	Description
19:16	YCNT	**Vertical Count.** When scaling is enabled (DC Memory Offset 08h[7] = 1), a counter counts up to X, where X is a number from 0 to 15. When the count equals VP0, VP1, or VP2, the corresponding source line is replicated. Note that the counter does NOT hold its count for the repeated line, but continues to advance the count for each line. To repeat less than three lines per group, two or three of the positions (VP0, VP1, VP2) should be set to the same value. If line doubling is enabled (DC Memory Offset 08h[15] = 1), the counter counts every other line.
15:12	XP2	**Horizontal Position 2.** This value represents the pixel count within the current pixel group for which the corresponding source pixel should be replicated.
11:8	XP1	**Horizontal Position 1.** This value represents the pixel count within the current pixel group for which the corresponding source pixel should be replicated.
7:4	XP0	**Horizontal Position 0.** This value represents the pixel count within the current pixel group for which the corresponding source pixel should be replicated.
3:0	XCNT	**Pixel Count.** When scaling is enabled (DC Memory Offset 08h[7] = 1), a counter counts up to X, where X is a number from 0 to 15. When the count equals XP0, XP1, or XP2, the corresponding source pixel is replicated. Note that the counter does NOT hold its count for the repeated pixel, but continues to advance the count for each pixel. To repeat less than three pixels per group, two or three of the positions (XP0, XVP1, XP2) should be set to the same value. If pixel doubling is enabled (DC Memory Offset 08h[14] = 1), the counter counts every other pixel.

5.3.4 Memory Organization Registers

The graphics memory region is up to 16 MB in size. The graphics memory is made up of the normal uncompressed frame buffer, compressed display buffer, icon buffer, cursor buffer, and video buffer(s). Each buffer begins at a programmable offset within the graphics memory region.

The various memory buffers are arranged so as to efficiently pack the data within the graphics memory region. This requires flexibility in the way that the buffers are arranged when different display modes are in use. The cursor and icon buffers are linear blocks so addressing is straightforward. The frame buffer and compressed display buffer are arranged based upon scan lines. Each scan line has a maximum number of valid or active QWORDs and a pitch that, when added to the previous line offset, points to the next line. In this way, the buffers may be stored as linear blocks or as rectangular blocks.

The various buffers' addresses are all located within the same 16 MB aligned region. Thus, a separate register, GLIU0_MEM_OFFSET (DC Memory Offset 84h), is used to set a 16 MB aligned base address.

5.3.4.1 DC Frame Buffer Start Address (DC_FB_ST_OFFSET)

DC Memory Offset 10h
Type R/W
Reset Value xxxxxxxxh

This register specifies the offset at which the frame buffer starts.

DC_FB_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																											

DC_FB_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

DC_FB_ST_OFFSET Bit Descriptions (Continued)

Bit	Name	Description
27:0	OFFSET	**Frame Buffer Start Offset.** This value represents the byte offset of the starting location of the displayed frame buffer. This value may be changed to achieve panning across a virtual desktop or to allow multiple buffering. When this register is programmed to a non-zero value, the compression logic should be disabled (DC Memory Offset 04h[5] = 1). The memory address defined by bits [27:3] takes effect at the start of the next frame scan. The pixel offset defined by bits [2:0] is latched at the end of vertical sync and added to the pixel panning offset to determine the actual panning value.

5.3.4.2 DC Compression Buffer Start Address (DC_CB_ST_OFFSET)

DC Memory Offset 14h
Type R/W
Reset Value xxxxxxxxh

This register specifies the offset at which the compressed display buffer starts.

DC_CB_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																								0h			

DC_CB_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.
27:0	OFFSET	**Compressed Display Buffer Start Offset**. This value represents the byte offset of the starting location of the compressed display buffer. The lower four bits should always be programmed to zero so that the start offset is aligned to a 16-byte boundary (to optimize performance). This value should change only when a new display mode is set due to a change in size of the frame buffer.

5.3.4.3 DC Cursor Buffer Start Address (DC_CURS_ST_OFFSET)

DC Memory Offset 18h
Type R/W
Reset Value xxxxxxxxh

This register specifies the offset at which the cursor memory buffer starts.

DC_CURS_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																								0h			

DC_CURS_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

DC_CURS_ST_OFFSET Bit Descriptions (Continued)

Bit	Name	Description
27:0	OFFSET	**Cursor Start Offset**. This value represents the byte offset of the starting location of the cursor display pattern. The lower four bits should always be programmed to zero so that the start offset is 16-byte aligned (to optimize performance). Note that if there is a Y offset for the cursor pattern, the cursor start offset should be set to point to the first displayed line of the cursor pattern.

5.3.4.4 DC Icon Buffer Start Address (DC_ICON_ST_OFFSET)

DC Memory Offset 1Ch
Type R/W
Reset Value xxxxxxxxh

This register specifies the offset at which the cursor memory buffer starts.

DC_ICON_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																								0h			

DC_ICON_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.
27:0	OFFSET	**Icon Start Offset.** This value represents the byte offset of the starting location of the icon display pattern. The lower four bits should always be programmed to zero so that the start offset is 16-byte aligned (to optimize performance).

5.3.4.5 DC Video Y Buffer Start Address Offset (DC_VID_Y_ST_OFFSET)

DC Memory Offset 20h
Type R/W
Reset Value 00000000h

This register specifies the offset at which the video Y (YUV 4:2:0) or YUV (YUV 4:2:2) buffer starts.

DC_VID_Y_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																								0h			

DC_VID_Y_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

DC_VID_Y_ST_OFFSET Bit Descriptions (Continued)

Bit	Name	Description
27:0	OFFSET	**Video Y Buffer Start Offset.** This value represents the starting location for video Y buffer. The lower four bits should always be programmed as zero so that the start offset is aligned to a 16-byte boundary (to optimize performance). If YUV 4:2:2 mode is selected (DC Memory Offset 04h[20] = 0), the video Y buffer is used as a singular buffer holding interleaved Y, U, and V data. If YUV 4:2:0 is selected (DC Memory Offset 04h[20] = 1), the video Y buffer is used to hold only Y data while U and V data are stored in separate buffers whose start offsets are represented in DC_VID_U_ST_OFFSET (DC Memory Offset 24h[27:0]) and DC_VID_V_ST_OFFSET (DC Memory Offset 28h[27:0].

5.3.4.6 DC Video U Buffer Start Address Offset (DC_VID_U_ST_OFFSET)

DC Memory Offset 24h
Type R/W
Reset Value 00000000h

This register specifies the offset at which the video U (YUV 4:2:0) buffer starts.

DC_VID_U_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																									0h		

DC_VID_U_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.
27:0	OFFSET	**Video U Buffer Start Offset**. This value represents the starting location for the video U buffer. The lower three bits should always be programmed as zero so that the start offset is aligned to a QWORD boundary. A buffer for U data is only used if YUV 4:2:0 display mode is selected (DC Memory Offset 04h[20] = 1).

5.3.4.7 DC Video V Buffer Start Address Offset (DC_VID_V_ST_OFFSET)

DC Memory Offset 28h
Type R/W
Reset Value 00000000h

This register specifies the offset at which the video V (YUV 4:2:0) buffer starts.

DC_VID_V_ST_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				OFFSET																									0h		

DC_VID_V_ST_OFFSET Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

DC_VID_V_ST_OFFSET Bit Descriptions (Continued)

Bit	Name	Description
27:0	OFFSET	**Video V Buffer Start Offset**. This value represents the starting location for the video V buffer. The lower three bits should always be programmed as zero so that the start offset is aligned to a QWORD boundary. A buffer for V data is only used if YUV 4:2:0 display mode is selected (DC Memory Offset 04h[20] = 1).

5.3.4.8 DC Line Size (DC_LINE_SIZE)

DC Memory Offset 30h
Type R/W
Reset Value 00000000h

This register specifies the number of bytes to transfer for a line of frame buffer, compression buffer, and video buffer data. The compressed line buffer is invalidated if it exceeds the CB_LINE_SIZE.

DC_LINE_SIZE Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
VID_LINE_SIZE								0	CB_LINE_SIZE							RSVD						FB_LINE_SIZE									

DC_LINE_SIZE Bit Descriptions

Bit	Name	Description
31:24	VID_LINE_SIZE	**Video Line Size.** This value specifies the number of QWORDs (8-byte segments) to transfer for each source line from the video buffer in YUV 4:2:2 mode. In YUV 4:2:0 mode, it specifies the number of QWORDs to transfer for the U or V stream for a source line (2x this amount is transferred for the Y stream).
23	RSVD	**Reserved.** Write as 0.
22:16	CB_LINE_SIZE	**Compressed Display Buffer Line Size.** This value represents the number of QWORDs for a valid compressed line plus 1. It is used to detect an overflow of the compressed data FIFO. When the compression data for a line reaches CB_LINE_SIZE QWORDs, the line is deemed incompressible. Note that the DC actually writes CB_LINE_SIZE+4 QWORDs to memory, so if X QWORDs are allocated for each compression line, then X-4+1 (or X-3) must be programmed into this register. Note also that the CB_LINE_SIZE field must never be larger than 65 (41h) since the maximum size of the compressed data FIFO is 64 QWORDs.
15:11	RSVD	**Reserved.** Write as 0.
10:0	FB_LINE_SIZE	**Frame Buffer Line Size.** This value specifies the number of QWORDs (8-byte segments) to transfer for each display line from the frame buffer.

5.3.4.9 DC Graphics Pitch (DC_GFX_PITCH)

DC Memory Offset 34h
Type R/W
Reset Value 00000000h

This register stores the pitch for the graphics display buffers.

DC_GFX_PITCH Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CB_PITCH																FB_PITCH															

DC_GFX_PITCH Bit Descriptions

Bit	Name	Description
31:16	CB_PITCH	**Compressed Display Buffer Pitch.** This value represents number of QWORDs between consecutive scan lines of compressed buffer data in memory.
15:0	FB_PITCH	**Frame Buffer Pitch.** This value represents number of QWORDs between consecutive scan lines of frame buffer data in memory.

5.3.4.10 DC Video YUV Pitch (DC_VID_YUV_PITCH)

DC Memory Offset 38h
Type R/W
Reset Value 00000000h

This register stores the pitch for the video buffers.

DC_VID_YUV_PITCH Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
UV_PITCH																Y_PITCH															

DC_VID_YUV_PITCH Bit Descriptions

Bit	Name	Description
31:16	UV_PITCH	**Video U and V Buffer Pitch.** This value represents number of QWORDs between consecutive scan lines of U or V buffer data in memory. (U and V video buffers are always the same pitch.) A pitch up to 512 kB is supported to allow for vertical decimation for downscaling.
15:0	Y_PITCH	**Video Y Buffer Pitch.** This value represents number of QWORDs between consecutive scan lines of Y buffer data in memory. A pitch up to 512 kB is supported to allow for vertical decimation for downscaling.

5.3.5 Timing Registers

The timing registers control the generation of sync, blanking, and active display regions. These registers are generally programmed by the BIOS from an INT 10h call or by the extended mode driver from a display timing file. Note that the horizontal timing parameters are specified in character clocks, which actually means pixels divided by 8, since all characters are bit mapped.

5.3.5.1 DC Horizontal and Total Timing (DC_H_ACTIVE_TIMING)

DC Memory Offset 40h
Type R/W
Reset Value xxxxxxxxh

DC_H_ACTIVE_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				H_TOTAL									RX			RSVD				H_ACTIVE									RX		

DC_H_ACTIVE_TIMING Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** These bits should be programmed to zero.

DC Register Descriptions (Continued)

DC_H_ACTIVE_TIMING Bit Descriptions (Continued)

Bit	Name	Description
27:19	H_TOTAL	**Horizontal Total.** This field represents the total number of character clocks for a given scan line minus 1. Note that the value is necessarily greater than the H_ACTIVE field (bits [11:3]) because it includes border pixels and blanked pixels. For flat panels, this value never changes. The field [27:16] may be programmed with the pixel count minus 1, although bits [18:16] are ignored. The horizontal total is programmable on 8-pixel boundaries only.
18:16	RX	**Reserved.** These bits are readable and writable but have no effect. See H_TOTAL (bits [27:19]) description.
15:12	RSVD	**Reserved.** These bits should be programmed to zero.
11:3	H_ACTIVE	**Horizontal Active.** This field represents the total number of character clocks for the displayed portion of a scan line minus 1. The field [11:0] may be programmed with the pixel count minus 1, although bits [2:0] are ignored. The active count is programmable on 8-pixel boundaries only. Note that for flat panels, if this value is less than the panel active horizontal resolution (H_PANEL; used in the equation below), the parameters H_BLK_START (DC Memory Offset 44h[11:3]), H_BLK_END (DC Memory Offset 44h[27:19]), H_SYNC_START (DC Memory Offset 48h[11:3]), and H_SYNC_END (DC Memory Offset 48h[27:19])should be reduced by the value of H_ADJUST (or the value of H_PANEL - H_ACTIVE / 2) to achieve horizontal centering.
2:0	RX	**Reserved.** These bits are readable and writable but have no effect. See H_ACTIVE (bits [11:3]) description.

5.3.5.2 DC CRT Horizontal Blanking Timing (DC_H_BLANK_TIMING)

DC Memory Offset 44h
Type R/W
Reset Value xxxxxxxxh

This register contains horizontal blank timing information.

Note: A minimum of four character clocks is required for the horizontal blanking portion of a line in order for the timing generator to function correctly.

DC_H_BLANK_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				H_BLK_END									RX			RSVD				H_BLK_START									RX		

DC_H_BLANK_TIMING Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as 0.
27:19	H_BLK_END	**Horizontal Blank End.** This field represents the character clock count at which the (internal) horizontal blanking signal becomes inactive minus 1. The field [27:16] may be programmed with the pixel count minus 1, although bits [18:16] are ignored. The blank end position is programmable on 8-pixel boundaries only.
18:16	RX	**Reserved.** These bits are readable and writable but have no effect. See H_BLK_END (bits [27:19]) description.
15:12	RSVD	**Reserved.** Write as 0.
11:3	H_BLK_START	**Horizontal Blank Start.** This field represents the character clock count at which the horizontal blanking signal becomes active minus 1. The field [11:0] may be programmed with the pixel count minus 1, although bits [2:0] are ignored. The blank start position is programmable on 8-pixel boundaries only.

DC Register Descriptions (Continued)

DC_H_BLANK_TIMING Bit Descriptions (Continued)

Bit	Name	Description
2:0	RX	**Reserved.** These bits are readable and writable but have no effect. See H_BLK_START (bits [11:3]) description.

5.3.5.3 DC CRT Horizontal Sync Timing (DC_H_SYNC_TIMING)

DC Memory Offset 48h
Type R/W
Reset Value xxxxxxxxh

This register contains CRT horizontal sync timing information. Note, however, that this register should also be programmed appropriately for flat panel only display since the horizontal sync transition determines when to advance the vertical counter.

DC_H_SYNC_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				H_SYNC_END									RX			RSVD				H_SYNC_ST								RX		

DC_H_SYNC_TIMING Bit Descriptions

Bit	Name	Description
31:28	RSVD	**Reserved.** Write as 0.
27:19	H_SYNC_END	**Horizontal Sync End.** This field represents the character clock count at which the CRT horizontal sync signal becomes inactive minus 1. The field [27:16] may be programmed with the pixel count minus 1, although bits [18:16] are ignored. The sync end position is programmable on 8-pixel boundaries only.
18:16	RX	**Reserved.** These bits are readable and writable but have no effect. See H_SYNC_END (bits [27:19]) description.
15:12	RSVD	**Reserved.** Write as 0.
11:3	H_SYNC_ST	**Horizontal Sync Start.** This field represents the character clock count at which the CRT horizontal sync signal becomes active minus 1. The field [11:0] may be programmed with the pixel count minus 1, although bits [2:0] are ignored. The sync start position is programmable on 8-pixel boundaries only.
2:0	RX	**Reserved.** These bits are readable and writable but have no effect. See H_SYNC_ST (bits [11:3]) description.

5.3.5.4 DC Vertical and Total Timing (DC_V_ACTIVE_TIMING)

DC Memory Offset 50h
Type R/W
Reset Value xxxxxxxxh

This register contains vertical active and total timing information. The parameters pertain to both CRT and flat panel display. All values are specified in lines.

DC_V_ACTIVE_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					V_TOTAL											RSVD					V_ACTIVE										

DC Register Descriptions (Continued)

DC_V_ACTIVE_TIMING Bit Descriptions

Bit	Name	Description
31:27	RSVD	**Reserved.** Write as 0.
26:16	V_TOTAL	**Vertical Total.** This field represents the total number of lines for a given frame scan minus 1. Note that the value is necessarily greater than the V_ACTIVE field (bits 10:0]) because it includes border lines and blanked lines.
15:11	RSVD	**Reserved.** Write as 0.
10:0	V_ACTIVE	**Vertical Active.** This field represents the total number of lines for the displayed portion of a frame scan minus 1. Note that for flat panels, if this value is less than the panel active vertical resolution (V_PANEL; used in the equation below), the parameters V_BLANK_START (DC Memory Offset 54h[10:0]), V_BLANK_END (DC Memory Offset 54h[26:16]), V_SYNC_START (DC Memory Offset 58h[10:0]), and V_SYNC_END (DC Memory Offset 58h[26:16])should be reduced by the following value (V_ADJUST) to achieve vertical centering: V_ADJUST = (V_PANEL - V_ACTIVE) / 2

5.3.5.5 DC CRT Vertical Blank Timing (DC_V_BLANK_TIMING)

DC Memory Offset 54h
Type R/W
Reset Value xxxxxxxxh

This register contains vertical blank timing information. All values are specified in lines. For interlaced display, no border is supported, so blank timing is implied by the total/active timing.

DC_V_BLANK_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					V_BLANK_END											RSVD					V_BLANK_ST										

DC_V_BLANK_TIMING Bit Descriptions

Bit	Name	Description
31:27	RSVD	**Reserved.** Write as 0.
26:16	V_BLANK_END	**Vertical Blank End.** This field represents the line at which the vertical blanking signal becomes inactive minus 1. If the display is interlaced, no border is supported, so this value should be identical to V_TOTAL (DC Memory Offset 50h[26:16]).
15:11	RSVD	**Reserved.** Write as 0.
10:0	V_BLANK_ST	**Vertical Blank Start.** This field represents the line at which the vertical blanking signal becomes active minus 1. If the display is interlaced, this value should be programmed to V_ACTIVE (DC Memory Offset 50h[10:0])plus 1.

5.3.5.6 DC CRT Vertical Sync Timing (DC_V_SYNC_TIMING)

DC Memory Offset 58h
Type R/W
Reset Value xxxxxxxxh

This register contains vertical sync timing information. All values are specified in lines.

DC_V_SYNC_TIMING Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					V_SYNC_END											RSVD					V_SYNC_ST										

DC_V_SYNC_TIMING Bit Descriptions

Bit	Name	Description
31:27	RSVD	**Reserved.** Write as 0.
26:16	V_SYNC_END	**Vertical Sync End.** This field represents the line at which the CRT vertical sync signal becomes inactive minus 1.
15:11	RSVD	**Reserved.** Write as 0.
10:0	V_SYNC_ST	**Vertical Sync Start.** This field represents the line at which the CRT vertical sync signal becomes active minus 1. For interlaced display, note that the vertical counter is incremented twice during each line and since there are an odd number of lines, the vertical sync pulse triggers in the middle of a line for one field and at the end of a line for the subsequent field.

5.3.6 Cursor Position and Line Compare Registers

The cursor registers contain pixel coordinate information for the cursor. These values are not latched by the timing generator until the start of the frame to avoid tearing artifacts when moving the cursor.

The DC_LINE_CNT/STATUS register contains status information for the current display state, including the current scan line for the display.

5.3.6.1 DC Cursor X Position (DC_CURSOR_X)

DC Memory Offset 60h
Type R/W
Reset Value xxxxxxxxh

This register contains the X position information of the hardware cursor.

DC_CURSOR_X Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD															X_OFFSET						CURSOR_X										

DC_CURSOR_X Bit Descriptions

Bit	Name	Description
31:17	RSVD	**Reserved.** Write as read.
16:11	X_OFFSET	**X Offset.** This field represents the X pixel offset within the 64x64 cursor pattern at which the displayed portion of the cursor is to begin. Normally, this value is set to zero to display the entire cursor pattern, but for cursors for which the "hot spot" is not at the left edge of the pattern, it may be necessary to display the right-most pixels of the cursor only as the cursor moves close to the left edge of the display.
10:0	CURSOR_X	**Cursor X.** This field represents the X coordinate of the pixel at which the upper left corner of the cursor is to be displayed. This value is referenced to the screen origin (0,0) which is the pixel in the upper left corner of the screen.

DC Register Descriptions (Continued)

5.3.6.2 DC Cursor Y Position (DC_CURSOR_Y)

DC Memory Offset 64h
Type R/W
Reset Value xxxxxxxxh

This register contains the Y position information of the hardware cursor.

DC_CURSOR_Y Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD															Y_OFFSET						CURSOR_Y										

DC_CURSOR_Y Bit Descriptions

Bit	Name	Description
31:17	RSVD	**Reserved.** Write as read.
16:11	Y_OFFSET	**Y Offset.** This field represents the Y line offset within the 64x64 cursor pattern at which the displayed portion of the cursor is to begin. Normally, this value is set to zero to display the entire cursor pattern, but for cursors for which the "hot spot" is not at the top edge of the pattern, it may be necessary to display the bottom-most lines of the cursor only as the cursor moves close to the top edge of the display. Note that if this value is non-zero, the DC_CURS_ST_OFFSET must be set to point to the first cursor line to be displayed.
10:0	CURSOR_Y	**Cursor Y.** This field represents the Y coordinate of the line at which the upper left corner of the cursor is to be displayed. This value is referenced to the screen origin (0,0) which is the pixel in the upper left corner of the screen.

5.3.6.3 DC Icon X Position (DC_ICON_X)

DC Memory Offset 68h
Type R/W
Reset Value xxxxxxxxh

This register contains the X position information of the hardware cursor.

DC_ICON_X Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																					ICON_X										

DC_ICON_X Bit Descriptions

Bit	Name	Description
31:11	RSVD	**Reserved.** Write as read.
10:0	ICON_X	**Icon X.** This field represents the X coordinate of the pixel at which the upper left corner of the icon is to be displayed. This value is referenced to the screen origin (0,0) which is the pixel in the upper left corner of the screen. The full pattern of the icon must be displayed.

DC Register Descriptions (Continued)

5.3.6.4 DC Line Count/Status (DC_LINE_CNT/STATUS)

DC Memory Offset 6Ch
Type R
Reset Value xxxxxxxxh

This register contains status information for the current display state, including the current scan line for the display (V_LINE_CNT, bits [26:16]). This portion of the register is read-only and is used by software to time update the frame buffer to avoid tearing artifacts. This scan line value is driven directly off of the DOTCLK, and consequently it is not synchronized with the CPU clock. Software should read this register twice and compare the result to ensure that the value is not transitioning.

This register also contains the line count at which the lower screen begins in a VGA split-screen mode (SS_LINE_CMP). When the internal line counter reaches this value, the frame buffer address is reset to 0. This function is enabled with the SSLC bit in the DC_DISPLAY_CFG register (DC Memory Offset 08h[13]).

Several additional read-only display status bits are provided to allow software to properly time the programming of registers and to detect the source of display-generated interrupts.

DC_LINE_CNT Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DNA	VNA	VSA	VINT	FLIP	V_LINE_CNT											VFLIP	CRCC	RSVD													

DC_LINE_CNT Bit Descriptions

Bit	Name	Description
31	DNA	**Display Not Active (Read Only).** 0: Display active. 1: Display not active (i.e., blanking or border).
30	VNA	**Vertical Not Active (Read Only).** 0: Vertical display active. 1: Vertical display not active (i.e., vertical blanking or border).
29	VSA	**Vertical Sync Active (Read Only).** 0: Vertical sync not active. 1: Vertical sync active.
28	VINT	**Vertical Interrupt (Read Only).** 0: Vertical retrace interrupt not active. 1: Vertical retrace interrupt has been issued. Programming VIEN to 0 (DC Memory Offset 08h[5] = 0) clears the VINT flag.
27	FLIP	**Flip (Read Only).** 0: Newly programmed DC_FB_ST_OFFSET (DC Memory Offset 10h[27:0]) has not been latched by display address generation hardware yet. 1: Previously programmed DC_FB_ST_OFFSET (DC Memory Offset 10h[27:0]) has been latched by display address generation hardware.
26:16	V_LINE_CNT	**Vertical Line Count.** This value is the current scan line of the display.
15	VFLIP	**Video Flip (Read Only).** 0: Newly programmed DC_VID_Y_ST_OFFSET (DC Memory Offset 20h[27:0]) has not been latched by display address generation hardware yet. 1: Previously programmed DC_VID_Y_ST_OFFSET (DC Memory Offset 20h[27:0]) has been latched by display address generation hardware.
14	SIGC	**Signature Complete (Read Only).** A 1 in this bit indicates that the CRC signature operation has completed and the resulting signature value may be safely read by software.
13:0	RSVD	**Reserved.** Write as 0.

DC Register Descriptions (Continued)

5.3.7 Palette Access and RAM Diagnostic Registers

The palette access registers are used for accessing the internal palette RAM and extensions. In addition to the standard 256 entries for color translation, the DC palette has extensions for cursor and icon colors and overscan (border) color.

The RAM diagnostic registers are provided to enable testability of the display FIFO RAM and the compressed line buffer (FIFO) RAM.

5.3.7.1 DC Palette Address (DC_PAL_ADDRESS)

DC Memory Offset 70h
Type R/W
Reset Value xxxxxxxxh

This register should be written with the address (index) location to be used for the next access to the DC_PAL_DATA register (DC Memory Offset 74h[23:0]).

DC_PAL_ADDRESS Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																							PAL_ADDR								

DC_PAL_ADDRESS Bit Descriptions

Bit	Name	Description
31:9	RSVD	**Reserved.** Write as read.
8:0	PAL_ADDR	**PAL Address.** This 9-bit field specifies the address to be used for the next access to the DC_PAL_DATA register (DC Memory Offset 74h[23:0]). Each access to the data register automatically increments the palette address register. If non-sequential access is made to the palette, the address register must be loaded between each non-sequential data block. The address ranges are as follows. **Address** — **Color** 0h - FFh — Standard Palette Colors 100h — Cursor Color 0 101h — Cursor Color 1 102h — Icon Color 0 103h — Icon Color 1 104h — Overscan Color 105h - 1FFh — Not Valid Note that in general, 24-bit values are loaded for all color extensions. However, if 16 BPP mode is active, only the appropriate most significant bits are used (5:5:5 or 5:6:5).

5.3.7.2 DC Palette Data (DC_PAL_DATA)

DC Memory Offset 74h
Type R/W
Reset Value xxxxxxxxh

This register contains the data for a palette access cycle. When a read or write to the palette RAM occurs, the previous output value is held for one additional DOTCLK period. This effect goes unnoticed and provides for sparkle-free update. Prior to a read or write to this register, the DC_PAL_ADDRESS register (DC Memory Offset 70h[8:0] must be loaded with the appropriate address. The address automatically increments after each access to this register, so for sequential access, the address register need only be loaded once.

If the SGRE bit in DC_GENERAL_CFG is set (DC Memory Offset 04h[25] = 1), this register reads back the state of the graphics output pixel stream signature.

DC_PAL_DATA Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								PAL_DATA																							

DC Register Descriptions (Continued)

DC_PAL_DATA Bit Descriptions

Bit	Name	Description
31:24	RSVD	**Reserved.** Write as read.
23:0	PAL_DATA	**PAL Data.** This 24-bit field contains the read or write data for a palette access. If the SGRE bit in DC_GENERAL_CFG is set (DC Memory Offset 04h[25] = 1), a read to this register reads back the state of the graphics output pixel stream signature.

5.3.7.3 DC Display FIFO Diagnostic (DC_DFIFO_DIAG)

DC Memory Offset 78h
Type R/W
Reset Value xxxxxxxxh

This register is provided to enable testability of the display FIFO RAM. Before it is accessed, the DIAG bit in the DC_GENERAL_CFG register should be set high (DC Memory Offset 04h[28] = 1) and the DFLE bit should be set low (DC Memory Offset 04h[0] = 0). Since each FIFO entry is 64 bits, an even number of write operations should be performed. Each pair of write operations causes the FIFO write pointer to increment automatically. After all write operations have been performed, a pair of reads of don't care data must be performed to load 64-bits of data into the output latch. Each subsequent read contains the appropriate data that was previously written. Each pair of read operations causes the FIFO read pointer to increment automatically.

This register is also used for writing to the compressed line buffer. Each pair of writes to this register stores a 64-bit data value that is used for the next write to the compressed line buffer. The write pulse to the compressed line buffer is generated by writing dummy data to the DC_PAL_DATA register (DC Memory Offset 74h[23:0]) while in DIAG mode.

DC_DFIFO_DIAG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DFIFO_DATA																															

DC_DFIFO_DIAG Bit Descriptions

Bit	Name	Description
31:0	DFIFO_DATA	**Display FIFO Diagnostic Read or Write Data**

5.3.7.4 DC Compression FIFO Diagnostic (DC_CFIFO_DIAG)

DC Memory Offset 7Ch
Type R/W
Reset Value xxxxxxxxh

This register is provided to enable testability of the compressed line buffer (FIFO) RAM. Before it is accessed, the DIAG bit in the DC_GENERAL_CFG register should be set high (DC Memory Offset 04h[28] = 1) and the DFLE bit should be set low (DC Memory Offset 04h[0] = 0). Also, the CFRW bit in DC_GENERAL_CFG (DC Memory Offset 04h[29]) should be set appropriately depending on whether a series of reads or writes is to be performed. After each write, the FIFO write pointer automatically increments. After all write operations have been performed, set CFRW high to enable read addresses to the FIFO and then a pair of reads of don't care data must be performed to load 64-bits of data into the output latch. Each subsequent read contains the appropriate data that was previously written. After each pair of reads, the FIFO read pointer automatically increments.

DC_CFIFO_DIAG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CFIFO_DATA																															

DC Register Descriptions (Continued)

DC_CFIFO_DIAG Bit Descriptions

Bit	Name	Description
31:0	CFIFO_DATA	**Compressed Data FIFO Diagnostic Read or Write Data**

5.3.7.5 DC Video Downscaling Delta (DC_VID_DS_DELTA)

DC Memory Offset 80h
Type R/W
Reset Value xxxxxxxxh

These registers control various aspects of the interface within the DC's internal (GeodeLink) interface. One register (DC_VID_DS_DELTA) is provided to allow high-quality downscaling of the video overlay image by selective skipping of source lines. A DDA engine is used to identify lines to be skipped according to the following algorithm:

At vertical retrace:

```
PHASE = 0;                          // clear PHASE initially
skip_flag = 0;                      // never skip the first line
linenum = 0;                        // point to first line
```

For each line of video:

```
send_video_line(linenum);           // send line to graphics companion
linenum++;                          // move on to next line
{skip_flag, PHASE} = PHASE + DELTA; // skip_flag is carry from add
if (skip_flag) linenum++;           // skip a line if flag was set
```

DC_VID_DS_DELTA Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DELTA														RSVD																	

DC_VID_DS_DELTA Bit Descriptions

Bit	Name	Description
31:18	DELTA	**Delta.** A 0.14 fixed-point fraction used as the delta value for the DDA engine that calculates which video lines to skip for video downscaling. This register is enabled when the VDSE bit in DC_GENERAL_CFG is set (DC Memory Offset 04h[19] = 1).
17:0	RSVD	**Reserved.** Write as read.

The value to program into DC_VID_DS_DELTA is calculated as follows:

parameters: DWORD ORIGINAL_LINES = full size image line count
DWORD SCALED_LINES = line count of scaled image

equation: DWORD DC_VID_DS_DELTA = ((ORIGINAL_LINES << 14) / SCALED_LINES) << 18;

Note: The scaling algorithm is only intended to work for ratios from 1 down to 1/2. The equation above clips the value to the 14 bits of accuracy in the hardware.

DC Register Descriptions (Continued)

5.3.8 GLIU Control Registers

These registers control the GeodeLink interface and Dirty/Valid RAM in the Display Controller.

5.3.8.1 GLIU0 Memory Offset Register (GLIU_MEM_OFFSET)

DC Memory Offset 84h
Type R/W
Reset Value 00000000h

This register controls the Write Protect feature for the palette. The value in this register is added to all outgoing memory addresses. Because the base address must be aligned to a 16 MB region, only bits [31:24} of this register are used.

GLIU0_MEM_OFFSET Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GLIU(MBUS)_MEM_OFFSET								RSVD													DV_RAM_AD										

Table 5-13. GLIU0_MEM_OFFSET Bit Descriptions

Bit	Name	Description
31:24	GLIU_MEM_ OFFSET	**GLIU Memory Offset.** Base address (16 MB aligned) for the graphics memory region. This value is added to all outgoing memory addresses.
23:11	RSVD	**Reserved.** Write as 0.
10:0	DV_RAM_AD	**DV RAM Address.** This value is used to allow direct software access to the Dirty/Valid (DV) RAM. The address must be written in this location before reading or writing the DV RAM Access Register (DC Memory Offset 8Ch).

5.3.8.2 Dirty/Valid RAM Access Register (DV_ACC)

DC Memory Offset 8Ch
Type R/W
Reset Value xxxxxxxxh

DV_ACCESS Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														DV_DIRTY	DV_VALID

DV_ACCESS Bit Descriptions

Bit	Name	Description
31:2	RSVD	**Reserved.** Write as 0.
1	DV_DIRTY	**D/V Dirty.** Writes to this register place the value of this bit into the “dirty” entry of the dirty/valid RAM. Reads return the value of the “dirty” entry. The D/V RAM Address is determined by the value in bits [10:0] in the GLIU0 Memory Offset register (GLIU MEM_OFFSET), DC Memory Offset 84h).
0	DV_VALID	**D/V Valid.** Writes to this register place the value of this bit into the “valid” entry of the dirty/valid RAM. Reads return the value of the “valid” entry. The D/V RAM Address is determined by the value in bits [10:0] in the GLIU0 Memory Offset register (GLIU MEM_OFFSET), DC Memory Offset 84h).

DC Register Descriptions (Continued)

5.3.9 VGA Unit Configuration Registers

5.3.9.1 VGA Configuration Register (VGA_CONFIG)

DC Memory Offset 100h
Type R/W
Reset Value 00000000h

This register enables writes to the palette.

VGA_CONFIG Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																												DOT_FREQ		RSVD	WPPAL

VGA_CONFIG Bit Descriptions

Bit	Name	Description
31:4	RSVD	**Reserved.** Write as 0.
3:2	DOT_FREQ	In standard VGA implementations, this field controls the DOTCLK rate. This functionality is not supported in GX2. However, this field can be read and written to.
1	RSVD	**Reserved.** Write as 0.
0	WPPAL	**Write Protect Palette.** If set to 1, VGA palette write operations are NOT written to the palette RAMs. Palette writes behave normally, except that the data is discarded.

5.3.9.2 Reserved (RSVD)

DC Memory Offset 104h
Type RO
Reset Value 00000000h

This register is reserved for National internal use only.

VGA_STATUS Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

VGA_STATUS Bit Descriptions

Bit	Name	Description
31:0	RSVD	**Reserved.** Reads as 0.

5.3.9.3 VGA Extended Start Offset Register

DC Memory Offset 108h
Type RW
Reset Value 00000000h

VGA_STATUS Register Map

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved																										Extended Start Address					

VGA_STATUS Bit Descriptions

Bit	Name	Description
31:6	RSVD	**Reserved.** Write as 0.
5:0	Extended Start Address	**Start Address Register Bits [21:16].** These bits extend the VGA start address to 22 bits. Bits [15:8] are in Start Address Hi, and bits [7:0] are in Start Address Lo.

5.3.10 VGA Unit Standard Registers

5.3.10.1 Miscellaneous Output Register

Read Address 3CCh
Write Address 3C2h
Type R/W
Reset Value 02h

Miscellaneous Output Register Bit Descriptions

Bit	Name	Description
7	VSYNC_POL	**Vertical Sync Polarity.** VSYNC pulse detection selection. 0: Positive. 1: Negative.
6	HSYNC_POL	**Horizontal Sync Polarity.** HSYNC pulse detection selection. 0: Positive. 1: Negative.
5	PAGE	**Page Bit.** This bit is used to replace memory address bit A0 as the LSB when bit 1 of the graphics controller Miscellaneous register (GC Index 06h) is set to 1.
4	RSVD	**Reserved**
3:2	CLK_SEL	****Not Implemented**** (Clock Select)
1	RAM_EN	**RAM Enable.** Enables the video frame buffer address decode when set to 1.
0	ID_ADDR_SEL	**I/O Address Select.** Determines the I/O address of the CRTC Index and Data registers (CRTC Index 3?4h and 3?5h, see Section 5.3.12.1 and Section 5.3.12.2 on page 254), Feature Control register (Address 3?Ah, see Section 5.3.10.4 on page 247), and Input Status Register 1 (Address 3?Ah, see Section 5.3.10.3 on page 247) as follows: 0: ? translates to B (MDA I/O address emulation). 1: ? translates to D (CGA address emulation).

5.3.10.2 Input Status Register 0

Read Address 3C2h
Write Address --
Type R/W
Reset Value 00h

Input Status Register 0 Bit Descriptions

Bit	Name	Description
7	CRTC_INT	****Not Implemented**** (CRTC Interrupt Pending)
6:5	RSVD	**Reserved.** Reads as 0.
4	DISP_SEN	****Not Implemented**** (Display Sense)

DC Register Descriptions (Continued)

Input Status Register 0 Bit Descriptions (Continued)

Bit	Name	Description
3:0	RSVD	**Reserved.** Reads as 0.

5.3.10.3 Input Status Register 1

Read Address 3BAh or 3DAh
Write Address --
Type R/W
Reset Value 01h

Input Status Register 1 Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Reads as 0.
3	VSYNC	**Vertical SYNC.** When a 1, indicates that the VSYNC signal is active.
2:1	RSVD	**Reserved.** Reads as 0.
0	DISP_EN	**Display Enable.** Reads as a 0 when both horizontal and vertical display enable are active. Reads as a 1 when either display enable signal is inactive.

5.3.10.4 Feature Control Register

Read Address 3CAh
Write Address 3BAh or 3DAh
Type R/W
Reset Value xxh

Feature Control Register Bit Descriptions

Bit	Name	Description
7:2	RSVD	**Reserved.** Write as read.
1:0	FC	****Not Implemented**** (Feature Controls)

DC Register Descriptions (Continued)

5.3.11 VGA Sequencer Registers

Index Register Address: 3C4h
Data Register Address: 3C5h

The Sequencer registers are accessed by writing an index value to the Sequencer Index register (3C4h) and reading or writing the register using the Sequencer Data register (3C5h).

Table 5-14. VGA Sequencer Registers Summary

SQ Index	Type	Register	Reset Value	Reference
--	R/W	Sequencer Index	0xh	Page 248
--	R/W	Sequencer Data	xxh	Page 248
00h	R/W	Reset	00h	Page 249
01h	R/W	Clocking Mode	02h	Page 249
02h	R/W	Map Mask	00h	Page 249
03h	R/W	Character Map Select	xxh	Page 250
04h	R/W	Memory Mode	02h	Page 251

5.3.11.1 Sequencer Index

Index Address 3C4h
Type R/W
Reset Value 0xh

Sequencer Index Register Bit Descriptions

Bit	Name	Description
7:3	RSVD	**Reserved.** Write as read.
2:0	INDEX	**Index**

5.3.11.2 Sequencer Data

Data Address 3C5h
Type R/W
Reset Value xxh

Sequencer Data Register Bit Descriptions

Bit	Name	Description
7:0	DATA	**Data**

DC Register Descriptions (Continued)

5.3.11.3 Reset

SQ Index 00h
Type R/W
Reset Value 00h

Reset Register Bit Descriptions

Bit	Name	Description
7:2	RSVD	**Reserved.** Write as read.
1:0	SEQ_RESET	**Enable Display.** Both these bits should be set to 1 (value = 11) to enable display of the VGA screen image. If either of these bits are 0, the display is blanked. The VGA continues to respond to I/O and memory accesses.

5.3.11.4 Clocking Mode

SQ Index 01h
Type R/W
Reset Value 02h

Clocking Mode Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5	SCREEN_OFF	**Screen Off.** Setting this bit to a 1 blanks the screen while maintaining the HSYNC and VSYNC signals. This is intended to allow the CPU full access to the memory bandwidth. This bit must be 0 for the display image to be visible.
4	SHFT_4	****Not Supported **** (Shift4) Write as read.
3	DCLK_DIV2	**DOTCLK by 2.** When set to 1, the incoming pixel clock is divided by 2 to form the actual DOTCLK. When 0, the incoming pixel clock is used unchanged.
2	SHFT_LD	****Not Supported**** (Shift Load) Write as read.
1	RSVD	****Not Supported**** - Always returns 1 when read.
0	CHAR_WIDTH	**8-Dot Character Width.** When set to a 1, the character cells in text mode are eight pixels wide. When set to 0, the character cells are nine pixels wide. The 9th pixel is equal to the 8th pixel for character codes C0h-DFh (the line graphics character codes), and is 0 (background) for all other codes.

5.3.11.5 Map Mask

SQ Index 02h
Type R/W
Reset Value 00h

The bits in this register enable writing to their corresponding bytes in each DWORD of the frame buffer (i.e., EM3 enables byte 3, EM2 enables byte 2, etc.). The four maps or planes correspond to the four bytes in each DWORD of the frame buffer. Reads to all maps are always enabled, and are unaffected by these bits.

Map Mask Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3	EM3	**Enable Map 3.** Allow writes to byte 3 in each DWORD of the frame buffer. 0: Disable. 1: Enable.

Map Mask Register Bit Descriptions (Continued)

Bit	Name	Description
2	EM2	**Enable Map 2.** Allow writes to byte 2 in each DWORD of the frame buffer. 0: Disable. 1: Enable.
1	EM1	**Enable Map 1.** Allow writes to byte 1 in each DWORD of the frame buffer. 0: Disable. 1: Enable.
0	EM0	**Enable Map 0.** Allow writes to byte 0 in each DWORD of the frame buffer. 0: Disable. 1: Enable.

5.3.11.6 Character Map Select

SQ Index 03h
Type R/W
Reset Value xxh

These fields determine which font tables (stored in the 64 kB in Map 2) are used when displaying a character in text mode. When the character's attribute byte bit 3 = 1, Character Map A is used. When the character's attribute byte bit 3 = 0, Character Map B is used.

Table 5-15. Character Map Select Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5	CHAR_AZ	**Character Map A bit 2**
4	CHAR_BZ	**Character Map B bit 2**
3:2	CHAR_A	**Character Map A bits 1:0**
1:0	CHAR_B	**Character Map B bits 1:0**

Table 5-16. Font Table

Code	Font Table Location in Map 2
0	8 kB Block 0
1	8 kB Block 2
2	8 kB Block 4
3	8 kB Block 6
4	8 kB Block 1
5	8 kB Block 3
6	8 kB Block 5
7	8 kB Block 7

DC Register Descriptions (Continued)

5.3.11.7 Memory Mode

SQ Index 04h
Type R/W
Reset Value 02h

Memory Mode Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3	CHAIN4	**Chain4.** When set to a 1, CPU address bits 1 and 0 are used to select the map or plane in the frame buffer DWORD. For example if CPU A1:A0 = 3, then Map 3 is selected. If CPU A1:A0 = 1, then Map 1 is selected. If Chain4 is 0, then the frame buffer addressing is controlled by the Chain2 bit.
2	CHAIN2	**Chain2.** When set to a 0, CPU address bit 0 selects between frame buffer Maps 0 and 1, or Maps 2 and 3 depending on the value in the graphics controller Read Map Select field (GC Index 04h[1:0]). For example, if CPU A0 is 0, then Map 0 (or 2) is selected.
1	EXT_MEM	**Extended Memory.** This bit should always be set to a 1. It is a throwback to EGA where the standard frame buffer size was 64 kB and was upgradeable to 256 kB. The VGA always has (at least) 256 kB.
0	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

5.3.12 VGA CRT Controller Registers

Index Register Address: 3B4h or 3D4h
Data Register Address: 3B5h or 3D5h

The CRTC registers are accessed by writing an index value to the CRTC Index register (Address 3B4h or 3D4h) and reading or writing the register using the CRTC Data Register (Address 3B5h or 3D5h). See the description of the I/O Address Select bit (bit 0) in the Miscellaneous Output register (Section 5.3.10.1 on page 246) for more information on the I/O address of the CRTC registers.

Table 5-17. CRTC Register Settings

	VGA Mode														
Index	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**0D**	**0E**	**0F**	**10**	**11**	**12**	**13**
0	2D	2D	5F	5F	2D	2D	5F	5F	2D	5F	5F	5F	5F	5F	5F
1	27	27	4F	4F	27	27	4F	4F	27	4F	4F	4F	4F	4F	4F
2	28	28	50	50	28	28	50	50	28	50	50	50	50	50	50
3	90	90	82	82	90	90	82	82	90	82	82	82	82	82	82
4	29	29	51	51	29	29	51	51	29	51	51	51	51	51	51
5	8E	8E	9E	9E	8E	8E	9E	9E	8E	9E	9E	9E	9E	9E	9E
6	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	0B	0B	BF
7	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	3E	3E	1F
8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
9	4F	4F	4F	4F	C1	C1	C1	4F	C0	C0	40	40	40	40	41
A	0D	0D	0D	0D	00	00	00	0D	00	00	00	00	00	00	00
B	0E	0E	0E	0E	00	00	00	0E	00	00	00	00	00	00	00
C	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
D	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
10	9B	9B	9B	9B	9B	9B	9B	9B	9B	9B	83	83	E9	E9	9B
11	8D	8D	8D	8D	8D	8D	8D	8D	8D	8D	85	85	8B	8B	8D
12	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	5D	5D	DF	DF	8F
13	14	14	28	28	14	14	28	28	14	28	28	28	28	28	28
14	1F	1F	1F	1F	00	00	00	0F	00	00	0F	0F	00	00	40
15	97	97	97	97	97	97	97	97	97	97	65	65	E7	E7	98
16	B9	B9	B9	B9	B9	B9	B9	B9	B9	B9	B9	B9	04	04	B9
17	A3	A3	A3	A3	A2	A2	C2	A3	E3	E3	E3	E3	C3	E3	A3
18	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Note: The Extended VGA Registers are accessed through the CRTC interface. However, this section only discusses the base VGA registers. See Section 5.3.16 "VGA Unit Extended Registers" on page 277 for more information on the extended registers.

DC Register Descriptions (Continued)

Table 5-18. CRTC Registers Summary

CRTC Index	Type	Register	Reset Value	Reference
--	R/W	CRTC Index Register	00h	Page 254
--	R/W	CRTC Data Register	00h	Page 254
00h	R/W	Horizontal Total	00h	Page 254
01h	R/W	Horizontal Display Enable End	00h	Page 254
02h	R/W	Horizontal Blank Start	00h	Page 255
03h	R/W	Horizontal Blank End	00h	Page 255
04h	R/W	Horizontal Sync Start	00h	Page 255
05h	R/W	Horizontal Sync End	00h	Page 256
06h	R/W	Vertical Total	00h	Page 256
07h	R/W	Overflow	xxh	Page 256
08h	R/W	Preset Row Scan	00h	Page 257
09h	R/W	Maximum Scan Line	00h	Page 257
0Ah	R/W	Cursor Start	00h	Page 258
0Bh	R/W	Cursor End	00h	Page 258
0Ch	R/W	Start Address High	00h	Page 258
0Dh	R/W	Start Address Low	00h	Page 259
0Eh	R/W	Cursor Location High	00h	Page 259
0Fh	R/W	Cursor Location Low	00h	Page 259
10h	R/W	Vertical Sync Start	00h	Page 259
11h	R/W	Vertical Sync End	00h	Page 260
12h	R/W	Vertical Display Enable End	00h	Page 260
13h	R/W	Offset	00h	Page 260
14h	R/W	Underline Location	00h	Page 261
15h	R/W	Vertical Blank Start	00h	Page 261
16h	R/W	Vertical Blank End	00h	Page 261
17h	R/W	CRTC Mode Control	00h	Page 262
18h	R/W	Line Compare	00h	Page 263
22h	R/W	CPU Data Latch State	00h	Page 264
24h	R/W	Attribute Index/Data FF State	00h	Page 264
26h	R/W	Attribute Index State	xxh	Page 264

DC Register Descriptions (Continued)

5.3.12.1 CRTC Index Register

Index Address 3B4h or 3D4h
Type R/W
Reset Value 00h

CRTC Index Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved.** Write as read.
6:0	INDEX	**Index**

5.3.12.2 CRTC Data Register

Data Address 3B5h or 3D5h
Type R/W
Reset Value 00h

CRTC Data Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved.** Write as read.
6:0	DATA	**Data**

5.3.12.3 Horizontal Total

CRTC Index 00h
Type R/W
Reset Value 00h

Horizontal Total Register Bit Descriptions

Bit	Name	Description
7:0	H_TOTAL	**Horizontal Total.** This value specifies the number of character clocks per horizontal scan line minus 5. It determines the horizontal line rate/period.

5.3.12.4 Horizontal Display Enable End

CRTC Index 01h
Type R/W
Reset Value 00h

Horizontal Display Enable End Register Bit Descriptions

Bit	Name	Description
7:0	H_DISP_END	**Horizontal Display Enable End.** This value specifies the number of displayed characters minus 1. It determines the width of the (internal) horizontal display enable signal.

DC Register Descriptions (Continued)

5.3.12.5 Horizontal Blank Start

CRTC Index 02h
Type R/W
Reset Value 00h

Horizontal Blank Start Register Bit Descriptions

Bit	Name	Description
7:0	H_BLANK_ST	**Horizontal Blank Start.** This value specifies the character position on the line where the (internal) horizontal blanking signal goes active.

5.3.12.6 Horizontal Blank End

CRTC Index 03h
Type R/W
Reset Value 00h

Horizontal Blank End Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved.** Set to 1.
6:5	DISPEN_SKEW	**Display Enable Skew Control.** This value is a binary encoded value that specifies how many character clocks to skew the (internal) horizontal display enable signal by (0 character clocks - 3 character clocks) before it is sent to the attribute controller. This field is used to accommodate differences in the length of the video pipeline (frame buffer to pixel output) in various text and graphics modes. 00: 0 character clock. 01: 1 character clock. 01: 2 character clocks. 11: 3 character clocks.
4:0	H_BLANK_END	**Horizontal Blank End Register Bits [4:0].** This 6-bit value is a compare target for the character count where the (internal) horizontal blank signal ends. Bit 5 of this value is in the Horizontal Sync End Register (CRTC Index 05h[7]). Note that not all horizontal counter bits are compared, which can create aliased compares depending upon the binary values involved in the count range and compare values.

5.3.12.7 Horizontal Sync Start

CRTC Index 04h
Type R/W
Reset Value 00h

Horizontal Sync Start Register Bit Descriptions

Bit	Name	Description
7:0	H_SYNC_ST	**Horizontal Sync Start.** This value specifies the character position where the horizontal sync (HSYNC) signal starts.

DC Register Descriptions (Continued)

5.3.12.8 Horizontal Sync End

CRTC Index 05h
Type R/W
Reset Value 00h

Horizontal Sync End Register Bit Descriptions

Bit	Name	Description
7	H_BLANK_ END5	**Horizontal Blank End Bit 5.** See the description of the Horizontal Blank End Register (CRTC Index 03h), Section 5.3.12.6 on page 255.
6:5	H_SYNC_DLY	****Not Implemented**** (HSync Delay) (Write as read.)
4:0	H_SYNC_END	**Horizontal Sync End.** These bits represent the low 5 bits of the character position where the Horizontal Sync (HSYNC) signal ends.

5.3.12.9 Vertical Total

CRTC Index 06h
Type R/W
Reset Value 00h

Vertical Total Register Bit Descriptions

Bit	Name	Description
7:0	V_TOTAL	**Vertical Total Register Bits [7:0].** These bits represent the low 8 bits of a value that specifies the total number of scan lines on the screen minus 2. This value includes the blanking area and determines the vertical refresh rate. The high 2 bits of this value are in the Overflow register (CRTC Index 07h[5,0]).

5.3.12.10 Overflow

CRTC Index 07h
Type R/W
Reset Value xxh

These are the high-order bits for several of the vertical programming values.

Overflow Register Bit Descriptions

Bit	Name	Description
7	V_SYNC_ST9	**Vertical Sync Start Bit 9.** See Section 5.3.12.19 "Vertical Sync Start" on page 259.
6	V_DISP_END9	**Vertical Display Enable End Bit 9.** See Section 5.3.12.21 "Vertical Display Enable End" on page 260.
5	V_TOT9	**Vertical Total Bit 9.** See Section 5.3.12.9 "Vertical Total" on page 256.
4	LINE_COMP8	**Line Compare Bit 8.** See Section 5.3.12.27 "Line Compare" on page 263.
3	V_BLANK_ST8	**Vertical Blank Start Bit 8.** See Section 5.3.12.24 "Vertical Blank Start" on page 261.
2	V_SYNC_ST8	**Vertical Sync Start Bit 8.** See Section 5.3.12.19 "Vertical Sync Start" on page 259.
1	V_DISP_EN_ END8	**Vertical Display Enable End Bit 8.** See Section 5.3.12.21 "Vertical Display Enable End" on page 260.
0	V_TOTAL8	**Vertical Total Bit 8.** See Section 5.3.12.9 "Vertical Total" on page 256.

DC Register Descriptions (Continued)

5.3.12.11 Preset Row Scan

CRTC Index 08h
Type R/W
Reset Value 00h

Preset Row Scan Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved**
6:5	BYPE_PAN	**Byte Panning.** This value causes the pixel data stream to be fetched 0, 1, 2, or 3 character positions early for use with pel panning in the attribute controller (see Section 5.3.14.6 "Horizontal Pel Panning" on page 273). This field is used when the video serializers are chained together (by 2 or by 4) (see Section 5.3.11.7 "Memory Mode" on page 251). 00: 0 character positions. 01: 1 character positions. 10: 2 character positions. 11: 3 character positions.
4:0	ROW_SCAN	**Starting Row Scan.** This specifies the value loaded into the row scan counter on the first text line of the screen. Changing this value in text modes allows the screen to be scrolled on a scan line basis rather than a text line basis. The starting row scan count for all subsequent scan lines is 0.

5.3.12.12 Maximum Scan Line

CRTC Index 09h
Type R/W
Reset Value 00h

Maximum Scan Line Register Bit Descriptions

Bit	Name	Description
7	DBL_SCAN	**Double Scan.** When this bit is set to a 1, the row scan counter increments every other scan line. When this bit is cleared to 0, the row scan counter increments on every scan line. This bit is used to make 200 line text modes occupy 400 physical scan lines on the screen.
6	LN_CMP9	**Line Compare Register Bit 9.** See Section 5.3.12.27 "Line Compare" on page 263.
5	V_BLANK_ST9	**Vertical Blank Start Register Bit 9.** See Section 5.3.12.24 "Vertical Blank Start" on page 261.
4:0	MAX_LINE	**Maximum Scan Line.** This field specifies the number of scan lines per character row minus 1. The row scan counter counts up to this value then goes to 0 for the next character row.

DC Register Descriptions (Continued)

5.3.12.13 Cursor Start

CRTC Index 0Ah
Type R/W
Reset Value 00h

Cursor Start Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved**
5	CURS_OFF	**Cursor Off.** When set to 1, the cursor is turned off and does not appear on the screen. When this bit is 0, the cursor is displayed. This bit is only applicable in text modes.
4:0	CURS_ST	**Cursor Start.** This field specifies the first scan line in the character box where the cursor is displayed. If this value is greater than the Cursor End value (CRTC Index 0Bh[4:0]), then no cursor is displayed. If this value is equal to the Cursor End value, then the cursor occupies a single scan line.

5.3.12.14 Cursor End

CRTC Index 0Bh
Type R/W
Reset Value 00h

Cursor End Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved**
6:5	CURS_SKEW	**Cursor Skew.** This field allows the cursor to be skewed by 0, 1, 2, or 3 character positions to the right. 00: 0 character positions. 01: 1 character positions. 01: 2 character positions. 11: 3 character positions.
4:0	CURS_END	**Cursor End.** This field specifies the last scan line in the character box where the cursor is displayed. See the description of the Cursor Start field (CRTC Index 0Ah[4:0]) for more information.

5.3.12.15 Start Address High

CRTC Index 0Ch
Type R/W
Reset Value 00h

Start Address High Register Bit Descriptions

Bit	Name	Description
7:0	ST_ADDR_HI	**Start Address Register Bits [15:8].** Together with the Start Address Low register (CRTC Index 0Dh), this value specifies the frame buffer address used at the beginning of a screen refresh. It represents the upper left corner of the screen.

DC Register Descriptions (Continued)

5.3.12.16 Start Address Low

CRTC Index 0Dh
Type R/W
Reset Value 00h

Start Address Low Register Bit Descriptions

Bit	Name	Description
7:0	ST_ADDR_ LOW	**Start Address Register Bits [7:0].** Together with the Start Address High register (CRTC Index 0Ch), this value specifies the frame buffer address used at the beginning of a screen refresh. It represents the upper left corner of the screen.

5.3.12.17 Cursor Location High

CRTC Index 0Eh
Type R/W
Reset Value 00h

Cursor Location High Register Bit Descriptions

Bit	Name	Description
7:0	CURS_HI	**Cursor Location Register Bits [15:8].** Together with the Cursor Location Low register (CRTC Index 0Fh), this value specifies the frame buffer address where the cursor is displayed in text mode. The cursor appears at the character whose memory address corresponds to this value.

5.3.12.18 Cursor Location Low

CRTC Index 0Fh
Type R/W
Reset Value 00h

Cursor Location Low Register Bit Descriptions

Bit	Name	Description
7:0	CURS_LOW	**Cursor Location Register Bits [7:0].** Together with the Cursor Location High register (CRTC Index 0Eh), this value specifies the frame buffer address where the cursor is displayed in text mode. The cursor appears at the character whose memory address corresponds to this value.

5.3.12.19 Vertical Sync Start

CRTC Index 10h
Type R/W
Reset Value 00h

Vertical Sync Start Register Bit Descriptions

Bit	Name	Description
7:0	VERT_SYNC_ ST	**Vertical Sync Start Register Bits [7:0].** This value specifies the scan line number where the vertical sync signal goes active. This is a 10-bit value. Bits 9 and 8 are in the Overflow register (CRTC Index 07h[7,2]), see Section 5.3.12.10 "Overflow" on page 256.

DC Register Descriptions (Continued)

5.3.12.20 Vertical Sync End

CRTC Index 11h
Type R/W
Reset Value 00h

Vertical Sync End Register Bit Descriptions

Bit	Name	Description
7	WR_PROT	**Write-Protect Registers [7:0].** This bit is used to prevent old EGA programs from writing invalid values to the VGA horizontal timing registers. The Line Compare bit in the Overflow register (CRTC Index 07h[4]) is not protected by this bit.
6	REF_CYC	****Not Implemented**** (Refresh Cycle Select) (Write as read.)
5	EN_VI	****Not Implemented**** (Enable Vertical Interrupt) (Write as read.)
4	CLR_VI	****Not Implemented**** (Clear Vertical Interrupt) (Write as read.)
3:0	VERT_SYNC_ END	**Vertical Sync End Register Bits [3:0]**. This field represents the low 4 bits of a compare value that specifies which scan line that the vertical sync signal goes inactive.

5.3.12.21 Vertical Display Enable End

CRTC Index 12h
Type R/W
Reset Value 00h

Vertical Display Enable End Register Bit Descriptions

Bit	Name	Description
7:0	VERT_DISP_ EN_END	**Vertical Display Enable End Register Bits [7:0]**. This is a 10-bit value that specifies the scan line where the vertical display enable signal goes inactive. It represents the number of active scan lines minus 1. Bits 9 and 8 of this value are in the Overflow register (CRTC Index 07h[6,1]), see Section 5.3.12.10 "Overflow" on page 256.

5.3.12.22 Offset

CRTC Index 13h
Type R/W
Reset Value 00h

Offset Register Bit Descriptions

Bits	Name	Description
7:0	OFST	**Offset.** This field specifies the logical line with of the screen. This value (multiplied by two or four depending on the CRTC clocking mode is added to the starting address of the current scan line to get the starting address of the next scan line. CRTC Clocking Mode is programmed in the Sequencer's Clocking Mode register, described in Section 5.3.11.4 “Clocking Mode” on page 249. The bit in question is bit 3 of that register (DOTCLK by two).

DC Register Descriptions (Continued)

5.3.12.23 Underline Location

CRTC Index 14h
Type R/W
Reset Value 00h

Underline Location Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved.** Write as read.
6	DW	**Doubleword Mode.** When this bit is a 1, CRTC memory addresses are DWORD addresses, and the CRTC refresh counter effectively increments by 4. When this bit is a 0, the address increment is determined by the Byte Mode bit in the CRTC Mode Control register (CRTC Index 17h[6]), see Section 5.3.12.26 "CRTC Mode Control" on page 262.
5	CNT_4	****Not Implemented**** (Count by 4) (Write as read.)
4:0	UNDL_LOC	**Underline Location.** This field specifies the row scan value where the underline appears in the character box in text modes.

5.3.12.24 Vertical Blank Start

CRTC Index 15h
Type R/W
Reset Value 00h

Vertical Blank Start Register Bit Descriptions

Bit	Name	Description
7:0	VER_BL_STR	**Vertical Blank Start Register Bits [7:0].** These bits represents the low 8 bits of a value that specifies the starting scan line of the vertical blank signal. This is a 10-bit value. Bit 8 is in the Overflow register (CRTC Index 07h[3]), see Section 5.3.12.10 "Overflow" on page 256. Bit 9 is in the Maximum Scan Line register (CRTC Index 09h[5]), see Section 5.3.12.12 "Maximum Scan Line" on page 257.

5.3.12.25 Vertical Blank End

CRTC Index 16h
Type R/W
Reset Value 00h

Vertical Blank End Register Bit Descriptions

Bit	Name	Description
7:0	VER_BL_END	**Vertical Blank End.** This value specifies the low 8 bits of a compare value that represents the scan line where the vertical blank signal goes inactive.

DC Register Descriptions (Continued)

5.3.12.26 CRTC Mode Control

CRTC Index 17h
Type R/W
Reset Value 00h

CRTC Mode Control Register Bit Descriptions

Bit	Name	Description
7	ENSYNC	**Enable Syncs.** When set to 1, this bit enables the horizontal and vertical sync (HSYNC and VSYNC) signals. When 0, this bit holds both sync flip-flops reset.
6	BTMD	**Byte Mode.** If the Doubleword Mode bit in the Underline Location register (CRTC Index 14h[6]) is 0, then this bit configures the CRTC addresses for byte addresses (Byte Mode = 1) or word addresses (Byte Mode = 0). If the Doubleword Mode bit is a 1, then the Byte Mode bit is ignored. See Table 5-19 on page 263 for more information on the various CRTC addressing modes.
5	AW	**Address Wrap.** When the CRTC is addressing the frame buffer in Word Mode (Byte Mode = 0 (bit 6), Doubleword Mode = 0 (CRTC Index 14h[6])) then this bit determines which address bit occupies the MA0 bit position of the address sent to the frame buffer memory. If Address Wrap = 0, CRTC address counter bit 13 occupies the MA0 position. If Address Wrap = 1, then CRTC address counter bit 15 is in the MA0 position. See Table 5-19 on page 263 for more information on the various CRTC addressing modes.
4	RSVD	**Reserved.** Write as read.
3	RSVD	****Not Implemented**** (Count by 2) (Write as read.)
2	VCKL_SL	**VCLK Select.** This bit determines the clocking for the vertical portion of the CRTC. If this bit is 0, the horizontal sync signal clocks the vertical section. If this bit is 1, the horizontal sync divided by 2 clocks the vertical section.
1	SL_RSCBT	**Select Row Scan Bit.** This bit determines which CRTC signal appears on the MA14 address bit sent to the frame buffer memory. If this bit is a 0, bit 1 of the Row Scan counter appears on MA14. If this bit is a 1, then CRTC address counter bit 14, 13, or 12 appears on MA14. See Table 5-19 on page 263 for more information.
0	SL_A13	**Select A13.** This bit determines which CRTC signal appears on the MA13 address bit sent to the frame buffer memory. If this bit is a 0, bit 0 of the Row Scan counter appears on MA13. If this bit is a 1, then CRTC address counter bit 13, 12, or 11 appear on MA13. See Table 5-19 on page 263 for more information.

Table 5-19 illustrates the various frame buffer addressing schemes. In the table, MA[x] represents the frame buffer memory address signals, A[x] represents the CRTC address counter signals, RS[x] represents row scan counter output bits. The binary value in the column headings is a concatenation of the Doubleword Mode and Byte Mode bits. (i.e. {Doubleword-Mode, ByteMode} in verilog.)

Table 5-19. CRTC Memory Addressing Modes

Frame Buffer Memory Address Bit	BYTE Mode (01)	WORD Mode (00)	DWORD Mode (1X)
MA0	A0	A15 or A13	A12
MA1	A1	A0	A13
MA2	A2	A1	A0
MA3	A3	A2	A1
MA4	A4	A3	A2
MA5	A5	A4	A3
MA6	A6	A5	A4
MA7	A7	A6	A5
MA8	A8	A7	A6
MA9	A9	A8	A7
MA10	A10	A9	A8
MA11	A11	A10	A9
MA12	A12	A11	A10
MA13	A13 or RS0	A12 or RS0	A11 or RS0
MA14	A14 or RS1	A13 or RS1	A12 or RS1
MA15	A15	A14	A13

5.3.12.27 Line Compare

CRTC Index 18h
Type R/W
Reset Value 00h

Line Compare Register Bit Descriptions

Bit	Name	Description
7:0	LCRBT	**Line Compare Register Bits [7:0].** This value specifies the low 8 bits of a compare value that represents the scan line where the CRTC frame buffer address counter is reset to 0. This can be used to create a split screen by using the Start Address registers (CRTC Index 0Ch and 0Dh) to specify a non-zero location at which to begin the screen image. The lower portion of the screen (starting at frame buffer address 0) is immune to screen scrolling and pel panning as specified in the Attribute Mode Control register (AC Index 10h[5]). Line Compare is a 10-bit value. Bit 8 is located in the Overflow register (CRTC Index 07h[4], see Section 5.3.12.10 "Overflow" on page 256) and bit 9 is in the Maximum Scan Line register (CRTC Index 09h[6], see Section 5.3.12.12 "Maximum Scan Line" on page 257).

DC Register Descriptions (Continued)

5.3.12.28 CPU Data Latch State

CRTC Index 22h
Type R/W
Reset Value 00h

CPU Data Latch Register Bit Descriptions

Bit	Name	Description
7:0	DLV	**Data Latch Value.** This read-only field returns a byte of the CPU data latches and can be used in VGA save/restore operations. The graphics controller's Read Map Select field (GC Index 04h[1:0], see Section 5.3.13.7 "Read Map Select" on page 268) specifies which byte/map (0-3) is returned.

5.3.12.29 Attribute Index/Data FF State

CRTC Index 24h
Type R/W
Reset Value 00h

Attribute Index/Data FF State Register Bit Descriptions

Bit	Name	Description
7	FFST	**FF State.** This read-only bit indicates the state of the Attribute Controller Index/Data flip-flop. When this bit is 0, the next write to Address 3C0h writes an index value, when this bit is 1, the next write to Address 3C0h writes a data register value.
6:0	RSVD	**Reserved.** Write as read.

5.3.12.30 Attribute Index State

CRTC Index 26h
Type R/W
Reset Value xxh

Attribute Index State Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5:0	ATT_IN_VA (RO)	**Attribute Index Value.** This read-only value indicates the value of Attribute Controller Index/Data register bits [5:0] (Address 3C0h, see Section 5.3.14.1 "Attribute Controller Index/Data" on page 271).

DC Register Descriptions (Continued)

5.3.13 VGA Graphics Controller Registers

The VGA Graphics Controller registers are accessed by writing an index value to the Graphics Controller Index register (3CEh) and reading or writing the register using the Graphics Controller Data register (3CFh).

Table 5-20. VGA Graphics Controller Registers Summary

GC Index	Type	Register	Reset Value	Reference
--	R/W	Graphics Controller Index	xxh	Page 265
--	R/W	Graphics Controller Data	xxh	Page 265
00h	R/W	Set/Reset	xxh	Page 266
01h	R/W	Enable Set/Reset	xxh	Page 266
02h	R/W	Color Compare	xxh	Page 267
03h	R/W	Data Rotate	xxh	Page 267
04h	R/W	Read Map Select	xxh	Page 268
05h	R/W	Graphics Mode	xxh	Page 268
06h	R/W	Miscellaneous	xxh	Page 269
07h	R/W	Color Don't Care	xxh	Page 270
08h	R/W	Bit Mask	xxh	Page 270

5.3.13.1 Graphics Controller Index

Index Address 3CEh
Type R/W
Reset Value xxh

Graphics Controller Index Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3:0	INDEX	**Index**

5.3.13.2 Graphics Controller Data

Data Address 3CFh
Type R/W
Reset Value xxh

Graphics Controller Data Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3:0	DATA	**Data**

DC Register Descriptions (Continued)

5.3.13.3 Set/Reset

GC Index 00h
Type R/W
Reset Value xxh

Bits[3:0] allow bits in their respective maps to be set or reset through WriteMode0 or WriteMode3.

Set/Reset Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved**
3	SR_MP3	**Set/Reset Map 3.** Allows bits in Map 3 to be set/reset through WriteMode0 or WriteMode3 if EN_SR_MP3 = 0. 0: Enable 1: Disable
2	SR_MP2	**Set/Reset Map 2.** Allows bits in Map 2 to be set/reset through WriteMode0 or WriteMode3 if EN_SR_MP2 = 0. 0: Enable 1: Disable
1	SR_MP1	**Set/Reset Map 1.** Allows bits in Map 1 to be set/reset through WriteMode0 or WriteMode3 if EN_SR_MP1 = 0. 0: Enable 1: Disable
0	SR_MP0	**Set/Reset Map 0.** Allows bits in Map 0 to be set/reset through WriteMode0 or WriteMode3 if EN_SR_MP0 = 0. 0: Enable 1: Disable

5.3.13.4 Enable Set/Reset

GC Index 01h
Type R/W
Reset Value xxh

Bits[3:0] enable the set/reset function for their respective maps in WriteMode0.

Enable Set/Reset Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3	EN_SR_MP3	**Enable Set/Reset Map 3.** When in WriteMode0, this bit enables the set/reset function of Map 3. 0: Enable. 1: Disable.
2	EN_SR_MP2	**Enable Set/Reset Map 2.** When in WriteMode0, this bit enables the set/reset function of Map 3. 0: Enable. 1: Disable.
1	EN_SR_MP1	**Enable Set/Reset Map 1.** When in WriteMode0, this bit enables the set/reset function of Map 3. 0: Enable. 1: Disable.

DC Register Descriptions (Continued)

Enable Set/Reset Register Bit Descriptions (Continued)

Bit	Name	Description
0	EN_SR_MP0	**Enable Set/Reset Map 0.** When in WriteMode0, this bit enables the set/reset function of Map 3. 0: Enable. 1: Disable.

5.3.13.5 Color Compare

GC Index 02h
Type R/W
Reset Value xxh

Bits[3:0] specify a compare value that allows the CPU to compare pixels in planar modes. ReadMode 1 performs a comparison based on these bits combined with the Color Don't Care bits (GC Index 07h[3:0]). Data returned contains a 1 in each one of the eight pixel positions where a color match is found.

Color Compare Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3	CO_CM_MP3	**Color Compare Map 3.** This bit enables the color compare function for map 3. This function is used in Read Mode 1 to allow the CPU to perform color comparisons.
2	CO_CM_MP2	**Color Compare Map 2.** This bit enables the color compare function for map 2. This function is used in Read Mode 1 to allow the CPU to perform color comparisons.
1	CO_CM_MP1	**Color Compare Map 1.** This bit enables the color compare function for map 1. This function is used in Read Mode 1 to allow the CPU to perform color comparisons.
0	CO_CM_MP0	**Color Compare Map 0.** This bit enables the color compare function for map 0. This function is used in Read Mode 1 to allow the CPU to perform color comparisons.

5.3.13.6 Data Rotate

GC Index 03h
Type R/W
Reset Value xxh

Data Rotate Register Bit Descriptions

Bit	Name	Description
7:5	RSVD	**Reserved.** Write as read.
4:3	WROP	**Write Operation**. Data written to the frame buffer by the CPU can be logically combined with data already in the CPU data latches. 00: Copy (CPU data written unmodified). 01: CPU data ANDed with latched data. 10: CPU data ORed with latched data. 11: CPU data XORed with latched data.
2:0	ROTCNT	**Rotate Count.** This value is used to rotate the CPU data before it is used in WriteMode0 and WriteMode3. The CPU data byte written is rotated right, with low bits wrapping to the high bit positions.

DC Register Descriptions (Continued)

5.3.13.7 Read Map Select

GC Index 04h
Type R/W
Reset Value xxh

Read Map Select Register Bit Descriptions

Bit	Name	Description
7:2	RSVD	**Reserved.** Write as read.
1:0	R_MP_SL	**Read Map Select.** This field specifies which map CPU read data is taken from in ReadMode0. In Odd/Even modes (specified by the Odd/Even bit in the Graphics Mode register, GC Index 05h[4]) bit 1 of this field specifies which pair of maps returns data. When bit 1 is 0, data is returned from Maps 0 and 1. When bit 1 is 1, data is returned from Maps 2 and 3. The CPU read address bit A0 determines which byte is returned (low or high) in Odd/Even modes. In non-Odd/Even modes, these bits (both bits [1:0]) specify the map to read (Map 0, 1, 2, or 3) and the CPU accesses data sequentially within the specified map.

5.3.13.8 Graphics Mode

GC Index 05h
Type R/W
Reset Value xxh

Graphics Mode Register Bit Descriptions

Bit	Name	Description
7	RSVD	**Reserved**
6	256_CM	**256 Color Mode.** When set to a 1, this bit configures the video serializers in the graphics controller for the 256 color mode (BIOS mode 13h). When this bit is 0, the Shift Register Mode bit (bit 5) controls the serializer configuration.
5	SH_R_MD	**Shift Register Mode.** When set to a 1, this bit configures the video serializers for BIOS modes 4 and 5. When this bit is 0, the serializers are taken in parallel (i.e., configured for 4-bit planar mode operation). Note that the serializers are also wired together serially so that Map 3 bit 7 feeds Map 2 bit 0, Map 2 bit 7 feeds Map 1 bit 0, and Map 1 bit 7 feeds Map 0 bit 0. This allows for a 32-pixel 1 bit-per-pixel serializer to be used. For this configuration, color planes 1, 2, and 3 should be masked off using the Color Plane Enable register (AC Index 12h[3:0]).
4	ODD_EVEN	**Odd/Even.** When this bit is set to 1, CPU address bit A0 select between Maps 0 and 1 or Maps 2 and 3, depending on the state of the Read Map Select field (GC Index 04h[1:0]). When this bit is 0, the CPU accesses data sequentially within a map. This bit is equivalent to the Odd/Even bit in the Miscellaneous Register (GC Index 06h[1]), but is inverted in polarity from that bit.
3	RD_MD	**Read Mode.** This bit determines what is returned to the CPU when it reads the frame buffer. When this bit is 1, the result of a color compare operation is returned. The 8 bits in the CPU read data contain a 1 in each pixel position where the color compare operation was true, and a 0 where the operation was false. When this bit is 0, frame buffer map data is returned. 0: ReadMode 0. 1: ReadMode 1.
2	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

Graphics Mode Register Bit Descriptions (Continued)

Bit	Name	Description
1:0	WR_MD	**Write Mode.** This field specifies how CPU data is written to the frame buffer. Note that the Write Operation field in the Data Rotate register (GC Index 03h[4:3]) specifies how CPU data is combined with data in the data latches for WriteMode0, WriteMode2, and WriteMode3. 00: WriteMode0: CPU data is rotated by the count in the Data Rotate register (GC Index 03h[4:3]). Each map enabled by the Map Mask Register (SQ 02h[3:0]) is written by the rotated CPU data combined with the latch data (if set/reset is NOT enabled for that map, GC Index 00h[3:0]) or by the map's corresponding set/reset bit replicated across the 8-bit byte (if set/reset IS enabled for that map). The Bit Mask Register (GC Index 08h) is used to protect individual bits in each map from being updated. 01: WriteMode1: Each map enabled by the Map Mask Register (SQ 02h[3:0]) is written with its corresponding byte in the data latches. 10: WriteMode2: CPU data is replicated for each map and combined with the data latches and written to memory. The Bit Mask Register (GC Index 08h) is used to protect individual bits in each map from being updated. 11: WriteMode3: Each map is written with its corresponding Set/Reset bit replicated through a byte (Enable Set/Reset is ignored, GC Index 02h[3:0]). The CPU data is rotated and ANDed with the Bit Mask Register (GC Index 08h). The resulting mask is used to protect individual bits in each map.

5.3.13.9 Miscellaneous

GC Index 06h
Type R/W
Reset Value xxh

Miscellaneous Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved**
3:2	MEM_MAP	**Memory Map.** This field controls the address mapping of the frame buffer in the CPU memory space. 00: Memory Map 0: A0000 to BFFFF (128 kB). 01: Memory Map 1: A0000 to AFFFF (64 kB). 10: Memory Map 2: B0000 to B7FFF (32 kB). 11: Memory Map 3: B8000 to BFFFF (32 kB).
1	ODD_EVEN	**Odd/Even.** When set to 1, this bit replaces the CPU A0 address bit with a higher order bit when addressing the frame buffer. Odd maps are then selected when CPU A0 = 1, and even maps selected when CPU A0 = 0.
0	GPH_MD	**Graphics Mode.** 0: Text mode operation. 1: Graphics mode operation.

DC Register Descriptions (Continued)

5.3.13.10 Color Don't Care

GC Index 07h
Type R/W
Reset Value xxh

Color Don't Care Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved**
3	CM_PR3	**Compare Map 3**. This bit enables or excludes Map 3 from participating in a color compare operation. 0: Exclude. 1: Enable.
2	CM_PR2	**Compare Map 2**. This bit enables or excludes Map 2 from participating in a color compare operation. 0: Exclude. 1: Enable.
1	CM_PR1	**Compare Map 1.** This bit enables or excludes Map 1 from participating in a color compare operation. 0: Exclude. 1: Enable.
0	CM_PR0	**Compare Map 0.** This bit enables or excludes Map 0 from participating in a color compare operation. 0: Exclude. 1: Enable.

5.3.13.11 Bit Mask

GC Index 08h
Type R/W
Reset Value xxh

Bit Mask Register Bit Descriptions

Bit	Name	Description
7:0	BT_MSK	**Bit Mask.** The Bit Mask is used to enable or disable writing to individual bits in each map. A 1 in the bit mask allows a bit to be updated, while a 0 in the bit mask writes the contents of the data latches back to memory, effectively protecting that bit from update. The data latches must be set by doing a frame buffer read in order for the masking operation to work properly. The bit mask is used in WriteMode0, WriteMode2, and WriteMode3.

DC Register Descriptions (Continued)

5.3.14 Attribute Controller Registers

Index Register Address: 3C0h
Data Register Address: 3C0h (Write) 3C1h (Read)

The attribute controller registers are accessed by writing an index value to the Attribute Controller Index register (3C0h) and reading or writing the register using the Attribute Controller Data register (3C0h for writes, 3C1h for reads).

Table 5-21. Attribute Controller Registers Summary

AC Index	Type	Register	Reset Value	Reference
--	R/W	Attribute Controller Index/Data	xxh	Page 271
00h-0Fh	R/W	EGA Palette	xxh	Page 271
10h	R/W	Attribute Mode Control	xxh	Page 272
11h	R/W	Overscan Color	xxh	Page 273
12h	R/W	Color Plane Enable	xxh	Page 273
13h	R/W	Horizontal Pel Panning	xxh	Page 273
14h	R/W	Color Select	xxh	Page 274

5.3.14.1 Attribute Controller Index/Data

Index Address 3C0h
Data Address 3C1h (R)
3C0h (W)
Type R/W
Reset Value xxh

The attribute controller registers do not have a separate address for writing index and data information. Instead, an internal flip-flop alternates between index and data registers. Reading Input Status Register 1 (Address 3BAh or 3DAh) clears the flip-flop to the index state. The first write to Address 3C0h following a read from Input Status Register 1 updates the index register. The next write updates the selected data register. The next write specifies a new index, etc. Reading this register also clears the state of the Attribute Controller's index/data select flip-flop.

Attribute Controller Index Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5	INT_PAL_AD	**Internal Palette Address.** This bit determines whether the EGA palette is addressed by the video pixel stream (bit = 1) or by the Attribute Controller Index register (bit = 0). This bit should be set to 1 for normal VGA operation. CPU I/O accesses to the palette are disabled unless this bit is a 0.
4:0	DATA_RG_INX	**Data Register Index.** This field addresses the individual palette and data registers.

5.3.14.2 EGA Palette

AC Index 00h-0Fh
Type R/W
Reset Value xxh

EGA Palette Registers Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved**

EGA Palette Registers Bit Descriptions (Continued)

Bit	Name	Description
5:0	COL_VAL	**Color Value.** Each of these 16 registers (AC Index 00h-00Fh) is used to expand the pixel value from the frame buffer (1, 2, or 4 bits wide) into a 6-bit color value that is sent the video DAC. The EGA palette is “programmed out of the way” in 256 color mode. These registers can only be read or written when the Internal Palette Address bit in the Index register (Address 3C0h[5]) is 0.

5.3.14.3 Attribute Mode Control

AC Index 10h
Type R/W
Reset Value xxh

Attribute Mode Control Register Bit Descriptions

Bit	Name	Description
7	P54_SEL	**P5:4 Select.** When this bit is a 1, bits [5:4] of the 8-bit VGA pixel value are taken from bits [1:0] of the Color Select register (AC Index 14h). When a 0, bits [5:4] of the pixel are taken from bits [5:4] of the EGA palette output.
6	PEL_WIDTH	**Pel Width.** This bit is used in 256 color mode to shift four pixels through the attribute controller for each character clock. Clearing this bit shifts eight pixels for each character clock.
5	PEL_PAN_COMP	**Pel Panning Compatibility.** When this bit is a 1, the scan lines following a line compare are immune to the effects of the pel panning (see Section 5.3.14.6 "Horizontal Pel Panning" on page 273). When this bit is a 0, the entire screen is affected by pel panning, regardless of the line compare operation.
4	RSVD	**Reserved.** Write as read.
3	ENA_BLINK	**Enable Blink.** When this bit is a 1, attribute bit 7 is used to cause a character to blink (bit 7 = 1) or not (bit 7 = 0). When this bit is 0, attribute bit 7 is used as a background intensity bit.
2	ENA_LGC	**Enable Line Graphics Codes.** When this bit is 0, the 9th dot in 9-wide character modes is always set to the background color. When this bit is 1, the 9th dot is equal to the foreground color for character codes C0h-DFh, which are the line graphics character codes.
1	MONO_EMUL	**Monochrome Emulation.** When this bit is a 1, the underline in 9-dot mode extends for all 9 dots and an underlined phrase has a continuous line under it. When this bit is 0, the underline is only active for 8 dots, and an underlined phrase has a broken line under it.
0	GFX_MODE	**Graphics Mode (R/W).** When this bit is 1, graphics mode is selected (GC Index 06h[0] = 1) and pixel data from the frame buffer is used to produce the pixel stream. When this bit is 0, text mode is selected (GC Index 06h[0] = 0), and text attribute and font pattern information is used to produce the pixel stream.

DC Register Descriptions (Continued)

5.3.14.4 Overscan Color

AC Index 11h
Type R/W
Reset Value xxh

Overscan Color Register Bit Descriptions

Bit	Name	Description
7:0	OVERSCAN	**Overscan Color.** This value is output as the pixel value to the video DAC when the (internal) Display Enable signal from the CRTC is inactive. This field is applicable in CRT and FP modes.

5.3.14.5 Color Plane Enable

AC Index 12h
Type R/W
Reset Value xxh

Color Plane Enable Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved**
3	EN_CO_PN3	**Enable Color Plane 3.** This bit enables color plane 3. It is ANDed with it corresponding pixel bit and the resulting 4-bit value is used as the address into the EGA palette.
2	EN_CO_PN2	**Enable Color Plane 2.** This bit enables color plane 2. It is ANDed with it corresponding pixel bit and the resulting 4-bit value is used as the address into the EGA palette.
1	EN_CO_PN1	**Enable Color Plane 1.** This bit enables color plane 1. It is ANDed with it corresponding pixel bit and the resulting 4-bit value is used as the address into the EGA palette.
0	EN_CO_PN0	**Enable Color Plane 0.** This bit enables color plane 0. It is ANDed with it corresponding pixel bit and the resulting 4-bit value is used as the address into the EGA palette.

5.3.14.6 Horizontal Pel Panning

AC Index 13h
Type R/W
Reset Value xxh

Horizontal Pel Panning Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.

DC Register Descriptions (Continued)

Horizontal Pel Panning Register Bit Descriptions (Continued)

Bit	Name	Description
3:0		**Horizontal Pel Panning**. This field specifies how many pixels the screen image should be shifted to the left by.

Bits [3:0]	Mode 13h Panning	9-Wide Text Mode Panning	Panning for All Other Modes
0000	0	1	0
0001	--	2	1
0010	1	3	2
0011	--	4	3
0100	2	5	4
0101	--	6	5
0110	3	7	6
0111	--	8	7
1000	--	0	-
1001	--	--	--
1010	--	--	--
1011	--	--	--
1100	--	--	--
1101	--	--	--
1110	--	--	--
1111	--	--	--

5.3.14.7 Color Select

AC Index 14h
Type R/W
Reset Value xxh

Color Select Register Bit Descriptions

Bit	Name	Description
7:4	RSVD	**Reserved.** Write as read.
3:2	P[7:6]	**P7 and P6.** These bits are used to provide the upper two bits of the 8-bit pixel value sent to the video DAC in all modes except the 256 color mode (mode 13h).
1:0	P[5:4]	**P5 and P4.** These bits are used to provide bits 5 and 4 of the 8-bit pixel value sent to the video DAC when the P5:4 Select bit is set in the Attribute Mode Control register (AC Index 10h[7]). In this case they replace bits [5:4] coming from the EGA palette.

DC Register Descriptions (Continued)

5.3.15 Video DAC Registers

Video DAC palette registers are accessed by writing the Palette Address register at the read or write address, then performing three reads or writes, one for each of the red, green, and blue color values. The video DAC provides an address increment feature that allows multiple sets of color triplets to be read or written without writing the palette address register again. To invoke this feature, simply follow the first triplet read/write with the next triplet read/write.

The original IBM video DAC behavior for read operations is:

1) CPU initiates a palette read by writing INDEX to I/O address 3C7h.
2) Video DAC loads a temporary register with the value stored at palette[INDEX].
3) Video DAC increments INDEX (INDEX = INDEX + 1).
4) CPU reads red, green, blue color values from temporary register at I/O address 3C9h.
5) Loop to step 2.

The original IBM video DAC behavior for write operations is:

1) CPU initiates a palette write by writing INDEX to I/O address 3C8h.
2) CPU writes red, green, blue color values to temporary DAC registers at I/O address 3C9h.
3) Video DAC stores the temporary register contents in palette[INDEX].
4) Video DAC increments INDEX (INDEX = INDEX + 1).
5) Loop to step 2.

Table 5-22. Video DAC Registers Overview

Register	Read/Write	I/O Address
Palette Address (Write Mode)	R/W	3C8h
Palette Address (Read Mode)	W	3C7h
DAC State	R	3C7h
Palette Data	R/W	3C9h
Pel Mask	R/W	3C6h

5.3.15.1 Video DAC Palette Address

Read Address 3C8h
Write Address 3C7h (Palette Read Mode)
3C8h (Palette Write Mode)
Type RO
Reset Value 00h

Video DAC Palette Address Register Bit Descriptions

Bit	Name	Description
7:0	ADDR	**Palette Address**

DC Register Descriptions (Continued)

5.3.15.2 Video DAC State

Read Address 3C7h
Write Address --
Type RO
Reset Value 00h

Video DAC State Register Bit Descriptions

Bit	Name	Description
7:2	RSVD	**Reserved.** Write as read.
1:0	DAC_ST	**DAC State.** This register returns the DAC state for save/restore operations. If the last palette address write was to Address 3C7h (read mode), both bits are 1 (value = 11). If the last palette address write was to Address 3C8h (write mode), both bits are 0 (value = 00).

5.3.15.3 Video DAC Palette Data

Read Address 3C9h
Write Address 3C9h
Type R/W
Reset Value 00h

Video DAC Palette Data Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5:0	CO_CPN_VAL	**Color Component Value.** This is a 6-bit color component value that drives the video DAC for the appropriate color component when the current palette write address is used to address the video DAC in the pixel stream.

5.3.15.4 Video DAC Palette Mask

Read Address 3C6h
Write Address 3C6h
Type R/W
Reset Value 00h

Video DAC Palette Mask Register Bit Descriptions

Bit	Name	Description
7:0	PAL_MSK	**Palette Mask.** These bits enable their respective color bits between the final VGA 8-bit pixel output and the DAC palette. The bits are ANDed with the incoming VGA pixel value and the result used to address the palette RAM.

DC Register Descriptions (Continued)

5.3.16 VGA Unit Extended Registers

The Extended registers are accessed by writing an index value to the CRTC Index register (Address 3B4h or 3D4h) and reading or writing the register using the CRTC Data register (Address 3B5h or 3D5h). See the description of the I/O Address Select (bit 0) in the Miscellaneous Output register (Table 5.3.10.1 "Miscellaneous Output Register" on page 246) for more information on the I/O address of the CRTC registers.

Table 5-23. Extended Registers Summary

Index	Type	Register	Reset Value	Reference
30h	R/W	ExtendedRegisterLock	FFh	Page 277
43h	R/W(Note1)	ExtendedModeControl	00h	Page 277
44h	R/W (Note 1)	ExtendedStartAddress	00h	Page 278
47h	R/W (Note 1)	WriteMemoryAperture	00h	Page 278
48h	R/W (Note 1)	ReadMemoryAperture	00h	Page 279
60h	R/W (Note 1)	BlinkCounterCtl (for Sim/Test)	00h	Page 279
61h	R/W (Note 1)	BlinkCounter (for Sim/Test)	00h	Page 279
70h	R/W (Note 1)	VGALatchSavRes	00h	Page 280
71h	R/W (Note 1)	DACIFSavRes	00h	Page 280

Note 1. R/W when unlocked, RO otherwise (see Section 5.3.16.1 "ExtendedRegisterLock" for details).

5.3.16.1 ExtendedRegisterLock

CRTC Index 30h
Type R/W
Reset Value FFh

ExtendedRegisterLock Register Bit Descriptions

Bit	Name	Description
7:0	LOCK	**Lock.** A value of 4Ch unlocks the extended registers. Any other value locks the extended registers so they are read only. If the extended registers are currently locked, a read to this register returns FFh. If they are unlocked, a read returns 00h.

5.3.16.2 ExtendedModeControl

CRTC Index 43h
Type R/W
Reset Value 00h

ExtendedModeControl Register Bit Descriptions

Bit	Name	Description
7:5	RSVD	**Reserved.** Write as read.
4	FRC_8DCB	**Force 8-dot Character Width.** When this bit is set, then the VGA unit ignores the states of bit 2 (clock select) in the Miscellaneous Output register and bit 0 (8-dot character width) of the Clocking Mode register (SQ Index 01h), and force selection of the 25 MHz DOTCLK and 8-dot character width. This bit should be set for 640x480 flat panels.

DC Register Descriptions (Continued)

ExtendedModeControl Register Bit Descriptions (Continued)

Bit	Name	Description
3	FIX_TSE	**Fixed Timing Stretch Enable.** When this bit is set and the VGAFT bit in the DC_GENERAL_CFG register is set (DC Memory Offset 04h[18] = 1), the VGA screen image is stretched to fill the screen image size determined by the GUI unit timing registers. If this bit is 0 when fixed timing is enabled, then the VGA screen image is centered on the screen. Fixed Timing is enabled via DC General CFG register, bit 18. This bit is described in Section 5.3.3.2 “DC General Configuration (DC_GENERAL_CFG)” on page 224.
2:1	VG_RG_MAP	**DC Register Mapping.** These bits determine the DC register visibility within the standard VGA memory space (A0000h-BFFFFh). The decode below shows the mapping. Note that the VGA address space control bits override this feature. If the Miscellaneous Output register RAM Enable bit is 0, all VGA memory space is disabled. Or if the Memory Map bits of the Graphics Miscellaneous register (GC Index 06h[3:2]) are set the same as these bits, then the VGA frame buffer memory appears in this space instead of the GUI registers. 00: Disabled. 01: A0000h. 10: B0000h. 11: B8000h.
0	PACK_CH4	**Packed Chain4.** When this bit is set, the chain4 memory mapping does not skip DWORDs as in true VGA. Host reads and writes to frame buffer DWORDs are contiguous. When this bit is 0, host accesses behave normally and access 1 DWORD out of every 4. Note that this bit has no effect on the VGA display refresh activity. This bit is only intended to provide a front end for packed SVGA modes being displayed by DC.

5.3.16.3 ExtendedStartAddress

CRTC Index 44h
Type R/W
Reset Value 00h

ExtendedStartAddress Register Bit Descriptions

Bit	Name	Description
7:6	RSVD	**Reserved.** Write as read.
5:0	ST_AD_RG	**Start Address Register Bits [21:16].** These bits extend the VGA start address to 22 bits. Bits [15:8] are in Start Address High (CTRC Index 0Ch), and bits [7:0] are in Start Address Low (CRTC Index 0Dh).

5.3.16.4 WriteMemoryAperture

CRTC Index 47h
Type R/W
Reset Value 00h

WriteMemoryAperture Register Bit Descriptions

Bit	Name	Description
7:0	WR_BASE	**WriteBase.** Offset added to the graphics memory base to specify where VGA write operations start. This value provides DWORD address bits [21:14] when mapping host VGA writes to graphics memory. This allows the VGA base address to start on any 64 kB boundary within the 8 MB of graphics memory.

DC Register Descriptions (Continued)

5.3.16.5 ReadMemoryAperture

CRTC Index 48h
Type R/W
Reset Value 00h

ReadMemoryAperture Register Bit Descriptions

Bit	Name	Description
7:0	RD_BASE	**ReadBase.** Offset added to the graphics memory base to specify where VGA read operations start. This value provides DWORD address bits [21:14] when mapping host VGA reads to graphics memory. This allows the VGA base address to start on any 64 kB boundary within the 8 MB of graphics memory.

5.3.16.6 BlinkCounterCtl

CRTC Index 60h
Type R/W
Reset Value 00h

This register is for simulation and test only.

BlinkCounterCtl Register Bit Descriptions

Bit	Name	Description
7	HLD_CNT	**Hold Count.** When set, prevents the blink counter from incrementing with each leading edge VSYNC.
6:5	RSVD	**Reserved.** Write as read.
4:0	BLNK_CNT	**Blink Count.** The blink counter is loaded with this value while the sequencer's Reset register (SQ Index 00h) is in the reset state.

5.3.16.7 BlinkCounter

CRTC Index 61h
Type R/W
Reset Value 00h

This register is for simulation and test only.

BlinkCounter Register Bit Descriptions

Bit	Name	Description
7:5	RSVD	**Reserved.** Write as read.
4:0	BLNK_CNT	**Blink Count.** These bits provide a real-time blink counter value. This register is not synchronized to the system clock domain.

DC Register Descriptions (Continued)

5.3.16.8 VGALatchSavRes

CRTC Index 70h
Type R/W
Reset Value 00h

VGALatchSavRes Register Bit Descriptions

Bit	Name	Description
7:0	VGA_LSR	**VGALatchSavRes.** This register is used to save/restore the 32-bit VGA data latch. When the CRTC Index register (Address 3B4h or 3D4h) is written, an internal byte counter is cleared to 0. Four successive reads or writes to the CRTC Data register (Address 3B5h or 3D5h) at this index returns or writes bytes 0 (bits [7:0]), 1 (bits [15:8]), 2 (bits [23:16]), then 3 (bits [31:24]) in sequence.

5.3.16.9 DACIFSavRes

CRTC Index 71h
Type R/W
Reset Value 00h

DACIFSavRes Register Bit Descriptions

Bit	Name	Description
7:0	DACIFSR	**DACIFSavRes.** This register is used to save/restore the VGA palette interface logic state. When the CRTC Index register (Address 3B4h or 3D4h) is written, an internal byte counter is cleared to 0. Four successive reads or writes to the CRTC Data register (Address 3B5h or 3D5h) at this index returns or writes bytes 0 (bits [7:0]), 1 (bits [15:8]), 2 (bits [23:16]), then 3 (bits [31:24]) in sequence.

5.4 VIDEO PROCESSOR REGISTER DESCRIPTIONS

This section provides information on the registers associated with the Video Processor (VP): Standard GeodeLink Device and VP Specific MSRs (accessed via the RDMSR and WRMSR instructions), and two blocks of functional memory mapped registers (Video Processor and Flat Panel).

Table 5-24 through Table 5-27 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

For memory offset mapping details, see Section 3.1.3 "Memory and I/O Mapping" on page 55.

Table 5-24. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
C0002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_0013F0xxh	Page 283
C0002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)	00000000_00040Ex0h	Page 284
C0002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000000h	Page 284
C0002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 285
C0002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 285
C0002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000002_00000000h	Page 286

Table 5-25. VP Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
C0002010h	R/W	VP Diagnostic MSR (MSR_DIAG_VP)	00000000_00000000h	Page 287
C0002011h	R/W	Pad Select MSR (MSR_PADSEL)	00000000_00000000h	Page 287

Table 5-26. VP Control Registers Summary

VP Memory Offset	Type	Register	Reset Value	Reference
000h	R/W	Video Configuration Register (VCFG)	00000000_00000000h	Page 288
008h	R/W	Display Configuration (DCFG)	00000000_00000000h	Page 289
010h	R/W	Video X Position (VX)	00000000_00000000h	Page 291
018h	R/W	Video Y Position (VY)	00000000_00000000h	Page 291
020h	R/W	Video Scale (VS)	00000000_00000000h	Page 292
028h	R/W	Video Color-key Register (VCK)	00000000_00000000h	Page 293
030h	R/W	Video Color Mask (VCM)	00000000_00000000h	Page 293
038h	R/W	Gamma Address (GAR)	00000000_000000xxh	Page 294
040h	R/W	Gamma Data (GDR)	00000000_00xxxxxxh	Page 294
048h	--	Reserved (RSVD)	--	--

VP Register Descriptions (Continued)

Table 5-26. VP Control Registers Summary (Continued)

VP Memory Offset	Type	Register	Reset Value	Reference
050h	R/W	Miscellaneous (MISC)	00000000_00000C00h	Page 295
058h	R/W	CRT Clock Select (CCS)	00000000_00000000h	Page 296
060h-070h	--	Reserved (RSVD)	--	--
078h	R/W	Video Downscaler Control (VDC)	00000000_00000000h	Page 296
080h	R/W	Video Downscaler Coefficient (VCO)	00000000_00000000h	Page 297
088h	R/W	CRC Signature (CRC)	00000000_00000100h	Page 297
090h	RO	32-Bit CRC Signature (CRC32)	00000000_00000001h	Page 298
098h	R/W	Video De-Interlacing and Alpha Control (VDE)	00000000_00000400h	Page 299
0A0h	R/W	Cursor Color-key (CCK)	00000000_00000000h	Page 300
0A8h	R/W	Cursor Color Mask (CCM)	00000000_00000000h	Page 300
0B0h	R/W	Cursor Color Register 1 (CC1)	00000000_00000000h	Page 301
0B8h	R/W	Cursor Color Register 2 (CC2)	00000000_00000000h	Page 301
0C0h	R/W	Alpha Window 1 X Position (A1X)	00000000_00000000h	Page 302
0C8h	R/W	Alpha Window 1 Y Position (A1Y)	00000000_00000000h	Page 302
0D0h	R/W	Alpha Window 1 Color (A1C)	00000000_00000000h	Page 303
0D8h	R/W	Alpha Window 1 Control (A1T)	00000000_00000000h	Page 304
0E0h	R/W	Alpha Window 2 X Position (A2X)	00000000_00000000h	Page 304
0E8h	R/W	Alpha Window 2 Y Position (A2Y)	00000000_00000000h	Page 305
0F0h	R/W	Alpha Window 2 Color (AC2)	00000000_00000000h	Page 306
0F8h	R/W	Alpha Window 2 Control (A2T)	00000000_00000000h	Page 306
100h	R/W	Alpha Window 3 X Position (A3X)	00000000_00000000h	Page 307
108h	R/W	Alpha Window 3 Y Position (A3Y)	00000000_00000000h	Page 308
110h	R/W	Alpha Window 3 Color (A3C)	00000000_00000000h	Page 308
118h	R/W	Alpha Window 3 Control (A3T)	00000000_00000000h	Page 309
120h	R/W	Video Request (VRR)	00000000_001B0017h	Page 310
128h	RO	Alpha Watch (AWT)	00000000_00xxxxxxh	Page 310
130h	R/W	Video Processor Test Mode (VTM)	00000000_00000000h	Page 311
138h-3F8h	--	Reserved (RSVD)	--	

VP Register Descriptions (Continued)

Table 5-27. Flat Panel Control Registers Summary

FP Memory Offset	Type	Register	Reset Value	Reference
400h	R/W	Panel Timing Register 1 (PT1)	00000000_00000000h	Page 312
408h	R/W	Panel Timing Register 2 (PT2)	00000000_00000000h	Page 313
410h	R/W	Power Management (PM)	00000000_00000002h	Page 316
418h	R/W	Dither and Frame Rate Control (DFC)	00000000_00000000h	Page 317
420h	R/W	Blue LFSR Seed (BLFSR)	00000000_00000000h	Page 319
428h	R/W	Red and Green LFSR Seed (RLFSR)	00000000_00000000h	Page 319
430h	R/W	FRM Memory Index (FMI)	00000000_00000000h	Page 320
438h	R/W	FRM Memory Data (FMD)	00000000_00000000h	Page 321
440h	--	Reserved (RSVD)	--	--
448h	R/W	Dither RAM Control and Address (DCA)	00000000_00000000h	Page 321
450h	R/W	Dither Memory Data (DMD)	00000000_00000000h	Page 322
458h	R/W	Panel CRC Signature (CRC)	00000000_00000100h	Page 322
460h	R/W	Frame Buffer Base Address (FBB)	00000000_xxxx0000h	Page 323
468h	RO	32-Bit Panel CRC (CRC32)	00000000_00000001h	Page 324

5.4.1 Standard GeodeLink Device MSRs

5.4.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address C0002000h
Type RO
Reset Value 00000000_0013F0xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

Table 5-28. GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.** Reads back as 0.
23:8	DEV_ID	**Device ID.** Identifies device (13F0h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

VP Register Descriptions (Continued)

5.4.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address C0002001h
Type R/W
Reset Value 00000000_00040Ex0h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SP													GPRI			SP		DIV						PKG		FMT			PID		

GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:19	SP	**Spares.** Bits are read/write, but have no function.
18:16	GPRI	**GLIU Master Priority.** 000 in this field sets the VP at the lowest GLIU priority and 111 sets the VP at the highest GLIU priority.
15:14	SP	**Spares.** Bits are read/write, but have no function.
13:8	DIV	**Clock Divider.** GLIU clock divider to produce 14.3 MHz reference clock. Result must be equal to or less than 14.3 MHz. GLIU clock speed/DIV = reference clock. The reference clock is used for flat panel power up and down sequencing. See Section 5.4.4.3 "Power Management (PM)" on page 316 for more information on the Panel Power On bit (FP Memory Offset 410h[24]).
7:6	PKG (RO)	**Package Type (Read Only).** Affects reset value. 00: CRT. 01: Flat Panel. 10: Reserved. 11: Reserved.
5:3	FMT	**VP Output Format Select.** VP display outputs formatted for CRT or flat panel. Resets to CRT; software must change if a different mode is required. 000: CRT. 001: Flat Panel. 010: Reserved. 011: Reserved. 100: CRT Debug mode. 101: Reserved. 110: Reserved. 111: Reserved.
2:0	PID	**VP Priority Domain.** VP Assigned Priority Domain Identifier.

5.4.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address C0002002h
Type R/W
Reset Value 00000000_00000000h

This register is not used by the VP.

VP Register Descriptions (Continued)

5.4.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address C0002003h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															UNEXP_ADDR_ERR_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															UNEXP_ADDR_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:33	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
32	UNEXP_ADDR_ERR_FLAG	**Unexpected Address Error Flag**. If high, records that an ERR was generated due to an illegal address, such as an undefined VP GLIU register. Illegal GLIU cycle type accesses, such as an I/O access to the VP, also sets this bit. Write 1 to clear; writing 0 has no effect. UNEXP_ADDR_ERR_EN (bit 0) must be low to generate ERR and set flag.
31:1	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
0	UNEXP_ADDR_ERR_EN	**Unexpected Address Error Flag**. Write 0 to enable UNEXP_ADDR_ERR_FLAG (bit 32) and to allow the unexpected address event to generate an ERR and set flag.

5.4.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address C0002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				SP				RSVD														PMODE4		PMODE3		PMODE2		PMODE1		PMODE0	

VP Register Descriptions (Continued)

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:37	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
36:32	RSVD	**Reserved.** Write as 0.
31:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:24	SP	**Spare.** Read/write; no function.
23:10	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
9:8	PMODE4	**Power Mode 4 (VP DOTCLK).** This field controls the internal clock gating for the VP DOTCLK. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved. VP video DOTCLK can be gated off if VID_EN (VP Memory Offset 000h[0]) is 0. If the clock is gated off, hardware momentarily turns it on for a GLIU access to the VP.
7:6	PMODE3	**Power Mode 3 (FP DOTCLK).** This field controls the internal clock gating for the FP DOTCLK. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved. FP DOTCLK can be gated off in a GX2-FP if PANEL_OFF (FP Memory Offset 410h[1]) is 1. If the clock is gated off, hardware momentarily turns it on for a GLIU access to the VP.
5:4	PMODE2	**Power Mode 2 (FP GLIU Clock).** No FP GLIU clock control is implemented; the clock is always enabled in a GX2-FP. Write as 00.
3:2	PMODE1	**Power Mode 1 (VP Graphics DOTCLK).** This field controls the internal clock gating for the VP Graphics DOTCLK. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved. VP Graphics DOTCLK can be gated off if CRT_EN (VP Memory Offset 008h[0]) is 0. If the clock is gated off, hardware momentarily turns it on for a GLIU access to the VP.
1:0	PMODE0	**Power Mode 0 (VP GLIU Clock).** No VP GLIU clock control is implemented, the clock is always enabled. Write as 00.

5.4.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address C0002005h
Type R/W
Reset Value 00000002_00000000h

This register is reserved for internal use by National and should not be written to.

VP Register Descriptions (Continued)

5.4.2 VP Specific MSRs

5.4.2.1 VP Diagnostic MSR (MSR_DIAG_VP)

MSR Address C0002010h
Type R/W
Reset Value 00000000_00000000h

MSR_DIAG_VP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CM	NDM	RSVD														SP															

MSR_DIAG_VP Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31	CM	**32-Bit CRC Mode.** Selects 32-bit CRC generation. 0: Disable. 1: Enable.
30	NDM	**New Dither Mode.** Selects either the legacy dither mode, or new dither mode. The legacy dither mode has an errata with the first pixel. The new dither mode fixes this errata. This bit provides for backward compatibility. 0: Legacy dither mode. 1: New dither mode.
29:16	RSVD	**Reserved.** Reserved for diagnostics use.
15:0	SP	**Spares.** Read/write; no function.

5.4.2.2 Pad Select MSR (MSR_PADSEL)

MSR Address C0002011h
Type R/W
Reset Value 00000000_00000000h

MSR_PADSEL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD																														

MSR_PADSEL Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** This register is reserved for internal use by National. These bits should not be written to.

VP Register Descriptions (Continued)

5.4.3 VP Control Registers

5.4.3.1 Video Configuration Register (VCFG)

VP Memory Offset 000h
Type R/W
Reset Value 00000000_00000000h

VCFG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			EN_420	BIT_8_LINE_SIZE	RSVD		INIT_RD_LN_SIZE	INIT_RD_ADDR								VID_LIN_SIZ								YFILT_EN	XFILT_EN	RSVD		VID_FMT		RSVD	VID_EN

VCFG Bit Descriptions

Bit	Name	Description
63:29	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
28	EN_420	**Enable 4:2:0 Format.** 0: Disable. 1: Enable. **Note:** When input video stream in RGB, this bit must be set to 0.
27	BIT_8_ LINE_SIZE	**Bit 8 Line Size.** When enabled, this bit increases line size from VID_LIN_SIZ (bits [15:8]) DWORDs by adding 256 DWORDs. 0: Disable. 1: Enable.
26:25	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
24	INIT_RD_ LN_SIZE	**Increase Initial Buffer Read Address.** Increases INIT_RD_ADDR (bits [23:16]) by adding 256 DWORDs to the initial buffer address. (Effectively INIT_RD_ADDR becomes 9 bits (bits [24:16]) to accommodate 720 pixels.)
23:16	INIT_RD_ADDR	**Initial Buffer Read Address.** This field preloads the starting read address for the line buffers at the beginning of each display line. It is used for hardware clipping of the video window at the left edge of the active display. It represents the DWORD address of the source pixel that is to be displayed first. For an unclipped window, this value should be 0. For 420 mode, set bits [17:16] to 00.
15:8	VID_LIN_SIZ	**Video Line Size (in DWORDs).** Represents the number of DWORDs that make up the horizontal size of the source video data.
7	YFILT_EN	**Y Filter Enable.** Enables/disables the vertical filter. 0: Disable. 1: Enable. **Note:** This bit is used with Y upscaling logic, reset to 0 when not required.
6	XFILT_EN	**X Filter Enable.** Enables/disables the horizontal filter. 0: Disable. 1: Enable. **Note:** This bit is used with X upscaling logic, reset to 0 when not required.
5:4	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

VCFG Bit Descriptions (Continued)

Bit	Name	Description
3:2	VID_FMT	**Video Format.** Byte ordering of video data on the video input bus. The interpretation of these bits depends on the settings for bit 28 (EN_420) and bit 13 (GV_SEL) of the VDE register (VP Memory Offset 098h). If GV_SEL and EN_420 are both set to 0 (4:2:2): 00: Cb Y0 Cr Y1 01: Y1 Cr Y0 Cb 10: Y0 Cb Y1 Cr 11: Y0 Cr Y1 Cb If GV_SEL is set to 0 and EN_420 is set to 1 (4:2:0): 00: Y0 Y1 Y2 Y3 01: Y3 Y2 Y1 Y0 10: Y1 Y0 Y3 Y2 11: Y1 Y2 Y3 Y0 If GV_SEL is set to 1 and EN_420 is set to 0 (5:6:5): 00: P1L P1M P2L P2M 01: P2M P2L P1M P1L 10: P1M P1L P2M P2L 11: P1M P2L P2M P1L Both RGB 5:6:5 and YUV 4:2:2 contain two pixels in each 32-bit DWORD. YUV 4:2:0 contains a stream of Y data for each line, followed by U and V data for that same line. Cb = u, Cr = v.
1	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
0	VID_EN	**Video Enable.** Enables video acceleration hardware. 0: Disable (reset) video module. 1: Enable.

5.4.3.2 Display Configuration (DCFG)

VP Memory Offset 008h
Type R/W
Reset Value 00000000_00000000h

DCFG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SP				RSVD	DAC_VREF	RSVD				GV_GAM	VG_CK	RSVD			CRT_SYNC_SKW			SP				CRT_VSYNC_POL	CRT_HSYNC_POL	RSVD		SP		DAC_BL_EN	VSYNC_EN	HSYNC_EN	CRT_EN

DCFG Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:28	SP	**Spares.** Bits are read/write, but have no function.
27	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

DCFG Bit Descriptions (Continued)

Bit	Name	Description
26	DAC_VREF	**Select CRT DAC VREF.** Allows use of an external voltage reference for CRT DAC. If set, an external voltage reference should be connected to the VREF signal (GX2-CRT ball B5). 0: Disable external VREF. 1: Use external VREF.
25:22	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
21	GV_GAM	**Graphics/Video Gamma.** Selects whether the graphic or video data should pass through the Gamma Correction RAM. 0: Graphic data passes through the Gamma Correction RAM. 1: Video data passes through the Gamma Correction RAM.
20	VG_CK	**Video/Graphics Color-key Select.** Selects whether the graphic data is used for color-keying or the video data is used for chroma-keying. 0: Graphic data is compared to the color-key. 1: Video data is compared to the chroma-key.
19:17	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
16:14	CRT_SYNC_SKW	**CRT Sync Skew.** Represents the number of pixel clocks to skew the horizontal and vertical sync that are sent to the CRT. This field should be programmed to 100 (i.e., baseline sync is not moved) as the baseline. Via this register, the sync can be moved forward (later) or backward (earlier) relative to the pixel data. This register can be used to compensate for possible delay of pixel data being processed via the VP. 000: Sync moved 4 clocks backward. 001: Sync moved 3 clocks backward. 010: Sync moved 2 clocks backward. 011: Sync moved 1 clock backward. 100: Baseline sync is not moved. (**Default**) 101: Sync moved 1 clock forward. 110: Sync moved 2 clocks forward. 111: Sync moved 3 clocks forward.
13:10	SP	**Spares.** Bits are read/write, but have no function.
9	CRT_VSYNC_POL	**CRT Vertical Synchronization Polarity.** Selects the polarity for CRT vertical sync. 0: CRT vertical sync is normally low and is set high during the sync interval. 1: CRT vertical sync is normally high and is set low during the sync interval
8	CRT_HSYNC_POL	**CRT Horizontal Synchronization Polarity.** Selects the polarity for CRT horizontal sync. 0: CRT horizontal sync is normally low and is set high during sync interval. 1: CRT horizontal sync is normally high and is set low during sync interval
7:6	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
5:4	SP	**Spares.** Bits are read/write, but have no function.
3	DAC_BL_EN	**DAC Blank Enable.** Controls blanking of the CRT DACs. 0: DACs are constantly blanked. 1: DACs are blanked normally (i.e., during horizontal and vertical blank).
2	VSYNC_EN	**CRT Vertical Sync Enable.** Enables/disables CRT vertical sync (used for VESA DPMS support). 0: Disable. 1: Enable.
1	HSYNC_EN	**CRT Horizontal Sync Enable.** Enables/disables CRT horizontal sync (used for VESA DPMS support). 0: Disable. 1: Enable.

VP Register Descriptions (Continued)

DCFG Bit Descriptions (Continued)

Bit	Name	Description
0	CRT_EN	**CRT Enable.** Enables the graphics display control logic. This bit is also used to reset the display logic. 0: Reset display control logic. 1: Enable display control logic.

5.4.3.3 Video X Position (VX)

VP Memory Offset 010h
Type R/W
Reset Value 00000000_00000000h

VX Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				VID_X_END												RSVD				VID_X_START											

VX Bit Descriptions

Bit	Name	Description
63:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:16	VID_X_END	**Video X End Position.** Represents the horizontal end position of the video window. This register is programmed relative to CRT horizontal sync input (not the physical screen position). This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 13. (Note 1)
15:12	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
11:0	VID_X_START	**Video X Start Position.** Represents the horizontal Start position of the video window. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 14. (Note 1)

Note 1. H_TOTAL and H_SYNC_END are the values written in the DC module registers.

5.4.3.4 Video Y Position (VY)

VP Memory Offset 018h
Type R/W
Reset Value 00000000_00000000h

VY Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					VYE											RSVD					VYS										

Table 5-29. VY Bit Descriptions

Bit	Name	Description
63:27	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

Table 5-29. VY Bit Descriptions (Continued)

Bit	Name	Description
26:16	VID_Y_END	**Video Y End Position.** Represents the vertical end position of the video window. This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 2. (Note 1)
15:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:0	VID_Y_START	**Video Y Start Position.** Represents the vertical start position of the video window. This register is programmed relative to CRT Vertical sync input (not the physical screen position). This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 1. (Note 1)

Note 1. V_TOTAL and V_SYNC_END are the values written in the DC module registers.

5.4.3.5 Video Scale (VS)

VP Memory Offset 020h
Type R/W
Reset Value 00000000_00000000h

VS Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD		VID_Y_SCL														RSVD		VID_X_SCL													

VS Bit Descriptions

Bit	Name	Description
63:30	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
29:16	VID_Y_SCL	**Video Y Scale Factor.** Represents the vertical scale factor of the video window according to the following formula: VID_Y_SCL = 8192 * (Ys - 1) / (Yd - 1) Where: Ys = Video source vertical size in pixels Yd = Video destination vertical size in pixels **Note:** Upscale factor must be used. Yd is equal or bigger than Ys. If no scaling is intended, set to 2000h. The actual scale factor used is VID_Y_SCL/8192, but the formula above fits a given source number of lines into a destination window size.
15:14	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
13:0	VID_X_SCL	**Video X Scale Factor.** Represents horizontal scale factor of the video window according to the following formula: VID_X_SCL = 8192 * (Xs - 1) / (Xd - 1) Where: Xs = Video source horizontal size in pixels Xd = Video destination vertical size in pixels **Note:** Upscale factor must be used. Xd is equal or bigger than Xs. If no scaling is intended, set to 2000h. The actual scale factor used is VID_X_SCL/8192, but the formula above fits a given source number of pixels into a destination window size.

VP Register Descriptions (Continued)

5.4.3.6 Video Color-key Register (VCK)

VP Memory Offset 028h
Type R/W
Reset Value 00000000_00000000h

VCK Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								VID_CLR_KEY																							

VCK Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
23:0	VID_CLR_KEY	**Video Color-key.** The video color-key is a 24-bit RGB or YUV value. • If VG_CK (VP Memory Offset 008h[20]) is set to 0, the video pixel is selected within the target window if the corresponding graphics pixel matches the color-key. The color-key is an RGB value. • If VG_CK (VP Memory Offset 008h[20]) is set to 1, the video pixel is selected within the target window only if it (the video pixel) does not match the color-key. The color-key is usually an RGB value. However, if both bits 10 and 13 of the Video De-interlacing and Alpha Control register (VP Memory Offset 098h) are set to 0, the color-key is a YUV value (i.e., video is not converted to RGB). The graphics or video data being compared can be masked prior to the compare via the Video Color Mask register (described in Section 5.4.3.7 "Video Color Mask (VCM)" on page 293). The video color-key can be used to allow irregular shaped overlays of graphics onto video, or video onto graphics, within a scaled video window.

5.4.3.7 Video Color Mask (VCM)

VP Memory Offset 030h
Type R/W
Reset Value 00000000_00000000h

VCM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								VID_CLR_MASK																							

VCM Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

VCM Bit Descriptions (Continued)

Bit	Name	Description
23:0	VID_CLR_ MASK	**Video Color Mask.** This mask is a 24-bit RGB value. Zeros in the mask cause the corresponding bits in the graphics or video stream to be forced to match. For example: A mask of FFFFFFh causes all 24 bits to be compared (single color match). A mask of 000000h causes none of the 24 bits to be compared (all colors match). For more information about the color-key, see Section 5.4.3.6 "Video Color-key Register (VCK)" on page 293. The video color mask is used to mask bits of the graphics or video stream being compared to the color-key. It can be used to allow a range of values to be used as the color-key.

5.4.3.8 Gamma Address (GAR)

VP Memory Offset 038h
Type R/W
Reset Value 00000000_000000xxh

GAR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								GAM_ADDR							

GAR Bit Descriptions

Bit	Name	Description
63:8	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
7:0	GAM_ADDR	**Gamma Address.** Specifies the address to be used for the next access to the Gamma Data register (VP Memory Offset 040h[23:0]). Each access to the Data register automatically increments the Gamma Address register. If non-sequential access is made to the Gamma, the Address register must be loaded between each non-sequential data block.

5.4.3.9 Gamma Data (GDR)

VP Memory Offset 040h
Type R/W
Reset Value 00000000_00xxxxxxh

GDR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								GAM_DATA																							

GDR Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

GDR Bit Descriptions (Continued)

Bit	Name	Description
23:0	GAM_DATA	**Gamma Data.** Contains the read or write data for a Gamma Correction RAM. **Note:** When a read or write to the Gamma Correction RAM occurs, the previous output value is held for one additional DOTCLK period. This effect should go unnoticed during normal operation. Provides the Gamma data. The data can be read or written to the Gamma Correction RAM via this register. Prior to accessing this register, an appropriate address should be loaded to the Gamma Address register (VP Memory Offset 038h[7:0]). Subsequent accesses to the Gamma Data register cause the internal address counter to be incremented for the next cycle.

5.4.3.10 Miscellaneous (MISC)

VP Memory Offset 050h
Type R/W
Reset Value 00000000_00000C00h

MISC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																			SP	APWRDN	DACPWRDN	RSVD									BYP_BOTH

MISC Bit Descriptions

Bit	Name	Description
63:13	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
12	SP	**Spare.** Read/write; no function.
11	APWRDN	**Analog Interface Power Down.** Enables power down of the analog section of the internal CRT DAC. 0: Normal. 1: Power down.
10	DACPWRDN	**DAC Power Down.** Enables power down of the digital section of the internal CRT DAC. 0: Normal. 1: Power down.
9:1	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
0	GAM_EN	**Gamma Enable.** When enabled, graphics or video data is passed through the Gamma Correction RAM. Indicates if both graphics and video data should bypass gamma correction RAM. 0: Enable. The stream selected by GV_GAM (bit 21) in the Display Configuration register (VP Memory Offset 008h) is passed through Gamma Correction RAM. 1: Disable.

VP Register Descriptions (Continued)

5.4.3.11 CRT Clock Select (CCS)

VP Memory Offset 058h
Type R/W
Reset Value 00000000_00000000h

CCS Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD									SP															RSVD				SP			

CCS Bit Descriptions

Bit	Name	Description
63:23	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
22:8	SP	**Spare.** Read/write; no function.
7:4	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
3:0	SP	**Spare.** Read/write; no function.

5.4.3.12 Video Downscaler Control (VDC)

VP Memory Offset 078h
Type R/W
Reset Value 00000000_00000000h

VDC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																									DTS	RSVD	DFS				DCF

VDC Bit Descriptions

Bit	Name	Description
63:7	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
6	DTS	**Downscale Type Select.** 0: Type A (downscale formula is 1/m + 1, m pixels are dropped, one pixel is kept). 1: Type B (downscale formula is m/m + 1, m pixels are kept, one pixel is dropped).
5	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
4:1	DFS	**Downscale Factor Select.** Determines the downscale factor to be programmed into these bits, where m is used to derive the desired downscale factor depending on bit 6 (DTS). Only values up to 7 are valid.
0	DCF	**Downscaler and Filtering.** Enables/disables downscaler and filtering logic. 0: Disable. 1: Enable.

VP Register Descriptions (Continued)

5.4.3.13 Video Downscaler Coefficient (VCO)

VP Memory Offset 080h
Type R/W
Reset Value 00000000_00000000h

VCO Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				FLT_CO_4				RSVD				FLT_CO_3				RSVD				FLT_CO_2				RSVD				FLT_CO_1			

VCO Bit Descriptions

Bit	Name	Description
63:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:24	FLT_CO_4	**Filter Coefficient 4.** For the Tap-4 filter.
23:20	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
19:16	FLT_CO_3	**Filter Coefficient 3.** For the Tap-3 filter.
15:12	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
11:8	FLT_CO_2	**Filter Coefficient 2.** For the Tap-2 filter.
7:4	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
3:0	FLT_CO_1	**Filter Coefficient 1.** For the Tap-1 filter.

5.4.3.14 CRC Signature (CRC)

VP Memory Offset 088h
Type R/W
Reset Value 00000000_00000100h

CRC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SIG_VALUE																								RSVD					SIGN_FREE	RSVD	SIGN_EN

CRC Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:8	SIG_VALUE (RO)	**Signature Value (Read Only).** A 24-bit signature value is stored in this field that can be read at any time. The signature is produced from the RGB data before it is sent to the CRT DACs. This field is used for test purposes only. In 32-bit CRC mode, this field contains the lower 24 bits of the 32-bit CRC value. The full 32 bits can be read from the 32-Bit CRC Signature register (CRC32, VP Memory Offset 090h). See SIGN_EN (bit 0) description for more information.
7:3	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

CRC Bit Descriptions (Continued)

Bit	Name	Description
2	SIGN_FREE	**Signature Free Run.** 0: Disable (**Default**). If this bit was previously set to 1, the signature process stops at the end of the current frame (i.e., at the next falling edge of VSYNC). 1: Enable. If SIGN_EN (bit 0) is set to 1, the signature register captures data continuously across multiple frames.
1	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
0	SIGN_EN	**Signature Enable.** 0: Disable (**Default**). The SIG_VALUE (bits [31:8]) is reset to 000001h in 24-bit mode or 000000h in 32-bit mode and held (no capture). 1: Enable. When this bit is set to 1, the next falling edge of signal VSYNC is counted as the start of the frame to be used for CRC checking with each pixel clock beginning with the next VSYNC. If SIGN_FREE (bit 2) is set to 1, the signature register captures the pixel data signature continuously across multiple frames. If SIGN_FREE (bit 2) is cleared to 0, a signature is captured for one frame at a time, starting from the next falling VSYNC. After a signature capture is complete, the SIG_VALUE (bits [31:8]) can be read to determine the CRC check status. In 32-bit CRC mode, the full 32-bit signature can be read from the 32-Bit CRC Signature register (CRC32, VP Memory Offset 090h). Then reset the SIGN_EN to initialize the SIG_VALUE for the next round of CRC checks.

5.4.3.15 32-Bit CRC Signature (CRC32)

VP Memory Offset 090h
Type RO
Reset Value 00000000_00000001h

CRC32 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SIG_VALUE																															

CRC32 Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:0	SIG_VALUE (RO)	**Signature Value (Read Only).** A 32-bit signature value is stored in this field when in 32-bit CRC mode and can be read at any time. The 32-bit CRC mode select bit is located in GLD_MSR_DIAG_VP (MSR C0002010h[31]). The signature is produced from the RGB data before it is sent to the CRT DACs. This field is used for test purposes only. In 24-bit CRC mode this field contains the 24-bit CRC value in bits [23:0]. The 24-bit CRC can also be read from the CRC Signature (CRC) register SIG_VALUE field (VP Memory Offset 088h[31:8]). See Section 5.4.3.14 "CRC Signature (CRC)" on page 297 for more information.

VP Register Descriptions (Continued)

5.4.3.16 Video De-Interlacing and Alpha Control (VDE)

VP Memory Offset 098h
Type R/W
Reset Value 00000000_00000400h

VDE Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										A3P		A2P		A1P		RSVD		GV_SEL	SP		CSC_VIDEO	SP	GFX_INS_VIDEO	SP		RSVD	SP	RSVD	SP		

VDE Bit Descriptions

Bit	Name	Description
63:22	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
21:20	A3P	**Alpha Window 3 Priority.** Indicates the priority of alpha window 3. A higher number indicates a higher priority. Priority is used to determine display order for overlapping alpha windows. This field is reset by hardware to 00.
19:18	A2P	**Alpha Window 2 Priority.** Indicates the priority of alpha window 2. A higher number indicates a higher priority. Priority is used to determine display order for overlapping alpha windows. This field is reset by hardware to 00.
17:16	A1P	**Alpha Window 1 Priority.** Indicates the priority of alpha window 1. A higher number indicates a higher priority. Priority is used to determine display order for overlapping alpha windows. This field is reset by hardware to 00.
15:14	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
13	GV_SEL	**Graphics Video Select.** Selects input video format. 0: YUV format. 1: RGB format If this bit is set to 1, bit EN_420 (VP Memory Offset 000h[28]) must be set to 0.
12:11	SP	**Spares.** Read/write; no function.
10	CSC_VIDEO	**Color Space Converter for Video.** Determines whether or not the video stream from the video module is passed through the Color Space Converter (CSC). 0: Disable. The video stream is sent “as is” to the video mixer/blender. 1: Enable. The video stream is passed through the CSC (for YUV to RGB conversion).
9	SP	**Spare.** Read/write; no function.
8	GFX_INS_ VIDEO	**Graphics Window inside Video Window.** 0: Disable. The video window is assumed to be inside the graphics window. Outside the alpha window, graphics or video is displayed, depending on the result of color-key comparison. 1: Enable. The graphics window is assumed to be inside the video window. Outside the alpha windows, video is displayed instead of graphics. Color key comparison is not performed outside the alpha window.

VP Register Descriptions (Continued)

VDE Bit Descriptions (Continued)

Bit	Name	Description
7:6	SP	**Spares.** Read/write; no function.
5	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
4	SP	**Spare.** Read/write; no function.
3	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
2:0	SP	**Spares.** Read/write; no function.

5.4.3.17 Cursor Color-key (CCK)

VP Memory Offset 0A0h
Type R/W
Reset Value 00000000_00000000h

CCK Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD		CCK_EN	COLOR_REG_ OFFSET					CUR_COLOR_KEY																							

CCK Bit Descriptions

Bit	Name	Description
63:30	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
29	CCK_EN	**Cursor Color-key Enable.** 0: Cursor color-keying disabled. 1: Cursor color-keying enabled.
28:24	COLOR_REG_ OFFSET	**Cursor Color Register Offset.** This field indicates a bit in the incoming graphics stream that is used to indicate which of the two possible cursor color registers should be used for color-key matches for the bits in the graphics stream.
23:0	CUR_COLOR_ KEY	**Cursor Color-key.** Specifies the 24-bit RGB value of the cursor color-key. The incoming graphics stream is compared with this value. If a match is detected, the pixel is replaced by a 24-bit value from one of the cursor color registers.

5.4.3.18 Cursor Color Mask (CCM)

VP Memory Offset 0A8h
Type R/W
Reset Value 00000000_00000000h

CCM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								CUR_COLOR_MASK																							

VP Register Descriptions (Continued)

CCM Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
23:0	CUR_COLOR_ MASK	**Cursor Color Mask.** This mask is a 24-bit value. Zeroes in the mask cause the corresponding bits in the incoming graphics stream to be forced to match. Example: A mask of FFFFFFh causes all 24 bits to be compared (single color match). A mask of 000000h causes none of the 24 bits to be compared (all colors match).

5.4.3.19 Cursor Color Register 1 (CC1)

VP Memory Offset 0B0h
Type R/W
Reset Value 00000000_00000000h

CC1 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								CUR_COLOR_REG1																							

CC1 Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
23:0	CUR_COLOR_ REG1	**Cursor Color Register 1.** Specifies a 24-bit cursor color value. This is an RGB value (for RGB blending). This is one of two possible cursor color values. Bits[28:24] of the Cursor Color-key register (VP Memory Offset 0A0h) determine a bit of the graphics data that if even, selects this color to be used.

5.4.3.20 Cursor Color Register 2 (CC2)

VP Memory Offset 0B8h
Type R/W
Reset Value 00000000_00000000h

CC2 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								CUR_COLOR_REG2																							

CC2 Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

CC2 Bit Descriptions (Continued)

Bit	Name	Description
23:0	CUR_COLOR_ REG2	**Cursor Color Register 2.** Specifies a 24-bit cursor color value. This is an RGB value (for RGB blending). This is one of two possible cursor color values. Bits [28:24] of the Cursor Color-key register (VP Memory Offset 0A0h) determine a bit of the graphics data that if odd, selects this color to be used.

5.4.3.21 Alpha Window 1 X Position (A1X)

VP Memory Offset 0C0h
Type R/W
Reset Value 00000000_00000000h

A1X Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				ALPHA1_X_END												RSVD				ALPHA1_X_START											

A1X Bit Descriptions

Bit	Name	Description
63:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:16	ALPHA1_X_ END	**Alpha Window 1 X End.** Indicates the horizontal end position of alpha window 1. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 1. (Note 1)
15:12	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
11:0	ALPHA1_X_ START	**Alpha Window 1 X Start.** Indicates the horizontal start position of alpha window 1. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 2. (Note 1)

Note 1. H_TOTAL and H_SYNC_END are values programmed in the DC Module registers.
The value of (H_TOTAL – H_SYNC_END) is sometimes referred to as “horizontal back porch.”

5.4.3.22 Alpha Window 1 Y Position (A1Y)

VP Memory Offset 0C8h
Type R/W
Reset Value 00000000_00000000h

A1Y Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					ALPHA1_Y_END											RSVD					ALPHA1_Y_START										

VP Register Descriptions (Continued)

Table 5-30. A1Y Bit Descriptions

Bit	Name	Description
63:27	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
26:16	ALPHA1_Y_ END	**Alpha Window 1 Y End.** Indicates the vertical end position of alpha window 1. This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 2. (Note 1)
15:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:0	ALPHA1_Y_ START	**Alpha Window 1 Y Start.** Indicates the vertical start position of alpha window 1. This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 1. (Note 1)

Note 1. V_TOTAL and V_SYNC_END are values programmed in the DC Module registers.
The value of (V_TOTAL – V_SYNC_END) is sometimes referred to as “vertical back porch.”

5.4.3.23 Alpha Window 1 Color (A1C)

VP Memory Offset 0D0h
Type R/W
Reset Value 00000000_00000000h

A1C Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD							COLOR_REG_EN	ALPHA1_COLOR_REG																							

A1C Bit Descriptions

Bit	Name	Description
63:25	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
24	ALPHA1_ COLOR_REG_ EN	**Alpha Window 1 Color Register Enable.** Enable bit for the color-key matching in alpha window 1. 0: Disable. If this bit is disabled, the alpha window is enabled, and VG_CK = 0 (VP Memory Offset 008h[20]); then where there is a color-key match within the alpha window, video is displayed. If this bit is disabled, the alpha window is enabled, and VG_CK = 1 (VP Memory Offset 008h[20]); then where there is a chroma-key match within the alpha window, graphics are displayed. 1: Enable. If this bit is enabled and the alpha window is enabled, then where there is a color-key match within the alpha window; the color value in bits [23:0] of this register is displayed.
23:0	ALPHA1_ COLOR_REG	**Alpha Window 1 Color Register.** Specifies the color to be displayed inside the alpha window when there is a color-key match in the alpha window. This color is only displayed if the alpha window is enabled and the ALPHA1_COLOR_REG_EN (bit 24) is enabled.

VP Register Descriptions (Continued)

5.4.3.24 Alpha Window 1 Control (A1T)

VP Memory Offset 0D8h
Type R/W
Reset Value 00000000_00000000h

A1T Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														LOAD_ALPHA	ALPHA1_WIN_EN	ALPHA1_INC								ALPHA1_VAL							

A1T Bit Descriptions

Bit	Name	Description
63:18	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
17	LOAD_ALPHA (WO)	**Load Alpha (Write Only).** When set to 1, this bit causes the video processor to load the alpha value (bits [7:0]) at the start of the next frame. This bit is cleared by the de-assertion of VSYNC.
16	ALPHA1_WIN_EN	**Alpha Window 1 Enable.** Enable bit for alpha window 1. 0: Disable alpha window 1. 1: Enable alpha window 1.
15:8	ALPHA1_INC	**Alpha Window 1 Increment.** Specifies the alpha value increment/decrement. This is a signed 8-bit value that is added to the alpha value for each frame. The MSB (bit 15) indicates the sign (i.e., increment or decrement). When this value reaches either the maximum or the minimum alpha value (255 or 0), it keeps that value (i.e., it is not incremented/decremented) until it is reloaded via bit 17 of this register.
7:0	ALPHA1_VAL	**Alpha Window 1 Value.** Specifies the alpha value to be used for this window.

5.4.3.25 Alpha Window 2 X Position (A2X)

VP Memory Offset 0E0h
Type R/W
Reset Value 00000000_00000000h

A2X Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				ALPHA2_X_END												RSVD				ALPHA2_X_START											

A2X Bit Descriptions

Bit	Name	Description
63:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

A2X Bit Descriptions (Continued)

Bit	Name	Description
27:16	ALPHA2_X_ END	**Alpha Window 2 X End.** Indicates the horizontal end position of alpha window 2. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 1. (Note 1)
15:12	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
11:0	ALPHA2_X_ START	**Alpha Window 2 X Start.** Indicates the horizontal start position of alpha window 2. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 2. (Note 1)

Note 1. H_TOTAL and H_SYNC_END are values programmed in the DC Module registers.
The value of (H_TOTAL – H_SYNC_END) is sometimes referred to as “horizontal back porch.”

5.4.3.26 Alpha Window 2 Y Position (A2Y)

VP Memory Offset 0E8h
Type R/W
Reset Value 00000000_00000000h

A2Y Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					ALPHA2_Y_END											RSVD					ALPHA2_Y_START										

A2Y Bit Descriptions

Bit	Name	Description
63:27	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
26:16	ALPHA2_Y_ END	**Alpha Window 2 Y End.** Indicates the vertical end position of alpha window 2. This value is calculated according to the following formula: Value = desired screen position + (V_TOTAL – V_SYNC_END) + 2. (Note 1)
15:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:0	ALPHA2_Y_ START	**Alpha Window 2 Y Start.** Indicates the vertical start position of alpha window 2. This value is calculated according to the following formula: Value = desired screen position + (V_TOTAL – V_SYNC_END) + 1. (Note 1)

Note 1. V_TOTAL and V_SYNC_END are values programmed in the DC Module registers.
The value of (V_TOTAL – V_SYNC_END) is sometimes referred to as “vertical back porch.”

VP Register Descriptions (Continued)

5.4.3.27 Alpha Window 2 Color (AC2)

VP Memory Offset 0F0h
Type R/W
Reset Value 00000000_00000000h

A2C Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD							COLOR_REG_EN	ALPHA2_COLOR_REG																							

A2C Bit Descriptions

Bit	Name	Description
63:25	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
24	ALPHA2_ COLOR_REG_ EN	**Alpha Window 2 Color Register Enable.** Enable bit for the color-key matching in alpha window 2. 0: Disable. If this bit is disabled, the alpha window is enabled, and VG_CK = 0 (VP Memory Offset 008h[20]); then where there is a color-key match within the alpha window, video is displayed. If this bit is disabled, the alpha window is enabled, and VG_CK = 1 (VP Memory Offset 008h[20]); then where there is a chroma-key match within the alpha window, graphics are displayed. 1: Enable. If this bit is enabled and the alpha window is enabled, then where there is a color-key match within the alpha window; the color value in bits [23:0] of this register is displayed.
23:0	ALPHA2_ COLOR_REG	**Alpha Window 2 Color Register.** Specifies the color to be displayed inside the alpha window when there is a color-key match in the alpha window. This color is only displayed if the alpha window is enabled and the ALPHA2_COLOR_REG_EN bit (24) is enabled.

5.4.3.28 Alpha Window 2 Control (A2T)

VP Memory Offset 0F8h
Type R/W
Reset Value 00000000_00000000h

A2T Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														LOAD_ALPHA	ALPHA2_WIN_EN	ALPHA2_INC								ALPHA2_VAL						

VP Register Descriptions (Continued)

A2T Bit Descriptions

Bit	Name	Description
63:18	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
17	LOAD_ALPHA (WO)	**Load Alpha (Write Only).** When set to 1, this bit causes the VP to load the alpha value (in bits [7:0] of this register) at the start of the next frame. This bit is cleared by the de-assertion of VSYNC.
16	ALPHA2_WIN_EN	**Alpha Window 2 Enable.** Enable bit for alpha window 2. 0: Disable alpha window 2. 1: Enable alpha window 2.
15:8	ALPHA2_INC	**Alpha Window 2 Increment.** Specifies the alpha value increment/decrement. This is a signed 8-bit value that is added to the alpha value for each frame. The MSB (bit 15) indicates the sign (i.e., increment or decrement). When this value reaches either the maximum or the minimum alpha value (255 or 0) it keeps that value (i.e., it is not incremented/decremented) until it is reloaded via bit 17 of this register.
7:0	ALPHA2_VAL	**Alpha Window 2 Value.** Specifies the alpha value to be used for this window.

5.4.3.29 Alpha Window 3 X Position (A3X)

VP Memory Offset 100h
Type R/W
Reset Value 00000000_00000000h

A3X Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD				ALPHA3_X_END												RSVD				ALPHA3_X_START											

A3X Bit Descriptions

Bit	Name	Description
63:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:16	ALPHA3_X_END	**Alpha Window 3 X End.** Indicates the horizontal end position of alpha window 3. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 1. (Note 1)
15:12	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
11:0	ALPHA3_X_START	**Alpha Window 3 X Start.** Indicates the horizontal start position of alpha window 3. This value is calculated according to the following formula: Value = Desired screen position + (H_TOTAL – H_SYNC_END) – 2. (Note 1)

Note 1. H_TOTAL and H_SYNC_END are values programmed in the DC Module registers.
The value of (H_TOTAL – H_SYNC_END) is sometimes referred to as “horizontal back porch.”

VP Register Descriptions (Continued)

5.4.3.30 Alpha Window 3 Y Position (A3Y)

VP Memory Offset 108h
Type R/W
Reset Value 00000000_00000000h

A3Y Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					ALPHA3_Y_END											RSVD					ALPHA3_Y_START										

A3Y Bit Descriptions

Bit	Name	Description
63:27	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
26:16	ALPHA3_Y_ END	**Alpha Window 3 Y End.** Indicates the vertical end position of alpha window 3. This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 2. (Note 1)
15:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:0	ALPHA3_Y_ START	**Alpha Window 3 Y Start.** Indicates the vertical start position of alpha window 3. This value is calculated according to the following formula: Value = Desired screen position + (V_TOTAL – V_SYNC_END) + 1.

Note 1. V_TOTAL and V_SYNC_END are values programmed in the DC Module.
The value of (V_TOTAL – V_SYNC_END) is sometimes referred to as “vertical back porch.”

5.4.3.31 Alpha Window 3 Color (A3C)

VP Memory Offset 110h
Type R/W
Reset Value 00000000_00000000h

A3C Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD							EN	ALPHA3_COLOR_REG																							

A3C Bit Descriptions

Bit	Name	Description
63:25	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

A3C Bit Descriptions (Continued)

Bit	Name	Description
24	ALPHA3_ COLOR_REG_ EN	**Alpha Window 3 Color Register Enable.** Enable bit for the color-key matching in alpha window 3. 0: Disable. If this bit is disabled, the alpha window is enabled, and VG_CK = 0 (VP Memory Offset 008h[20]); then where there is a color-key match within the alpha window, video is displayed. If this bit is disabled, the alpha window is enabled, and VG_CK = 1 (VP Memory Offset 008h[20]); then where there is a chroma-key match within the alpha window; graphics are displayed. 1: Enable. If this bit is enabled and the alpha window is enabled, then where there is a color-key match within the alpha window; the color value in bits [23:0] of this register is displayed.
23:0	ALPHA3_ COLOR_REG	**Alpha Window 3 Color Register.** Specifies the color to be displayed inside the alpha window when there is a color-key match in the alpha window. This color is only displayed if the alpha window is enabled and the COLOR_REG_EN (bit 24) is enabled.

5.4.3.32 Alpha Window 3 Control (A3T)

VP Memory Offset 118h
Type R/W
Reset Value 00000000_00000000h

A3T Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														LOAD_ALPHA	ALPHA3_WIN_EN	ALPHA3_INC								ALPHA3_VAL							

A3T Bit Descriptions

Bit	Name	Description
63:18	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
17	LOAD_ALPHA (WO)	**Load Alpha (Write Only).** When set to 1, this bit causes the video processor to load the alpha value (in bits [7:0] of this register) at the start of the next frame. This bit is cleared by the de-assertion of VSYNC.
16	ALPHA3_WIN_ EN	**Alpha Window 3 Enable.** Enable bit for alpha window 3. 0: Disable alpha window 3. 1: Enable alpha window 3.
15:8	ALPHA3_INC	**Alpha Window 3 Increment.** Specifies the alpha value increment/decrement. This is a signed 8-bit value that is added to the alpha value for each frame. The MSB (bit 15) indicates the sign (i.e., increment or decrement). When this value reaches either the maximum or the minimum alpha value (255 or 0) it keeps that value (i.e., it is not incremented/decremented) until it is reloaded via bit 17 of this register.
7:0	ALPHA3_VAL	**Alpha Window 3 Value.** Specifies the alpha value to be used for this window.

VP Register Descriptions (Continued)

5.4.3.33 Video Request (VRR)

VP Memory Offset 120h
Type R/W
Reset Value 00000000_001B0017h

VRR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WRITE_ABORT	RSVD			XRQ												RSVD					YRQ									

VRR Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31	WRITE_ABORT	**Write Abort (Read Only).** Status indicating the video data received from the DC Module was not able to stay ahead of the actual video displayed to the CRT screen. Software can use this status to adjust the X and Y request locations elsewhere in this register. This bit is cleared when read.
30:28	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
27:16	XRQ	**Video X Request.** Indicates the horizontal (pixel) location at which to start requesting video data.
15:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:0	YRQ	**Video Y Request.** Indicates the line number at which to start requesting video data.

5.4.3.34 Alpha Watch (AWT)

VP Memory Offset 128h
Type RO
Reset Value 00000000_00xxxxxxh

Alpha values may be automatically incremented/decremented for successive frames. This register can be used to read alpha values that are being used in the current frame.

AWT Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								AW3								AW2								AW1							

AWT Bit Descriptions

Bit	Name	Description
63:24	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
23:16	AW3	**Alpha Value for Window 3**.
15:8	AW2	**Alpha Value for Window 2**.

VP Register Descriptions (Continued)

AWT Bit Descriptions (Continued)

Bit	Name	Description
7:0	AW1	**Alpha Value for Window 1**.

5.4.3.35 Video Processor Test Mode (VTM)

VP Memory Offset 130h
Type R/W
Reset Value 00000000_00000000h

VTM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SP	RSVD																				SP		RSVD		RTE	RSVD		TEST_CHAN			

VTM Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31	SP	**Spare.** Read/write; no function.
30:11	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
10:9	SP	**Spares.** Read/write; no function.
8:7	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
6	RSVD	**Reserved.** Reserved for test purposes.
5:4	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
3:0	RSVD	**Reserved.** Reserved for test purposes.

VP Register Descriptions (Continued)

5.4.4 Flat Panel Display Control Registers

5.4.4.1 Panel Timing Register 1 (PT1)

FP Memory Offset 400h
Type R/W
Reset Value 00000000_00000000h

PT1 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	FP_VSYNC_POL	FP_HSYNC_POL	RSVD	HSYNC_SRC	PAN_VSIZE											U	O	RSVD						HSYNC_ DELAY			HSYNC_PLS_ WIDTH				

PT1 Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31	RSVD	**Reserved.** This bit is not defined.
30	FP_VSYNC_ POL	**FP_VSYNC Input Polarity.** Selects positive or negative polarity of the FP_VSYNC input. Program this bit to match the polarity of the incoming FP_VSYNC signal. Note that FP Memory Offset 408h[23] controls the polarity of the output VSYNC. 0: FP_VSYNC is normally low, transitioning high during sync interval. (**Default**) 1: FP_VSYNC is normally high, transitioning low during sync interval
29	FP_HSYNC_ POL	**FP_HSYNC Input Polarity.** Selects positive or negative polarity of the FP_HSYNC input. Program this bit to match the polarity of the incoming FP_HSYNC signal. Note that FP Memory Offset 408h[22] controls the polarity of the output HSYNC. 0: FP_HSYNC is normally low, transitioning high during sync interval. (**Default)** 1: FP_HSYNC is normally high, transitioning low during sync interval
28	RSVD	**Reserved.** This bit is not defined.
27	HSYNC_SRC	**TFT Horizontal Sync Source.** Selects a delayed or undelayed TFT horizontal sync output. This bit determines whether to use the HSYNC for the TFT panel without delaying the input HSYNC, or delay the HSYNC before sending it on to TFT. Bits [7:5] determine the amount of the delay. 0: Do not delay the input HSYNC before it is output onto the LP/HSYNC. (**Default**) 1: Delay the input HSYNC before it is output onto the LP/HSYNC
26:16	PAN_VSIZE	**Panel Vertical Size.** This field represents the panel vertical size in terms of scan lines. The value programmed should be equal to the panel size that is being connected. This can be used only for DSTN/STN modes. Example: 640x480 = 1E0h, 800x600 = 258h, and 1024x768 = 300h.
15	U	**Underrun.** This bit is set by hardware GLIU master HW to indicate the DSTN UMA read engine has fallen behind the display side write engine. Clear on read. Possible indicator of slow GLIU read response or too short hblank times.
14	O	**Overrun.** This bit is set by hardware GLIU master HW to indicate the DSTN UMA write engine has fallen behind the display side read engine. Clear on read. Possible indicator of slow GLIU write response or too short hblank times.
13:8	RSVD	**Reserved.** These bits are not defined.

VP Register Descriptions (Continued)

PT1 Bit Descriptions (Continued)

Bit	Name	Description
7:5	HSYNC_DELAY	**Horizontal Sync Delay.** Selects the amount of delay in the output HSYNC pulse with respect to the input HSYNC pulse. The delay is programmable in steps of one DOTCLK. Bit 27 of this register (Memory Offset 400h) must be set in order for bits [7:5] to be recognized. Bits [7:5] are used only for TFT modes; for SSTN or DSTN modes these bits are ignored. 000: No delay from the input HSYNC. (**Default**) 001-111: Delay the HSYNC start by one to seven DOTCLKs.
4:0	HSYNC_PLS_ WIDTH	**Horizontal Sync Pulse Width.** Stretch the HSYNC pulse width by up to 31 DOTCLKs. The pulse width is programmable in steps of one DOTCLK. Bits [4:0] are used only for TFT modes; for SSTN or DSTN modes these bits are ignored. 00000: Does not generate the HSYNC pulse. The TFT panel uses the default input timing, which is selected by keeping the HSYNC_SRC bit (bit 27) set to 0. (**Default**) 00001-11111: The HSYNC pulse width can be varied from one to 31 DOTCLKs.

5.4.4.2 Panel Timing Register 2 (PT2)

FP Memory Offset 408h
Type R/W
Reset Value 00000000_00000000h

PT2 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SP	TFT_PASS_THRU	LPOL	RSVD	SCRC	LHS	LMS	VFS	VSP	HSP	PSEL		MCS	PIXF			RSVD		CLP	RSVD												

PT2 Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31	SP	**Spare.** Bit is read/write, but has no function.
30	TFT_PASS_ THRU	**TFT Pass Through.** Activates the TFT Pass Through mode. In TFT Pass Through mode, the input timing and the pixel data is passed directly on to the panel interface timing and the panel data pins to drive the TFT panel. In Pass Through mode the internal FP TFT logic and timing is not used. 0: Normal mode; uses the TFT logic and timing from the FP. 1: TFT Pass Through mode; FP TFT timing logic functions are not used.
29	LPOL	**Display Timing Strobe Polarity Select.** Selects the polarity of the LDE/MOD pin. This can be used for panels (either DSTN or TFT) that require an active low timing LDE (for TFT) or MOD (for DSTN) interface signal. 0: LDE/MOD signal is active high. (**Default**) 1: LDE/MOD signal is active low
28	RSVD	**Reserved.** This bit is not defined.

VP Register Descriptions (Continued)

PT2 Bit Descriptions (Continued)

Bit	Name	Description
27	SCRC	**Panel Shift Clock Retrace Activity Control.** Programs the shift clock (SHFCLK) to be either free running, or active only during the display period. Some TFT panels recommend keeping the shift clock running during the retrace time. This bit has no effect in DSTN or SSTN modes. 0: Shift clock is active only during active display period. 1: Shift clock is free running during the entire frame period.
26	LHS	**LP/HSYNC Select.** Selects the function of LP/HSYNC pin. Set this bit based on the panel type connected. For DSTN or Single scan STN panels, set this bit to 0. For TFT panels, set this bit to 1. 0: LP (output for DSTN panel). 1: HSYNC (output for TFT panel).
25	LMS	**LDE/MOD Select.** Selects the function of LDE/MOD pin. Set this bit based on the panel type connected. For DSTN or Single scan STN panels, set this bit to 0. For TFT panels, set this bit to 1. 0: MOD (output for DSTN panel). 1: LDE (output for TFT panel)
24	VFS	**FLM/VSYNC Select.** Selects function of FLM/VSYNC pin. Set this bit based on the panel type connected. For DSTN or Single scan STN panels, set this bit to 0. For TFT panels, set this bit to 1. 0: FLM (output for DSTN panel). 1: VSYNC (output for TFT panel)
23	VSP	**Vertical Sync Output Polarity.** Selects polarity of the output VSYNC signal. This bit is effective only for TFT panels; for this bit to function, bit 24 of this register (Memory Offset 408h) must be a 1. Note that Memory Offset 400h[30] selects the polarity of the input VSYNC. 0: VSYNC output is active high. 1: VSYNC output is active low
22	HSP	**Horizontal Sync Output Polarity.** Selects polarity of output HSYNC signal. This bit is effective only for TFT panels; for this bit to function, bit 26 of this register (Memory Offset 408h) must be a 1. Note that Memory Offset 400h[29] selects the polarity of the input HSYNC, and this bit controls the output polarity. 0: HSYNC output is active high. 1: HSYNC output is active low
21:20	PSEL	**Panel Type Select.** Selects panel type. The selection of the panel type in conjunction with the PIX_OUT(18:16) setting determines how pixel data is mapped on the output LD/UD pins. Panel Type Select also determines the selection of SHFCLK and other panel timing interface signals. 00: SSTN/DSTN panel. 01: TFT panel. 10: Reserved. 11: Reserved.
19	MCS	**Color/Mono Select.** Selects color or monochrome LCD panel. 0: Color. 1: Monochrome.

VP Register Descriptions (Continued)

PT2 Bit Descriptions (Continued)

Bit	Name	Description
18:16	PIXF	**Pixel Output Format**. These bits define the pixel output format. The selection of the pixel output format in conjunction with the panel type selection (bits [21:20]) and the color/monochrome selection (bit 19) determines how the pixel data is formatted before being sent on to the LD/UD pins. These settings also determine the SHFCLK frequency for the specific panel. 000: 8-bit DSTN panel or up to 24-bit TFT panel with one pixel per clock. Option1: Mono 8-bit DSTN ([21:20] = 00 and [19] = 1) (Color 8-bit DSTN is not supported). SHFCLK = 1/4 of DOTCLK. Option2: Color TFT with one pixel per clock ([21:20] = 01 and [19] = 0) SHFCLK = DOTCLK. 001: 16-bit DSTN panel or 18/24-bit TFT XGA panel with two pixels per clock. Option1: Color 16-bit DSTN ([21:20] = 00 and [19] = 0) SHFCLK = 1/(3:2:3) of DOTCLK. Option2: Mono16-bit DSTN ([21:20] = 00 and [19] = 1) SHFCLK = 1/8 of DOTCLK. Option3: Color TFT with two pixels per clock ([21:20] = 01 and [19] = 0) SHFCLK = 1/2 of DOTCLK. 010: 24-bit DSTN panel Color 24-bit DSTN ([21:20] = 00 and [19] = 0) (Mono 24-bit DSTN is not supported). SHFCLK = 1/4 of DOTCLK. 011: 8-bit Single Scan STN panel Color 8-bit Single Scan STN [(21:20] = 00 and [19] = 0) SHFCLK = 1/(3:2:3) of DOTCLK. 100, 101, 110, and 111: Reserved.
15:14	RSVD	**Reserved.** These bits are not defined.
13	CLP	**Continuous Line Pulses.** This bit selects whether line pulses are continuously output, or are output only during the active display time. In most cases, DSTN panels require continuous line pulses (LPs). 0: Continuous line pulses. 1: Line pulses during the display time only.
12:0	RSVD	**Reserved.** These bits are not defined.

VP Register Descriptions (Continued)

5.4.4.3 Power Management (PM)

FP Memory Offset 410h
Type R/W
Reset Value 00000000_00000002h

PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SP				PWR_SEQ_SEL	RSVD	D	P	PUB2	PUB1	PUB0	PD2	PD1	PD0	HDEL		VDEL		SINV	SP										PANEL_PWR_UP	PANEL_PWR_DOWN	PANEL_OFF	PANEL_ON

PM Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:28	SP	**Spares.** Read/write; no function.
27	PWR_SEQ_SEL	**Power Sequence Select.** Selects whether to use internal or external power sequence. The power sequence controls the order in which FP_VDDEN, FP_VCONEN, the data and control signals, and the backlight control signal DISPOFF# become active during power up, and inactive during power down. 0: Use internal power sequencing (timing is controlled by bits [24:18]). 1: Use external power sequencing Must be written to 0.
26	RSVD	**Reserved.** This bit should always be set to 0.
25	D	**Display Off Control Source.** Selects how DISPOFF# is controlled. Independent control may be used to disable the backlight to save power even if the panel is otherwise ON. 0: DISPOFF# is controlled by with the power up/down sequence. 1: DISPOFF# is controlled independently of the power sequence.
24	P	**Panel Power On.** Selects whether the panel is powered down or up following the power sequence mechanism. 0: Power down. 1: Power up. Panel power up and down phase timing is dependent upon a programmable reference clock. The reference clock is set to 14.3 MHz with the DIV field of the GLIU Device Master Configuration MSR to obtain 32 ms or 128 ms power sequence delays.
23	PUB2	**Panel Power Up Phase Bit 2.** Selects the amount of time from when VDD is enabled to when the panel data signals are enabled. 0: 32 ms 1: 128 ms
22	PUB1	**Panel Power Up Phase Bit 1.** Selects the time amount of from when the panel data signals are enabled to when panel VEE is enabled. 0: 32 ms. 1: 128 ms.

VP Register Descriptions (Continued)

PM Bit Descriptions (Continued)

Bit	Name	Description
21	PUB0	**Panel Power Up Phase Bit 0.** Selects the amount of time from when panel VEE is enabled to when BKLTON is enabled. 0: 32 ms. 1: 128 ms.
20	PD2	**Panel Power Down Phase Bit 2.** Selects the amount of time from when panel BKLTON is disabled to when panel VEE is disabled. 0: 32 ms. 1: 128 ms.
19	PD1	**Panel Power Down Phase Bit 1.** Selects the amount of time from when panel VEE is disabled to when the panel data signals are disabled. 0: 32 ms. 1: 128 ms.
18	PD0	**Panel Power Down Phase Bit 0.** Selects the amount of time from when the panel data signals are disabled to when panel VDD is disabled. 0: 32 ms. 1: 128 ms.
17:16	HDEL	**HSYNC Delay.** Delays HSYNC 0 - 3 DOT clocks.
15:14	VDEL	**VSYNC Delay.** Delays VSYNC 0 - 3 DOT clocks.
13	SINV	**SHFCLK Invert.** Invert shfclk to panel.
12:4	SP	**Spares.** Read/write; no function.
3	PANEL_PWR_UP	**Panel Power-Up Status (Read Only).** Status bit indicating the flat panel is currently powering up.
2	PANEL_PWR_DOWN	**Panel Power-Down Status (Read Only).** Status bit indicating the flat panel is currently powering down.
1	PANEL_OFF	**Panel OFF Status (Read Only).** Status bit indicating the flat panel is currently fully off.
0	PANEL_ON	**Panel ON Status (Read Only).** Status bit indicating the flat panel is currently fully on.

5.4.4.4 Dither and Frame Rate Control (DFC)

FP Memory Offset 418h
Type R/W
Reset Value 00000000_00000000h

DFC Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																			RRS	C2M	RVRS	RSVD			NFI			DBS			DENB

VP Register Descriptions (Continued)

DFC Bit Descriptions

Bit	Name	Description
63:13	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
12	RRS	**RAM or ROM Select.** This bit selects either internal ROM or internal RAM as the source of the dither patterns. 0: Selects fixed (internal to FP) ROM for dither patterns. (**Default**) 1: Selects programmable (internal to FP) RAM for dither patterns. To update the dither RAM, this bit must = 1. See FP Memory Offset 448h[6].
11	C2M	**Gray Scale Selection.** This bit chooses two methods of converting an incoming color pixel stream to shades of gray for display on monochrome panels. This bit is ignored if Memory Offset 408h[19] is set to 0 (color mode). 0: Green color only - Only the Green pixel data input is used to generate the gray shades. 1: NTSC weighting - Red, blue, and green pixel color inputs are used to generate the gray shades for the monochrome panel.
10	RVRS	**Negative Image.** This converts the black to white and white to black and all colors in between to their logical inverse to provide a negative image of the original image. It acts as though the incoming data stream were logically inverted (1 becomes 0 and 0 becomes 1). 0: Normal display mode. 1: Negative image display mode.
9:7	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
6:4	NFI	**Number Of FRM Intensities.** This field is used in conjunction with the DBS field of this register. DSTN Modes: The value, set by bits [6:4], is the number of intensities that exists due to Frame Rate Modulation, prior to dithering. This field selects how many of the incoming most significant (MS) data bits (per color) are used to generate the FRM intensities. DSTN definition: 000: 2 FRM intensities (selects 1 MS (most significant) bit for use by FRM). 001: 4 FRM intensities (selects 2 MS bits for use by FRM). 010: 8 FRM intensities (selects 3 MS bits for use by FRM). 011: 16 FRM intensities (selects 4 MS bits for use by FRM). 100: 32 FRM intensities (selects 5 MS bits for use by FRM). 101: 64 FRM intensities (selects 6 MS bits for use by FRM). 110, 111: Reserved. TFT Modes: The value in bits [6:4] sets the base color used prior to dithering. TFT panels do not use FRM. TFT definition: 000: Select 1 MSB for base color use prior to dithering. 001: Select 2 MSB for base color use prior to dithering. 010: Select 3 MSB for base color use prior to dithering. 011: Select 4 MSB for base color use prior to dithering. 100: Select 5 MSB for base color use prior to dithering. 101: Select 6 MSB for base color use prior to dithering. 110: Select 7 MSB for base color use prior to dithering. 111: Select 8 MSB for base color, no dithering.

VP Register Descriptions (Continued)

DFC Bit Descriptions (Continued)

Bit	Name	Description
3:1	DBS	**Dithering Bits Select.** This field is used to select the number of bits to be used for the dithering pattern. Dither bits are the least-significant bits of each pixel's final color value; FRM bits are the most-significant bits. 000: Selects 6-bits as dither bits. 001: Selects 5-bits as dither bits. 010: Selects 4-bits as dither bits. 011: Selects 3-bits as dither bits. 100: Selects 2-bits as dither bits. 101: Selects 1-bits as dither bits. 110, 111: RSVD
0	DENB	**Dithering Enable.** Enable/disable dithering. The dither bit must be enabled in order for dither RAM reads or writes to occur. When this bit is cleared, the internal dither RAM is powered down, which saves power. 0: Dither disable - The dithering function is turned off. When the dither is disabled the dither bits selection [3:1] do not have any effect and the dither RAM is not accessible. 1: Dither enable. The dither functions with the number of dither bits as set in [3:1].

5.4.4.5 Blue LFSR Seed (BLFSR)

FP Memory Offset 420h
Type R/W
Reset Value 00000000_00000000h

BLFSR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																	BLS														

BLFSR Bit Descriptions

Bit	Name	Description
63:15	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
14:0	BLS	**Blue LFSR Seed.** 15-bit value that specifies the seed value for the FRM conversion of the Blue component of each pixel

5.4.4.6 Red and Green LFSR Seed (RLFSR)

FP Memory Offset 428h
Type R/W
Reset Value 00000000_00000000h

RLFSR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	GLS															RSVD	RLS														

VP Register Descriptions (Continued)

RLFSR Bit Descriptions

Bit	Name	Description
63:31	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
30:16	GLS	**Green LFSR Seed.** 15-bit value that specifies the seed value for the FRM conversion of the Green component of each pixel
15	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
14:0	RLS	**Red LFSR Seed.** 15-bit value that specifies the seed value for the FRM conversion of the Red component of each pixel

5.4.4.7 FRM Memory Index (FMI)

FP Memory Offset 430h
Type R/W
Reset Value 00000000_00000000h

FMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																						SEL		RSVD		RIN					

FMI Bit Descriptions

Bit	Name	Description
63:10	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
9:8	SEL	**RGB Memory (FRM RAM) Select.** Allows reading or writing to individual R,G, and B memory FRM RAM locations or writing to all of them at the same time. 00: Read from R FRM RAM but write to RGB FRM RAM. 01: Read or write to R FRM RAM. 10: Read or write to G FRM RAM. 11: Read or write to B FRM RAM.
7:6	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
5:0	RIN	**FRM Memory Index.** This represents the index to the FRM RAM; each RAM is configured as 32x64. It requires two index values to update each row of FRM RAM. For example, the 00h index value updates the 32-bit (of 64-bit WORD) LSB of row “0” FRM RAM. The 01h index value updates the 32-bit (of 64-bit WORD) MSB of row “0” FRM RAM. To update all the RAM locations the index is programmed only once with starting value, normally “00”. This is used inside FP to auto increment the FRM RAM locations for every FRM RAM data access using the FP Memory Offset 438h[31:0].

VP Register Descriptions (Continued)

5.4.4.8 FRM Memory Data (FMD)

FP Memory Offset 438h
Type R/W
Reset Value 00000000_00000000h

FMD Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RDAT																															

FMD Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:0	RDAT	**RAM Data.** This 32-bit data represents FRM RAM data in accordance to the RGB_SEL (FP Memory Offset 430h[9:8]) and the index value (FP Memory Offset 430h[5:0]). **Note:** When programming the FRM RAM, data writes should always occur in pairs. The RAM data logic accumulates two 32-bit writes, then commits the full 64 bits. Undefined results occur if this rule is not followed.

5.4.4.9 Dither RAM Control and Address (DCA)

FP Memory Offset 448h
Type R/W
Reset Value 00000000_00000000h

DCA Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								A	U	ADDR					

DCA Bit Descriptions

Bit	Name	Description
63:8	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
7	A	**Dither RAM Access Bit.** Allows reads and writes to/from Dither RAM. 0: Disable (do not allow reads or writes). 1: Enable (allow reads and writes). To perform dither RAM writes and reads, both bits 7 and 6 must be set to 1. In addition Memory Offset 418h bits 12 and 0 must both be set to 1. If any of these bits are not set to 1, the RAM goes into power-down mode.
6	U	**Dither RAM Update.** This bit works in conjunction with bit 7. If this bit is enabled, it allows the data to update the RAM. 0: Disable (do not allow dither RAM accesses). 1: Enable (allow dither RAM accesses). To perform dither RAM writes and reads, both bits 7 and 6 must be set to 1. In addition Memory Offset 418h bits 12 and 0 must both be set to 1. If any of these bits are not set to 1, the RAM goes into power-down mode.

VP Register Descriptions (Continued)

DCA Bit Descriptions (Continued)

Bit	Name	Description
5:0	ADDR	**RAM Address.** This 6-bit field specifies the address to be used for the next access to the dither RAM.

5.4.4.10 Dither Memory Data (DMD)

FP Memory Offset 450h
Type R/W
Reset Value 00000000_00000000h

DMD Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RDAT																															

DMD Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:0	RDAT	**RAM Data.** This 32-bit field contains the read or write data for the RAM access.

5.4.4.11 Panel CRC Signature (CRC)

FP Memory Offset 458h
Type R/W
Reset Value 00000000_00000100h

CRC Register

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SIGA																								FRCT						SFR	SIGE

CRC Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:8	SIGA (RO)	**Signature Address (Read Only).** 24-bit signature data for dither logic or FRM logic. In 32-bit CRC mode, this field contains the lower 24 bits of the 32-bit signature. The full 32-bit signature can be read from the 32-Bit Panel CRC register (CRC32, FP Memory Offset 468h[31:0]).
7:2	FRCT (RO)	**Frame Count (Read Only).** Represents the frame count, which is an index for the generated signature for that frame.

VP Register Descriptions (Continued)

CRC Bit Descriptions (Continued)

Bit	Name	Description
1	SFR	**Signature Free Run.** If this bit is high, with signature enabled (bit 0 = 1), the signature generator captures data continuously across multiple frames. This bit may be set high when the signature is started, then later set low, which causes the signature generation process to stop at the end of the current frame. 0: Capture signature for only one frame. 1: Free run across multiple frames.
0	SIGE	**Signature Enable.** Enables/disables signature capture. 0: Disable signature capture. 1: Enable signature capture.

5.4.4.12 Frame Buffer Base Address (FBB)

FP Memory Offset 460h
Type R/W
Reset Value 00000000_xxxx0000h

FBB Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BAR													RSVD																	

FBB Bit Descriptions

Bit	Name	Description
63:32	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.
31:19	BAR	**Frame Buffer Base Address.** This 13-bit field contains the 512 kB frame buffer base address.
18:0	RSVD (RO)	**Reserved (Read Only).** Reads back as 0.

VP Register Descriptions (Continued)

5.4.5 32-Bit Panel CRC (CRC32)

FP Memory Offset 468h
Type RO
Reset Value 00000000_00000001h

CRC32 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CRC																															

CRC32 Bit Descriptions

Bit	Name	Description
63:32	RSVD	**Reserved (Read Only):** Reads back as 0.
31:0	CRC	**32-Bit CRC.** 32-Bit Signature when in 32-bit CRC mode. See FP Memory Offset 0458h for additional information.

5.5 GEODELINK CONTROL PROCESSOR REGISTER DESCRIPTIONS

All GeodeLink Control Processor (GLCP) registers are Model Specific Registers (MSRs) and are accessed via the RDMSR and WRMSR instructions.

The registers associated with the GLCP are the Standard GeodeLink Device MSRs and GLCP Specific MSRs. Table 5-31 and Table 5-32 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

Table 5-31. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
4C002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_000020xxh	Page 327
4C002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)	00000000_00000000h	Page 327
4C002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_0000000Fh	Page 328
4C002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 329
4C002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 330
4C002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 330

Table 5-32. GLCP Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
GLCP Control MSRs				
4C000008h	R/W	GLCP Clock Disable Delay Value (GLCP_CLK_DIS_DELAY)	00000000_00000000h	Page 331
4C000009h	R/W	GLCP Clock Mask for Sleep Request (GLCP_PMCLKDISABLE)	00000000_00000000h	Page 331
4C00000Ah	RO	Chip Fabrication Information (GLCP_FAB)	00000000_00000001h	Page 332
4C00000Bh	R/W	GLCP Global Power Management Controls (GLCP_GLB_PM)	00000000_00000000h	Page 332
4C00000Ch	R/W	GLCP Debug Output from Chip (GLCP_DBGOUT)	0000000000 00000000h	Page 333
4C00000Dh	R/W	GLCP Processor Status (GLCP_PROCSTAT)	Bootstrap Dependant	Page 334
4C00000Eh	R/W	GLCP DOWSER (GLCP_DOWSER)	00000000_00000000h	Page 335
4C00000Fh	R/W	GLCP I/O Delay Controls (GLCP_DELAY_CONTROLS)	00000000_00000000h	Page 335
4C000010h	R/W	GLCP Clock Control (GLCP_CLKOFF)	00000000_00000000h	Page 336
4C000011h	RO	GLCP Clock Active (GLCP_CLKACTIVE)	Input Determined	Page 338
4C000012h	R/W	GLCP Clock Mask for Debug Clock Stop Action (GLCP_CLKDISABLE)	00000000_00000000h	Page 338
4C000013h	R/W	GLCP Clock Active Mask for Suspend Acknowledge (GLCP_CLK4ACK)	00000000_00000000h	Page 339

GLCP Register Descriptions (Continued)

Table 5-32. GLCP Specific MSRs Summary(Continued)

MSR Address	Type	Register	Reset Value	Reference
4C000014h	R/W	GLCP System Reset and PLL Control (GLCP_SYS_RSTPLL)	Bootstrap Specific	Page 339
4C000015h	R/W	GLCP DOT Clock PLL Control (GLCP_DOTPLL)	000004A7_00008000h	Page 342
4C000016h	R/W	GLCP Debug Clock Control (GLCP_DBGCLKCTL)	00000000_00000002h	Page 344
4C000017h	RO	Chip Revision ID (GLCP_CHIP_REVID)	00000000_000000xxh	Page 344
GLCP I/O Address MSRs				
4C000018h	R/W - I/O Offset 00h	GLCP Control (GLCP_CNT)	00000000_000000Fh	Page 345
4C000019h	R/W - I/O Offset 04h	GLCP Level 2 (GLCP_LVL2)	00000000_00000000h	Page 345
4C00001Ah	RO - I/O Offset 08h	Reserved	00000000_00000000h	Page 345
4C00001Bh	R/W - I/O NA	Reserved	00000000_00000000h	Page 346
4C00001Ch	R/W - I/O Offset 10h	GLCP Throttle or C2 Start Delay (GLCP_TH_SD)	00000000_00000000h	Page 346
4C00001Dh	R/W - I/O Offset 14h	GLCP Scale factor (GLCP_TH_SF)	00000000_00000000h	Page 346
4C00001Eh	R/W - I/O Offset 18h	GLCP Processor Throttle Off Delay (GLCP_TH_OD)	00000000_00000000h	Page 347
4C00001Eh	R/W - I/O Offset 18h	GLCP Processor Throttle Off Delay (GLCP_TH_OD)	00000000_00000000h	Page 347
4C00001Fh	R/W - I/O NA	Reserved	00000000_00000000h	---
4C000020h through 4C0000FFh	R/W	Reserved for future use.	00000000_00000000h	---

GLCP Register Descriptions (Continued)

5.5.1 Standard GeodeLink Device MSRs

5.5.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 4C002000h
Type RO
Reset Value 00000000_000020xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.** Reads as 0.
23:8	DEV_ID	**Device ID.** Identifies device (0020h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

5.5.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address 4C002001h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													PID		

GLD_MSR_CONFIG Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.
2:0	PID	**Assigned Priority Domain.** Unused by the GLCP.

GLCP Register Descriptions (Continued)

5.5.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 4C002002h
Type R/W
Reset Value 00000000_0000000Fh

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD												PML2_SSMI_FLAG	PMCNT_SSMI_FLAG	DBG_ASMI_FLAG	ERR_ASMI_FLAG	RSVD												PML2_SSMI_EN	PMCNT_SSMI_EN	DBG_ASMI_EN	ERR_ASMI_EN

GLD_MSR_SMI Bit Descriptions

Bit	Name	Description
63:20	RSVD	**Reserved.** Write as read.
19	PML2_SSMI_FLAG	**Power Management GLCP_LVL2 Synchronous SMI Flag.** If high, records that an SSMI was generated due to a read of the GLCP_LVL2 register (MSR 4C000019h). Write 1 to clear; writing 0 has no effect. PML2_SSMI_EN (bit 3) must be low to generate SSMI and set flag.
18	PMCNT_SSMI_ FLAG	**Power Management GLCP_CNT Synchronous SMI Flag.** If high, records that an SSMI was generated due to a write of the GLCP_CNT register (MSR 4C000018h). Write 1 to clear; writing 0 has no effect. Write 1 to clear; writing 0 has no effect. PMCNT_SSMI_EN (bit 2) must be low to generate SSMI and set flag.
17	DBG_ASMI_FLAG	**Debug Asynchronous SMI Flag.** If high, records that an ASMI was generated due to a debug event or PROCSTAT access (MSR 4C00000Dh). Write 1 to clear; writing 0 has no effect. DBG_ASMI_EN (bit 1) must be low to generate ASMI and set flag.
16	ERR_ASMI_FLAG	**Error Signal Asynchronous SMI Flag.** If high, records that an ASMI was generated due to the ERR signal. Write 1 to clear; writing 0 has no effect. ERR_ASMI_EN (bit 0) must be low to generate ASMI and set flag.
15:4	RSVD	**Reserved.** Write as read.
3	PML2_SSMI_EN	**Power Management GLCP_LVL2 Synchronous SMI Enable.** Write 0 to enable power management logic to generate an SSMI when the GLCP_LVL2 register (MSR 4C000019h) is read and to set flag (bit 19).
2	PMCNT_SSMI_EN	**Power Management GLCP_CNT Synchronous SMI Flag**. Write 0 to enable power management logic to generate an SSMI when the GLCP_CNT register (MSR 4C000018h) is written and set flag (bit 18).
1	DBG_ASMI_EN	**Debug Asynchronous SMI Flag.** Write 0 to enable the debug logic to generate an ASMI and set flag (bit 17).
0	ERR_ASMI_EN	**Error Signal Asynchronous SMI Flag.** Write 0 to enable any GLIU1 device ERR signal (including GLCP) to cause an ASMI and set flag (bit 16).

GLCP Register Descriptions (Continued)

5.5.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 4C002003h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																												SYSPLL_ERR_FLAG	DOTPLL_ERR_FLAG	SIZE_ERR_FLAG	UNEXP_TYPE_ERR_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																												SYSPLL_ERR_EN	DOTPLL_ERR_EN	SIZE_ERR_EN	UNEXP_TYPE_ERR_EN

GLD_MSR_ERROR Bit Descriptions

Bit	Name	Description
63:36	RSVD	**Reserved.** Write as read.
35	SYSPLL_ERR_ FLAG	**System PLL Error Flag.** If high, records that an ERR occurred due to the system PLL lock signal being active when POR was inactive. Write 1 to clear; writing 0 has no effect. SYSPLL_ERR_EN (bit 3) must be low to generate ERR and set flag.
34	DOTPLL_ERR_ FLAG	**Dot Clock PLL Error Flag.** If high, records that an ERR occurred due to the DOT-CLK PLL lock signal being active when POR was inactive. Write 1 to clear; writing 0 has no effect. DOTPLL_ERR_EN (bit 2) must be low to generate ERR and set flag.
33	SIZE_ERR_FLAG	**Size Error Flag.** If high, records that the GLIU1 interface detected a read or write of more than 1 data packet (size = 16 bytes or 32 bytes). If a response packet is expected, the EXCEPTION bit is set; in all cases the asynchronous error signal is set. Write 1 to clear; writing 0 has no effect. SIZE_ERR_EN (bit 1) must be low to generate ERR and set flag.
32	UNEXP_TYPE_ ERR_FLAG	**Unexpected Type Error Flag.** An unexpected type was sent to the GLCP GLIU1 interface (start request with BEX type, snoop, PEEK_WRITE, DEBUG_REQ, or NULL type). If a response packet is expected, the EXCEPTION bit is set; in all cases the asynchronous error signal is set. Writing a 1 clears the error, writing a 0 leaves unchanged.
31:4	RSVD	**Reserved.** Write as read.
3	SYSPLL_ERR_EN	**System PLL Error Enable.** Write 0 to enable the ERR signal if the system PLL lock signal is active when POR is inactive and set flag (bit 35).
2	DOTPLL_ERR_EN	**Dot Clock PLL Error Enable.** Write 0 to enable the ERR signal if the DOTCLK PLL lock signal is active when POR is inactive and set flag (bit 34)
1	SIZE_ERR_EN	**Size Error Enable.** Write 0 to enable the ERR signal if the GLIU1 interface detects a read or write of more than 1 data packet and set flag (bit 33).

GLCP Register Descriptions (Continued)

GLD_MSR_ERROR Bit Descriptions (Continued)

Bit	Name	Description
0	TYPE_ERR_EN	**Type Error Enable.** Write 0 to enable the ERR signal if an unexpected type was sent to the GLCP GLIU1 interface and set flag (bit 32).

5.5.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 4C002004h
Type R/W
Reset Value 00000000_00000000h

The debug logic powers up selecting GLIU1 for its clock. Debug clock select is in GLCP_DBGCLKCTL (MSR 4C000016h[2:0]).

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																														PRQ1	PRQ0
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
RSVD																												PMODE1		PMODE0	

GLD_MSR_PM Bit Descriptions

Bit	Name	Description
63:34	RSVD	**Reserved.** Write as read.
33:32	RSVD	**Reserved.** Write as 0.
31:4	RSVD	**Reserved.** Write as read.
3:2	PMODE1	**Power Mode 1 (GLCP Debug Clock).** This field controls the internal clock gating for the GLCP Debug clock. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating if debug inactive (i.e. GLCP_DBGCLKCTL = 0, MSR 4C000016h[2:0]). 10: Reserved. 11: Reserved.
1:0	PMODE0	**Power Mode 0 (GLCP GLIU1 Clock).** This field controls the internal clock gating for the GLCP GLIU1 clock. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

5.5.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address 4C002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

GLCP Register Descriptions (Continued)

5.5.2 GLCP Specific MSRs

5.5.2.1 GLCP Clock Disable Delay Value (GLCP_CLK_DIS_DELAY)

MSR Address 4C000008h
Type R/W
Reset Value 00000000_00000000h

GLCP_CLK_DIS_DELAY Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								CLK_DELAY																							

GLCP_CLK_DIS_DELAY Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.** Write as read.
23:0	CLK_DELAY	**Clock Disable Delay.** If enabled in GLCP_GLB_PM (CLK_DLY_EN bit, MSR 4C00000Bh[4] = 1), indicates the period to wait from SLEEP_REQ before gating off clocks specified in GLCP_PMCLKDISABLE (MSR 4C000009h). If this delay is enabled, it overrides or disables the function of GLCP_CLK4ACK (MSR 4C000013h). If the CLK_DLY_EN bit is not set, but this register is non-zero, then this register serves as a timeout for the CLK4ACK behavior.

5.5.2.2 GLCP Clock Mask for Sleep Request (GLCP_PMCLKDISABLE)

MSR Address 4C000009h
Type R/W
Reset Value 00000000_00000000h

GLCP_PMCLKDISABLE Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			GLCPDBG	GLCPGL	VPDOT2	VPDOT1	VPDOT0	VPGL1	VPGL0	GLPCIPCIF	GLPCIPCI	GL_GLPCI	GL1_GLIU1	GL0_GLIU1	GIOPCI	GIOGL	DCGL1	DCGL0	DCDOT1	DCDOT0	GL1_GLIU0	GL0_GLIU0	GP	GL_GLMC	DRAM	GL_BC	CPU_BC	CPU_MSS	CPU_IPIPE	FPUFAST	FPUSLOW

GLCP_PMCLKDISABLE Bit Descriptions

Bit	Name	Description
63:28	RSVD	**Reserved.** Write as read.
28:0	PMCLKDISABLE	**Clock Mask for Sleep Request.** These bits correspond to the Clock Off (CLKOFF) bits in GLCP_CLKOFF (MSR 4C000010h). If a bit in this field is set, then the corresponding CLK_OFF bit is set when the power management circuitry disables clocks when entering Sleep.

GLCP Register Descriptions (Continued)

5.5.2.3 Chip Fabrication Information (GLCP_FAB)

MSR Address 4C00000Ah
Type RO
Reset Value 00000000_00000001h

This is a read only register is used to track various fab, process, and product family parameters. It is meant for National Semiconductor internal use only.

GLCP_FAB Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

GLCP_FAB Register Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** Reads return reset value.

5.5.2.4 GLCP Global Power Management Controls (GLCP_GLB_PM)

MSR Address 4C00000Bh
Type R/W
Reset Value 00000000_00000000h

GLCP_GLB_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD														DOTPLL_EN	SYSPLL_EN	RSVD			OUT_DF	OUT_GIO	OUT_MC	OUT_PCI	OUT_OTHER	RSVD			CLK_DLY_EN	CLK_DIS_EN	RSVD	RSVD	THT_EN

GLCP_GLB_PM Bit Descriptions

Bit	Name	Description
63:18	RSVD	**Reserved.** Write as read.
17	DOTPLL_EN	**Turn Off DOTCLK PLL during Sleep.** 0: Disable. 1: Enable.
16	SYSPLL_EN	**Turn Off System PLL during Sleep.** 0: Disable. 1: Enable.
15:13	RSVD	**Reserved.** Write as read.
12	OUT_DF	**TRI-STATE DF Outputs during Sleep.** 0: Disable. 1: Enable.

GLCP Register Descriptions (Continued)

GLCP_GLB_PM Bit Descriptions (Continued)

Bit	Name	Description
11	OUT_GIO	**TRI-STATE GIO Outputs during Sleep.** 0: Disable. 1: Enable.
10	OUT_MC	**TRI-STATE MC Outputs during Sleep.** 0: Disable. 1: Enable.
9	OUT_PCI	**TRI-STATE PCI outputs during Sleep.** 0: Disable. 1: Enable.
8	OUT_OTHER	**TRI-STATE TDBGO and SUSPA# during Sleep.** 0: Disable. 1: Enable.
7:5	RSVD	**Reserved.** Write as read.
4	CLK_DLY_EN	**Clock Delay Enable.** Enables gating off clock enables from a delay rather than GLCP_CLK4ACK (MSR 4C000013h). 0: Disable. 1: Enable.
3	CLK_DIS_EN	**Assert GLIU CLK_DIS_REQ during Sleep.** 0: Disable. 1: Enable.
2:1	RSVD	**Reserved.** Write as read.
0	THT_EN	**Processor Throttling Functions Enable.** 0: All the functions related to throttling are disabled (GLCP_TH_OD, GLCP_CNT, etc.). 1: All the functions related to throttling are enabled (GLCP_TH_OD, GLCP_CNT, etc.).

5.5.2.5 GLCP Debug Output from Chip (GLCP_DBGOUT)

MSR Address 4C00000Ch
Type R/W
Reset Value 0000000000 00000000h

GLCP_DBGOUT Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

GLCP_DBGOUT Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** This register is reserved for internal use by National.

GLCP Register Descriptions (Continued)

5.5.2.6 GLCP Processor Status (GLCP_PROCSTAT)

MSR Address 4C00000Dh
Type R/W
Reset Value Bootstrap Dependant

Note that the names of these bits have the read status data before the "_" and the write behavior after it.

GLCP_PROCSTAT Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																									RESET_NONE	STOPCLK_NONE	GLACT_UNSTALL	GLCPSTALL_DMI	STALL_SMI	SUSP_STOPCLK	DMI_STALL

GLCP_PROCSTAT Bit Descriptions

Bit	Name	Description
63:7	RSVD	**Reserved.** Writing these bits have no effect.
6	RESET_NONE	**Reset Status.** When read, this bit is high if a hard or soft reset to the GX2 has occurred since this register was last read. Writing this bit has no effect.
5	STOPCLK_ NONE	**Stop Clock Status.** When read, this bit is high if a GLCP stop clock action has occurred since this register was last read. Writing this bit has no effect.
4	GLACT_UNSTALL	**GLIU1 Debug Action Status.** When read, this bit is high if the GLCP has triggered a GLIU1 debug action since this register was last read. Writing this bit high unstalls the processor.
3	GLCPSTALL_ DMI	**GeodeLink Control Processor Stall Status.** When read, this bit is high if the GLCP is stalling the CPU. Writing this bit high causes a GLCP DMI to the processor.
2	STALL_ SMI	**CPU Stall Status.** When read, this bit is high if the CPU is stalled for any reason. Writing this bit high causes an GLCP SMI to the processor. Bit 1 of GLD_MSR_SMI (MSR 4C002002h) gets set by this SMI and an SMI is triggered, assuming appropriate SMI enable settings.
1	SUSP_ STOPCLK	**CPU Suspended Stop Clock Status.** When read, this bit is high if the CPU has suspended execution for any reason since this register was last read. Writing this bit high causes the GLCP to stop all clocks identified in GLCP_CLKDISABLE (MSR 4C000012h).
0	DMI_STALL	**CPU DMI Stall Status.** When read, this bit is high if the CPU is in DMI mode. Writing this bit high causes the GLCP to “DEBUG_STALL” the processor.

GLCP Register Descriptions (Continued)

5.5.2.7 GLCP DOWSER (GLCP_DOWSER)

MSR Address 4C00000Eh
Type R/W
Reset Value 00000000_00000000h

GLCP_DOWSER Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
SW Defined																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SW Defined																															

GLCP_DOWSER Bit Descriptions

Bit	Name	Description
63:0	---	**Software Defined.** This 64-bit scratchpad register was specifically added for SW debugger use (DOWSER). The register resets to zero with both hard and soft resets

5.5.2.8 GLCP I/O Delay Controls (GLCP_DELAY_CONTROLS)

MSR Address 4C00000Fh
Type R/W
Reset Value 00000000_00000000h

Note: This register should be initialized by boot software to: 830D40FA_86A0AD6Ah for SDR and 830D40FA_8EA0AD6Ah for DDR.

GLCP_DELAY_CONTROLS Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
EN	RSVD		GIO					PCI_IN					PCI_OUT					VCONEN					DOTCLK					DRGB			
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
<	SDCLK_IN					SDCLK_OUT					MEM_CTL					RSVD									MEM_ODDOUT	RSVD		DQS_CLK_IN		DQS_CLK_OUT	

GLCP_DELAY_CONTROLS Bit Descriptions

Bit	Name	Description
63	EN	**Delay Settings Enable.** Enable the delay settings in this MSR to override the 62-bit JTAG register. The JTAG register does not have this bit.
62:61	RSVD	**Reserved.** Write as read.
60:56	GIO	**Delay Geode I/O Companion.** Add Delay to GIO input pads: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111. Higher delays increase the setup time required on INTR, SUSP#, and SMI# relative to SYSREF while decreasing the hold time required.
55:51	PCI_IN	**Delay PCI Inputs.** Add delay to PCI inputs: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111. Higher delays increase setup time required and decrease hold time required on all PCI inputs (AD, REQ#, etc.) plus TDBGI.

GLCP Register Descriptions (Continued)

GLCP_DELAY_CONTROLS Bit Descriptions (Continued)

Bit	Name	Description
50:46	PCI_OUT	**Delay PCI Outputs.** Add delay to PCI outputs: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111. Higher delays increase the clock-to-Q output time for all PCI outputs (AD, GNT#, etc.) plus TDBGO, SUSPA#, and IRQ13. For special setting 00101, only the odd data bits are delayed, this could be useful for minimizing noise generated by the PCI signals.
45:41	VCONEN	**Delay FP_VCONEN.** Add delay to FP_VCONEN clock-to-Q output time: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111.
40:36	DOTCLK	**Delay Dot Clock.** Add delay to DOTCLK output time: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111.
35:31	DRGB	**Delay Digital RGBs.** Add delay to DRGBs clock-to-Q output time as well as HSYNC, VSYNC, FP_DISP_EN, FP_VDDEN, and FP_LDE_MOD: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111. For special setting 00101, only the odd data bits are delayed, this could be useful for minimizing noise generated by the DRGB signals.
30:26	SDCLK_IN	**Delay SDRAM Clock Input.** Delay to SD_WR_CLK: 10101 is no delay; use SD_WR_CLK pad input, 00000 is shortest delay; use SD_FB_CLK internal bypass, 00001, 00011, ..., 11111. When not set to 10101, the internal clock that drives the SD_FP_CLK output pad is directly used, this allows delays that are shorter than a board trace would allow since the pad input and output times are avoided.
25:21	SDCLK_OUT	**Delay SDRAM Clock Output.** Add delay to SD_FB_CLK and SDCLK[11:0] outputs: 10101 is no delay, 00000 is shortest, 00001, 00011, ..., 11111.
20:16	MEM_CTL	**Delay Memory Controls.** Add delay to memory controls clock-to-Q output time: 10101 is no delay, 00000 is shortest, ..., 11111.
15:7	RSVD	**Reserved.** Write as read.
6	MEM_ODDOUT	**Delay Odd Memory Data Output Bits.** Add delay to memory data out on odd bits. High value adds a few hundred ps delay on odd memory bit output times. This could be useful for minimizing noise generated by the memory data output pins.
5:4	RSVD	**Reserved.** Write as read.
3:2	DQS_CLK_IN	**Delay DQS Before Clocking Input.** Delay for DQS before clocking input memory data: 00 shortest, 01,10,11. Higher delays allow more skew between DQS and input data from memory.
1:0	DQS_CLK_OUT	**Delay DQS Before Clocking Output.** Delay for DQS before clocking memory data from core: 00 shortest, 01,10,11. Higher delays allow more internal time for signals from NP core logic to reach the pad logic. Increasing this delay effectively increases the clock-to-Q output time of the memory data signals relative to the DQS output during a write.

5.5.2.9 GLCP Clock Control (GLCP_CLKOFF)

MSR Address 4C000010h
Type R/W
Reset Value 00000000_00000000h

This register has bits that, when set, force clocks off using GeodeLink Clock Control (GLCC logic in the system. This is for debugging only, and should not be used for power management.

GLCP Register Descriptions (Continued)

GLCP_CLKOFF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			GLCPDBG	GLCPGL	VPDOT2	VPDOT1	VPDOT0	VPGL1	VPGL0	GLPCIPCIF	GLPCIPCI	GL_GLPCI	GL1_GLIU1	GL0_GLIU1	GIOPCI	GIOGL	DCGL1	DCGL0	DCDOT1	DCDOT0	GL1_GLIU0	GL0_GLIU0	GP	GL_GLMC	DRAM	GL_BC	CPU_BC	CPU_MSS	CPU_IPIPE	FPUFAST	FPUSLOW	

GLCP_CLKOFF Bit Descriptions

Bit	Name	Description
28	GLCPDBG	**GeodeLink Control Processor Debug Clock Off.** When set, disables GLCP DBG logic clock.
27	GLCPGL	**GeodeLink Control Processor GeodeLink Clock Off.** When set, disables GLCP GL clock.
26	VPDOT2	**Video Processor Dot Clock 2 Off.** When set, disables VP DOTCLK 2 (VP_VID).
25	VPDOT1	**Video Processor Dot Clock 1 Off.** When set, disables VP DOTCLK 1 (LCD_PIX).
24	VPDOT0	**Video Processor Dot Clock 0 Off.** When set, disables VP DOTCLK 0 (VP_PIX).
23	VPGL1	**Video Processor GeodeLink Clock 1 Off.** When set, disables VP GL clock 1 (LCD).
22	VPGL0	**Video Processor GeodeLink Clock 0 Off.** When set, disables VP GL clock 0 (VP).
21	GLPCIPCIF	**GeodeLink PCI Bridge Fast-PCI Clock Off.** When set, disables Fast-PCI clock inside GLPCI.
20	GLPCIPCI	**GeodeLink PCI Bridge PCI Clock Off.** When set, disables normal PCI clock inside GLPCI.
19	GL_GLPCI	**GeodeLink Clock to GeodeLink PCI Bridge Clock Off.** When set, disables GL clock from entering GLPCI.
18	GL1_GLIU1	**GeodeLink Clock 1 to GLIU1 Off.** When set, disables main GL clock to GLIU1.
17	GL0_GLIU1	**GeodeLink Clock 0 to GLIU1 Off.** When set, disables GL clock to timer logic of GLIU1.
16	GIOPCI	**Geode I/O Companion PCI Clock Off.** When set, disables GIO PCI clock.
15	GIOGL	**Geode I/O Companion GL Clock Off.** When set, disables GIO GL clock.
14	DCGL1	**Display Controller GeodeLink Clock 1 Off.** When set, disables DC GL clock 1 (VGA).
13	DCGL0	**Display Controller GeodeLink Clock 0 Off.** When set, disables DC GL clock 0 (VG).
12	DCDOT1	**Display Controller Dot Clock 1 Off.** When set, disables DC DOTCLK 1 (VGA).
11	DCDOT0	**Display Controller Dot Clock 0 Off.** When set, disables DC DOTCLK 0 (VG).
10	GL1_GLIU0	**GeodeLink Clock 1 to GLIU0 Off.** When set, disables main GL clock to GLIU0.
9	GL0_GLIU0	**GeodeLink Clock 0 to GLIU0 Off.** When set, disables GL clock to timer logic of GLIU0.
8	GP	**Graphics Processor Clock Off.** When set, disables GP clock.
7	GL_GLMC	**GeodeLink Clock to GeodeLink Memory Controller Off.** When set, disables GL clock to GLMC.
6	DRAM	**DRAM Clocks Off.** When set, disables external DRAM clocks (and, hence, feedback clocks).
5	GL_BC	**GeodeLink Clock to Bus Controller Off.** When set, disables GL clock to the the BC block in the CPU Core.
4	CPU_BC	**CPU Core Clock to Bus Controller Off.** When set, disables the CPU Core clock to the BC block in the CPU Core.

GLCP Register Descriptions (Continued)

GLCP_CLKOFF Bit Descriptions (Continued)

Bit	Name	Description
3	CPU_MSS	**CPU Core Clock to Memory Subsystem Off.** When set, disables the CPU Core clock to MSS block in the CPU Core.
2	CPU_IPIPE	**CPU Core Clock to Instruction Pipeline Off.** When set, disables the CPU Core clock to IPIPE block in the CPU Core.
1	FPUFAST	**Fast FPU Clock Off.** When set, disables the "fast" FPU clock.
0	FPUSLOW	**Slow FPU Clock Off.** When set, disables the "slow" CPU Core clock to FPU.

5.5.2.10 GLCP Clock Active (GLCP_CLKACTIVE)

MSR Address 4C000011h
Type RO
Reset Value Input Determined

GLCP_CLKACTIVE Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			GLCPDBG	GLCPGL	VPDOT2	VPDOT1	VPDOT0	VPGL1	VPGL0	GLPCIPCIF	GLPCIPCI	GL_GLPCI	GL1_GLIU1	GL0_GLIU1	GIOPCI	GIOGL	DCGL1	DCGL0	DCDOT1	DCDOT0	GL1_GLIU0	GL0_GLIU0	GP	GL_GLMC	DRAM	GL_BC	CPU_BC	CPU_MSS	CPU_IPIPE	FPUFAST	FPUSLOW

GLCP_CLKACTIVE Bit Descriptions

Bit	Name	Description
63:29	RSVD	**Reserved.**
28:0	CLKACTIVE	**Clock Active.** This register has bits that, when set, indicate that a block is internally enabling its own clock. The clock inside a block can still be toggling even though the GLCP_CLKACTIVE bit is clear if the local clock gating MSR forces the clock to always be on. Also, the clock can be off even though the GLCP_CLKACTIVE bit is set if the GLCP_CLKOFF bit is set in the GLCP_CLKCTL register.

5.5.2.11 GLCP Clock Mask for Debug Clock Stop Action (GLCP_CLKDISABLE)

MSR Address 4C000012h
Type R/W
Reset Value 00000000_00000000h

GLCP_CLKDISABLE Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

GLCP Register Descriptions (Continued)

GLCP_CLKDISABLE Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** This register is reserved for internal testing only. These bits should not be written to.

5.5.2.12 GLCP Clock Active Mask for Suspend Acknowledge (GLCP_CLK4ACK)

MSR Address 4C000013h
Type R/W
Reset Value 00000000_00000000h

GLCP_CLK4ACK Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD			GLCPDBG	GLCPGL	VPDOT2	VPDOT1	VPDOT0	VPGL1	VPGL0	GLPCIPCIF	GLPCIPCI	GL_GLPCI	GL1_GLIU1	GL0_GLIU1	GIOPCI	GIOGL	DCGL1	DCGL0	DCDOT1	DCDOT0	GL1_GLIU0	GL0_GLIU0	GP	GL_GLMC	DRAM	GL_BC	CPU_BC	CPU_MSS	CPU_IPIPE	FPUFAST	FPUSLOW

GLCP_CLK4ACK Bit Descriptions

Bit	Name	Description
63:29	RSVD	**Reserved.**
28:0	CLK4ACK	**Clock for Acknowledge.** This register has bits that correspond to the Clock Off (CLKOFF) bits in GLCP_CLKOFF. If the bit in GLCP_CLK4ACK is set, then the SUSPA# signal does not go low unless the clock is inactive.

5.5.2.13 GLCP System Reset and PLL Control (GLCP_SYS_RSTPLL)

MSR Address 4C000014h
Type R/W
Reset Value Bootstrap Specific

This register is initialized during POR, but otherwise is not itself reset by any “soft-reset” features. Note that although all PLL and timing control bits can be written and read back the last written data, none of the frequency control bit writes take effect on the system until the CHIP_RESET bit is set (MDIV, VDIV, FBDIV, BYPASS, TST, SDRMODE, VA_SEMI_SYNC_MODE, PCI_SEMI_SYNC_MODE). Writing this register with the CHIP_RESET bit set never sends a write-response over GLIU1.(This allows halting bus traffic before the reset occurs.) Writing to the PD or RESET bits has an immediate effect.

GLCP Register Descriptions (Continued)

GLCP_SYS_RSTPLL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																			MDIV				VDIV			FBDIV					
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SWFLAGS						LOCK	LOCKWAIT	HOLD_COUNT								BYPASS	PD	PLLRESET	TST		SDRMODE	VA_SEMI_SYNC_MODE	PCI_SEMI_SYNC_MODE	BOOTSTRAPS			DOTPOSTDIV3	DOTPREMULT2	DOTPREDIV2	CHIP_RESET	

GLCP_SYS_RSTPLL Bit Descriptions

Bit	Name	Description
63:45	RSVD	**Reserved.** Write as read.
44:41	MDIV	**GLIU1 Divisor.** The divider for the GLIU1 clock. 0000: Divide by 2, ... , 1111: Divide by 17. These bits are read/write but the actual clock divider control is only changed when CHIP_RESET (bit 0) is also set.
40:38	VDIV	**CPU Core Divisor.** The divider setting for the CPU Core clock. 000: Divide by 2 (Default), ..., 111: Divide by 9. These bits are read/write but the actual clock divider control is only changed when CHIP_RESET (bit 0) is also set.
37:32	FBDIV	**Feedback Divisor.** The feedback divider setting for the system PLL are pseudo-random due to the design of the high-speed PLL divider (see Table 5-33 "FBDIV Setting for Desired PLL Divider Results" on page 342 for decode). These bits are read/write but the actual PLL control is only changed when CHIP_RESET (bit 0) is also set.
31:26	SWFLAGS	**Software Flags.** Flags that are reset only by the POR# signal, not the CHIP_RESET. They are reset to 0 and can be used as flags in the boot code that survive CHIP_RESET.
25	LOCK (RO)	**Lock (Read Only).** Lock signal from the system PLL.
24	LOCKWAIT	**Lock Wait.** Allow the chip to release reset when the PLL lock signal is set. 0: Disable (Default). 1: Enable.
23:16	HOLD_COUNT	**Hold Count.** The number of PLL reference clock cycles (multiply by 16) that the PLL is powered down for and also the number before releasing CHIP_RESET (bit 0). (LOCK-WAIT can cause reset to release earlier, but this timeout allows the releasing of reset if lock is not achieved in a certain period). 00000000: Wait 0 clock cycles (Default), 00000001: Wait 1*16 clock cycles..., 11111111: Wait 16*255 clock cycles.
15	BYPASS	**PLL Bypass.** This signal controls the bypass mode of the system PLL. If this bit is high, the DOTREF input clock directly drives the raw system PLL output, bypassing the FBDIV (bits [37:32]) logic. This bit is read/writable but the actual bypass behavior is only changed when CHIP_RESET (bit 0) is also set.
14	PD	**Power Down.** This signal controls the power down mode of the system PLL. It is active high. It has an immediate effect, so it is not recommended unless either BYPASS (bit 15) is set or CHIP_RESET (bit 0) is set. This bit is always cleared by a CHIP_RESET.

GLCP Register Descriptions (Continued)

GLCP_SYS_RSTPLL Bit Descriptions (Continued)

Bit	Name	Description
13	RESETPLL	**PLL Reset.** This signal resets the voltage control setting of the voltage-controlled oscillator on the system PLL. This potentially allows lock to be acquired in the case that the PLL itself has intermittent behavior. It is active high. It has an immediate effect, so it is not recommended unless either BYPASS (bit 15) is set or CHIP_RESET (bit 0) is set. This bit is always cleared by a CHIP_RESET.
12:11	TST	**PLL Test.** These signals control the test signals into the system PLL in order to access internal test points.
10	SDRMODE	**SDR or DDR Mode.** When this signal is active (high), the memory controller output pads are configured for SDR communication and the memory controller control logic is clocked with the GLIU1 clock determined from MDIV. When this signal is low, the memory controller output pads are configured for DDR communication and the memory controller control logic is clocked with a clock running at half of the GLIU1 frequency. This bit is read/writable but the actual memory frequency is only changed when CHIP_RESET is also set.
9	VA_SEMI_ SYNC_MODE	**Synchronous CPU Core and GLIU1.** This bit controls whether the CPU Core processor uses a FIFO for interfacing with GLIU1 or not. If the bit is high, the CPU Core does not use the FIFO; it behaves as if the CPU Core and GLIU1 domains were synchronous. This bit can be set high as long as the CPU Core and GLIU1 frequencies are multiples of each other. The bit always resets low. This bit is read/writable but the actual signal to the CPU Core is only changed when CHIP_RESET (bit 0) is also set
8	PCI_SEMI_ SYNC_MODE	**Synchronous CPU Core and GLIU1.** This bit controls whether the PCI uses the falling edges of MB_FUNC_CLK and PCI_FUNC_CLK for interfacing with GLIU1 or not. If the bit is high, PCI does not use falling clock edges; it behaves as if the CPU Core and GLIU1 domains were synchronous. This bit can be set high as long as the PCI and GLIU1 frequencies are multiples of each other. The bit always resets low. This bit is read/writable but the actual signal to the PCI block is only changed when CHIP_RESET (bit 0) is also set.
7:4	BOOTSTRAPS (RO)	**Bootstrap Status (Read Only).** Stable copies of state of bootstap[3:0] when power-on reset (PCI reset) was released. Bit 7 indicates that the system booted up stalled (for debugging), the other three bits control the initial clock frequencies. The 5th pin bootstrapped during power-on reset, usable as TRST, is not latched.
3	DOTPOSTDIV3	**DOTPLL Post-Divide by 3.** This read/writable bit has an immediate effect on the DOTPLL behavior. It post-divides the PLL output frequency by three. Refer to the GLCP_DOTPLL register for details.
2	DOTPREMULT2	**DOTPLL Pre-Multiply by 2.** This read/writable bit has an immediate effect on the DOTPLL behavior. It pre-multiplies the PLL input frequency by two. Refer to the GLCP_DOTPLL register for details.
1	DOTPREDIV2	**DOTPLL Pre-Divide by 2.** This read/writable bit has an immediate effect on the DOTPLL behavior. It pre-divides the PLL input frequency by two. Refer to the GLCP_DOTPLL register for details.
0	CHIP_RESET	**Chip Reset:** When written to a 1, the chip enters reset and does not come out of reset until the HOLD_COUNT is reached or until the PLL is locked if LOCKWAIT is set. This register and the JTAG logic are not reset by CHIP_RESET, but otherwise the entire chip is reset. (Default = 0.)

Table 5-33. FBDIV Setting for Desired PLL Divider Results

FBDIV	PLL Divide	FBDIV	PLL Divide	FBDIV	PLL Divide	FBDIV	PLL Divide
59	Don't use	48	49	26	33	10	17
55	Don't use	33	48	52	32	21	16
47	Don't use	2	47	41	31	42	15
30	Don't use	5	46	18	30	20	14
60	61	11	45	36	29	40	13
57	60	23	44	8	28	16	12
51	59	46	43	17	27	32	11
39	58	28	42	34	26	0	10
14	57	56	41	4	25	1	9
29	56	49	40	9	24	3	8
58	55	35	39	19	23	7	7
53	54	6	38	38	22	15	6
43	53	13	37	12	21	31	Don't use
22	52	27	36	25	20	62	Don't use
44	51	54	35	50	19	61	Don't use
24	50	45	34	37	18	63	Don't use

Table 5-34. FBDIV Setting to PLL Divide Mapping

FBDIV	PLL Divide	FBDIV	PLL Divide	FBDIV	PLL Divide	FBDIV	PLL Divide
63	Don't use	47	Don't use	31	Don't use	15	6
62	Don't use	46	43	30	Don't use	14	57
61	Don't use	45	34	29	56	13	37
60	61	44	51	28	42	12	21
59	Don't use	43	53	27	36	11	45
58	55	42	15	26	33	10	17
57	60	41	31	25	20	9	24
56	41	40	13	24	50	8	28
55	Don't use	39	58	23	44	7	7
54	35	38	22	22	52	6	38
53	54	37	18	21	16	5	46
52	32	36	29	20	14	4	25
51	59	35	39	19	23	3	8
50	19	34	26	18	30	2	47
49	40	33	48	17	27	1	9
48	49	32	11	16	12	0	10

5.5.2.14 GLCP DOT Clock PLL Control (GLCP_DOTPLL)

MSR Address 4C000015h
Type R/W
Reset Value 000004A7_00008000h

This register does not include HW handshake controls like the GLCP_SYS_PLLRST register, so care should be taken when changing the settings. For example, to change the DIV settings: write the register with the RESET bit set and either in the same write or another write change the DIV settings; read the register until the LOCK bit goes active (or until a timeout occurs, if desired); write the register with the same DIV settings and with the RESET bit clear. The MDIV, NDIV, and PDIV settings work in conjunction with the DOTPOSTDIV3, DOTPREMULT2, DOTPREDIV2 bits in the GLCP_SYS_RSTPLL MSR to create the internal DOTCLK using this equation:

GLCP Register Descriptions (Continued)

$$Fout = Fin \cdot \frac{(NDIV + 1) \cdot 2^{DOTPREMULT2}}{(MDIV + 1) \cdot 2^{PDIV} \cdot 2^{DOTPREDIV2} \cdot 3^{DOTPOSTDIV3}}$$

For example, with bits [44:32] in the GLCP_DOTPLL register set to 0x4A7 (default) and bit 3 in GLCP_SYS_RSTPLL set (not the default), the DOTCLK frequency that DC and VP would run with would be:

$$Fout = 14.318MHz \cdot \frac{(41 + 1) \cdot 2^{0}}{(2 + 1) \cdot 2^{3} \cdot 2^{0} \cdot 3^{1}} = 8.35MHz$$

However, not all M, N, and P settings lock and not all that lock have good long-term jitter characteristics.

The M, N, and P in this register connect directly to the DOTPLL inputs.

GLCP_DOTPLL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																			MDIV				NDIV							PDIV	
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SWFLAGS						LOCK	RSVD									BYPASS	PD	TST			IN27 MHz	RSVD									DOTRESET

GLCP_DOTPLL Bit Descriptions

Bit	Name	Description
63:45	RSVD	**Reserved.** Write as read.
44:41	MDIV	**Input Clock Divisor.** The DOTPLL M setting (resets to VGA timing).
40:34	NDIV	**Dot Clock PLL Divisor.** The DOTPLL N setting (resets to VGA timing).
33:32	PDIV	**Post Scaler Divisor.** The DOTPLL P setting (resets to VGA timing).
31:26	SWFLAGS	**Software Flags.** Unlike in the SYS_RSTPLL register, these bits are reset to 0 by a soft reset to the chip. These bits are otherwise read/writable by software. They are not reset by a DOTRESET.
25	LOCK (RO)	**Lock (Read Only).** Lock signal from the DOTCLK PLL
24:16	RSVD	**Reserved.** Write as read.
15	BYPASS	**Dot PLL Bypass.** This signal controls the bypass mode of the DOTCLK PLL. If this bit is high, the DOTREF input clock directly drives the raw DOTCLK, bypassing the MDIV, NDIV, and PDIV logic.
14	PD	**Power Down.** This bit controls the power down mode of the DOTCLK PLL. It is active high.
13:11	TST	**Test.** These bits control the test signals into the DOTCLK PLL in order to access internal test points.
10	IN27MHZ	**27 MHz Input.** Needs to be set by software if the input clock is 27 MHz instead of 14.318 MHz. Setting this bit allows VGA clock overrides to work correctly.
9:1	RSVD	**Reserved.** Write as read.
0	DOTRESET	**Dot Clock Reset:** The reset pin to the DOTCLK time blocks. The Dot reset is held active when CHIP_RESET is high, but this bit resets to 0. It is recommended that software set this bit when changing PLL settings and observe LOCK before releasing this reset. Unlike the SYS_RSTPLL register, this bit is not required to be set before the other bits in this register affect the PLL.

GLCP Register Descriptions (Continued)

5.5.2.15 GLCP Debug Clock Control (GLCP_DBGCLKCTL)

MSR Address 4C000016h
Type R/W
Reset Value 00000000_00000002h

Note that after the mux to select the clock, a standard MCC clock gate exists. This register should never be changed from one non-zero value to another. Always write this register to 0 when moving to an alternative debug clock.

GLCP_DBGCLKCTL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																													CLKSEL		

GLCP_DBGCLKCTL Bit Descriptions

Bit	Name	Description
63:3	RSVD	**Reserved.** Write as read.
2:0	CLKSEL	**Clock Select.** Selects the clock to drive into the debug logic. 000: None. 001: CPU Core clock. 010: GLIU1 clock. 011: DOTCLK. 100: PCI clock. 101-111: Reserved.

5.5.2.16 Chip Revision ID (GLCP_CHIP_REVID)

MSR Address 4C000017h
Type RO
Reset Value 00000000_000000xxh

GLCP_CHIP_REVID Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								MAJ				MIN			

GLCP_CHIP_REVID Bit Descriptions

Bit	Name	Description
63:8	RSVD	**Reserved.** Reads as 0.
7:4	MAJ	**Major Revision.** Identifies major silicon revision. See *Geode™ GX2 Processor Series Device Errata* document for value.
3:0	MIN	**Minor Revision.** Identifies minor silicon revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

GLCP Register Descriptions (Continued)

5.5.2.17 GLCP Control (GLCP_CNT)

MSR Address 4C000018h
Type R/W - I/O Offset 00h
Reset Value 00000000_000000Fh

This register is used in conjunction with the GLIU1 Power Management described in a separate chapter. I/O writes, which include the lowest byte of this register may trigger an SMI if GLD_MSR_SMI is configured appropriately. MSR writes do not cause SMIs. The throttle sequence starts after the delay specified by GLCP_TH_SD, which can allow for SMI handling time or any other preparations. Throttling is temporarily stopped in IRQ, SSMI, ASMI, or DMI. NMI and system sleep (C2) always clear THT_EN.

GLCP_CNT Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																											THT_EN	CLK_VAL				

GLCP_CNT Bit Descriptions

Bit	Name	Description
63:5	RSVD	**Reserved.** Write as read.
4	THT_EN	**Throttle Enable.** When high, enables throttling of processor for power management. This bit is always cleared by an NMI to the processor or when system sleep initiates, it may clear from an SMI or IRQ depending on GLCP_TH_OD settings.
3:0	CLK_VAL	**Clock Throttling Value.** The value 0000 is reserved and should not be used. The value 0001 yields the most throttling while the value 1111 has the effect of no throttling (1111 is the reset value). Reads return value written. THT_EN must be low to change the value of CLK_VAL. See also GLCP_TH_SF. During processor throttling, processor suspend is applied the amount of time of “(15-CLK_VAL)*GLCP_TH_SF” and then removed the amount of time of “CLK_VAL*GLCP_TH_SF”.

5.5.2.18 GLCP Level 2 (GLCP_LVL2)

MSR Address 4C000019h
Type R/W - I/O Offset 04h
Reset Value 00000000_00000000h

This register has no writable bits. I/O reads to the lower byte of this register (with or without reading the other three bytes) return 0 AND cause the system to enter “C2 processor state” as defined by the GLIU1 power management spec; that is, suspend the processor. I/O reads to the lower byte of this register may trigger an SMI if GLD_MSR_SMI is configured appropriately. Note that the suspend starts after a delay specified by GLCP_TH_SD, which can allow for SMI handling or any other preparations. There is a bit in GLCP_TH_SD that can abort the suspend operation. MSR reads to this register and returns 0, but performs no further action.

5.5.2.19 Reserved

MSR Address 4C00001Ah
Type RO - I/O Offset 08h
Reset Value 00000000_00000000h

This register is reserved for internal use by National.

GLCP Register Descriptions (Continued)

5.5.2.20 Reserved

MSR Address 4C00001Bh
Type R/W - I/O NA
Reset Value 00000000_00000000h

This register is reserved for internal use by National.

5.5.2.21 GLCP Throttle or C2 Start Delay (GLCP_TH_SD)

MSR Address 4C00001Ch
Type R/W - I/O Offset 10h
Reset Value 00000000_00000000h

GLCP_TH_SD Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																			P_LVL2_IN	THT_DELAY											

GLCP_TH_SD Bit Descriptions

Bit	Name	Description
63:13	RSVD	**Reserved.** By convention, always write zero.
12	P_LVL2_IN	**Enable Indicator.** If P_LVL2 was read, then this bit reads high. If this bit is written to a one, the suspend is aborted. This bit is always cleared and suspend de-asserted on NMI, IRQ, SSMI, ASMI, DMI, or system sleep.
11:0	THT_DELAY	**Throttle Delay.** Indicates how long to wait before beginning the processor throttling process as defined by GLCP_CNT. The delay setting is multiplied by 16 to get the number of PCI clock cycles to wait, thus setting THT_DELAY = 3 causes a wait of 48 PCI clock cycles.

5.5.2.22 GLCP Scale factor (GLCP_TH_SF)

MSR Address 4C00001Dh
Type R/W - I/O Offset 14h
Reset Value 00000000_00000000h

GLCP_TH_SF Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																								SCALE							

GLCP_TH_SF Bit Descriptions

Bit	Name	Description
63:8	RSVD	**Reserved.** By convention, always write 0.

GLCP Register Descriptions (Continued)

GLCP_TH_SF Bit Descriptions (Continued)

Bit	Name	Description
7:0	SCALE	**Scale Factor.** This value is used in conjunction with CLK_VAL in the GLCP_CNT MSR. This value times CLK_VAL (or 15-CLK_VAL) indicates the number of PCI clock cycles to wait during processor active (or suspend) periods. The setting is multiplied by 16 to get the number of PCI clock cycles per period, thus SCALE = 3 and CLK_VAL = 5 will have the processor active for 240 PCI clocks and suspended for 480 PCI clocks.

5.5.2.23 GLCP Processor Throttle Off Delay (GLCP_TH_OD)

MSR Address 4C00001Eh
Type R/W - I/O Offset 18h
Reset Value 00000000_00000000h

GLCP_TH_OD Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																IRQ_EN	SMI_EN	OFF_DELAY													

GLCP_TH_OD Bit Descriptions

Bit	Name	Description
63:16	RSVD	**Reserved.** By convention, always write 0.
15	IRQ_EN	**Enable Throttling Restart after IRQ.** If this bit is set and throttling is not disabled during the IRQ handling, throttling restarts after the period specified by OFF_DELAY. If this bit is clear, then an IRQ clears the THT_EN bit in GLCP_CNT.
14	SMI_EN	**Enable Throttling Restart after SMI.** If this bit is set and throttling is not disabled during the SMI handling, throttling restarts after the period specified by OFF_DELAY. If this bit is clear, then an ASMI clears the THT_EN bit in GLCP_CNT.
13:0	OFF_DELAY	**Throttle Off Delay.** Indicates the period to wait from receipt of IRQ or SMI before restarting throttle operation. This setting is multiplied by 16 to get the number of PCI clock cycles to wait.

Note: There is a bit in the CPU Core, which prevents or allows the CPU Core to Suspend during SMIs and DMIs (even synchronous ones). This bit may be useful for power management, but does not affect these registers.

5.6 GEODELINK PCI BRIDGE REGISTER DESCRIPTIONS

All GeodeLink PCI Bridge (GLPCI) registers are Model Specific Registers (MSRs) and are accessed via the RDMSR and WRMSR instructions.

The registers associated with the GLPCI are the Standard GeodeLink Device MSRs and GLPCI Specific MSRs. Table 5-35 and Table 5-36 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

Table 5-35. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
50002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_001050xxh	Page 349
50002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)	00000000_00000000h	Page 349
50002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_0000003Fh	Page 350
50002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_000000037h	Page 351
50002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 352
50002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 353

Table 5-36. GLPCI Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
50002010h	R/W	GLPCI Global Control (CTRL)	44000000_00000000h	Page 354
50002011h	R/W	PCI Arbiter Control (ARB)	00000000_00000000h	Page 358
50002012h	R/W	PCI VPH / PCI Configuration Cycle Control (PBUS)	00FF0000_00000000h	Page 359
50002013h	R/W	Debug Packet Configuration (DEBUG)	00000000_00000000h	Page 360
50002014h	R/W	Fixed Region Enables (REN)	00000000_00000000h	Page 361
50002015h	R/W	Fixed Region Configuration A0-BF (A0)	00000000_00000000h	Page 362
50002016h	R/W	Fixed Region Configuration C0-DF (C0)	00000000_00000000h	Page 363
50002017h	R/W	Fixed Region Configuration E0-FF (E0)	00000000_00000000h	Page 363
50002018h	R/W	Memory Region 0 Configuration (R0)	00000000_00000000h	Page 364
50002019h	R/W	Memory Region 1 Configuration (R1)	00000000_00000000h	Page 365
5000201Ah	R/W	Memory Region 2 Configuration (R2)	00000000_00000000h	Page 365
5000201Bh	R/W	Memory Region 3 Configuration (R3)	00000000_00000000h	Page 366
5000201Ch	R/W	Memory Region 4 Configuration (R4)	00000000_00000000h	Page 367
5000201Dh	R/W	Memory Region 5 Configuration (R5)	00000000_00000000h	Page 368
5000201Eh	R/W	External MSR Access Configuration (EXT-MSR)	00000000_00000000h	Page 369
5000201Fh	R/W	Spare	00000000_00000003h	Page 370

GLPCI Register Descriptions (Continued)

5.6.1 Standard GeodeLink Device MSRs

5.6.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 50002000h
Type RO
Reset Value 00000000_001050xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.** Reserved for future use.
23:8	DEV_ID	**Device ID.** Identifies device (1050h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

5.6.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address 50002001h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_CONFIG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																									PRI			RSVD	PID		

GLD_MSR_CONFIG Register Bit Descriptions

Bit	Name	Description
63:7	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
6:4	PRI	**Priority.** Default priority.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2:0	PID	**Priority ID.** Assigned priority domain.

GLPCI Register Descriptions (Continued)

5.6.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 50002002h
Type R/W
Reset Value 00000000_0000003Fh

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										PARE_ASMI_FLAG	SYSE_ASMI_FLAG	VPHE_SSMI_FLAG	BME_ASMI_FLAG	TARE_ASMI_FLAG	MARE_ASMI_FLAG	RSVD										PARE_ASMI_EN	SYSE_ASMI_EN	VPHE_SSMI_EN	BME_ASMI_EN	TARE_ASMI_EN	MARE_ASMI_EN

GLD_MSR_SMI Register Bit Descriptions

Bit	Name	Description
63:20	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
21	PARE_ASMI_ FLAG	**Parity Error Event Asynchronous SMI Flag.** If high, records that an ASMI was generated due to detection of a PCI bus parity error. Write 1 to clear; writing 0 has no effect. PARE_ASMI_EN (bit 5) must be low to generate ASMI and set flag. Additionally, the PS_ASMI_EN bit in the CTRL register (MSR 50002010h[27]) must be set to enable this event.
20	SYSE_ASMI_ FLAG	**System Error Event Asynchronous SMI Flag.** If high, records that an ASMI was generated due to the detection of a PCI bus system error. Write 1 to clear; writing 0 has no effect. SYSE_ASMI_EN (bit 4) must be low to generate ASMI and set flag. Additionally, the PS_ASMI_EN bit in the CTRL register (MSR 50002010h[27]) must be set to enable this event.
19	VPHE_SSMI_ FLAG	**Virtual PCI Header Event Synchronous SMI Flag.** If high, records that an SSMI was generated due to a flag being set by the Virtual PCI Header support logic. Write 1 to clear; writing 0 has no effect. VPHE_SSMI_EN (bit 3) must be low to generate SSMI and set flag.
18	BME_ASMI_ FLAG	**Broken Master Event Asynchronous SMI Flag.** If high, records that an ASMI was generated due to detection of a broken PCI bus master. Write 1 to clear; writing 0 has no effect. BM_EN (bit 2) must be low to generate ASMI and set flag. Additionally, the BM_ASMI_EN bit in the CTRL register (MSR 50002010h[26]) must be set to enable this event.
17	TARE_ASMI_ FLAG	**Target Abort Received Event Asynchronous SMI Flag.** If high, records that an ASMI was generated due to reception of a target abort on PCI. Write 1 to clear; writing 0 has no effect. TAR_EN (bit 1) must be low to generate ASMI and set flag. Additionally, the TAR_ASMI_EN bit in the CTRL register (MSR 50002010h[25]) must be set to enable this event.
16	MARE_ASMI_ FLAG	**Master Abort Received Event (Read/Write-1-to-Clear).** If high, records that an ASMI was generated due to reception of a master abort on PCI. Write 1 to clear; writing 0 has no effect. MAR_EN (bit 0) must be low to generate ASMI and set flag. Additionally, the MAR_ASMI bit in the CTRL register (MSR 50002010h[24]) must be set to enable this event.
15:5	RSVD	**Reserved.** Write as read.
5	PARE_ASMI_ EN	**Parity Error Event Asynchronous SMI Enable.** Write 0 to enable a parity error event to generate an ASMI and to set flag (bit 21).

GLPCI Register Descriptions (Continued)

GLD_MSR_SMI Register Bit Descriptions

Bit	Name	Description
4	SYSE_ASMI_EN	**System Error Event Asynchronous SMI Enable.** Write 0 to enable a system error event to generate an ASMI and to set flag (bit 20).
3	VPHE_SSMI_EN	**Virtual PCI Header Event Synchronous SMI Enable.** Write 0 to allow SSMI flag to be set in selected GLIU response packets. I/O reads and writes to location CFCh may cause an SSMI depending upon the configuration of this bit and the DEV bits in the PBUS register (MSR 50002012h[31:0]). Writing 0 also enables flag (bit 19) to be set upon event.
2	BME_ASMI_EN	**Broken Master Event Asynchronous SMI Enable.** Write 0 to enable a broken PCI bus master event to generate an ASMI and to set flag (bit 18).
1	TARE_ASMI_EN	**Target Abort Received Event Asynchronous SMI Enable.** Write 0 to enable a target abort received event to generate an ASMI and to set flag (bit 17).
0	MARE_ASMI_EN	**Master Abort Received Event Asynchronous SMI Enable.** Write 0 to enable a master abort received event to generate an ASMI and to set flag (bit 16).

5.6.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 50002003h
Type R/W
Reset Value 00000000_000000037h

GLD_MSR_ERROR Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD										PARE_ERR_FLAG	SYSE_ERR_FLAG	RSVD	BME_ERR_FLAG	TARE_ERR_FLAG	MARE_ERR_FLAG	RSVD										PARE_ERR_EN	SYSE_ERR_EN	RSVD	BME_ERR_EN	TARE_ERR_EN	MARE_ERR_EN

GLD_MSR_ERROR Register Bit Descriptions

Bit	Name	Description
63:22	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
21	PARE_ERR_FLAG	**Parity Error Event Error Flag.** If high, records an ERR occurred due to detection of a PCI bus parity error. Write 1 to clear; writing 0 has no effect. PARE_ERR_EN (bit 5) must be low to generate ERR and set flag. Additionally, the PS_ERR_EN bit in the CTRL register (MSR 50002010h[31]) must be set to enable this event.
20	SYSE_ERR_FLAG	**System Error Event Error Flag.** If high, records an ERR occurred due to detection of a PCI bus system error. Write 1 to clear; writing 0 has no effect. SYSE_ERR_EN (bit 4) must be low to generate ERR and set flag. Additionally, the PS_ERR_EN bit in the CTRL register (MSR 50002010h[31]) must be set to enable this event.
19	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
18	BME_ERR_FLAG	**Broken Master Event Error Flag.** If high, records an ERR occurred due to detection of a broken PCI bus master. Write 1 to clear; writing 0 has no effect. BME_ERR_EN (bit 2) must be low to generate ERR and set flag. Additionally, the BM_ERR_EN bit in the CTRL register (MSR 50002010h[30]) must be set to enable this event.

GLPCI Register Descriptions (Continued)

GLD_MSR_ERROR Register Bit Descriptions

Bit	Name	Description
17	TARE_ERR_ FLAG	**Target Abort Received Event Error Flag.** If high, records an ERR occurred due to the reception of a target abort on PCI. Write 1 to clear; writing 0 has no effect. TARE_ERR_EN (bit 1) must be low to generate ERR and set flag. Additionally, the TAR_ERR_EN bit in the CTRL register (MSR 50002010h[29]) must be set to enable this event.
16	MARE_ERR_ FLAG	**Master Abort Received Event Error Flag.** If high, records an ERR occurred due to the reception of a master abort on PCI. Write 1 to clear; writing 0 has no effect. MAR_EN (bit 0) must be low to generate ERR and set flag. Additionally, the MAR_ERR bit in the CTRL register (MSR 50002010h[28]) must be set to enable this event.
15:6	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
5	PARE_ERR_EN	**Parity Error Event Enable.** Write 0 to enable a parity error event to generate an ERR and to set flag (bit 21).
4	SYSE_ERR_EN	**System Error Event Enable.** Write 0 to enable a system error event to generate an ERR and to set flag (bit 20).
3	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
2	BME_ERR_EN	**Broken Master Event Enable.** Write 0 to enable a broken PCI bus master event to generate an ERR and to set flag (bit 18).
1	TARE_ERR_EN	**Target Abort Received Event Enable.** Write 0 to enable a target abort received event to generate an ERR and to set flag (bit 17).
0	MARE_ERR_ EN	**Master Abort Received Event Enable.** Write 0 to enable a master abort received event to generate an ERR and to set flag (bit 16).

5.6.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 50002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																										PMODE2		PMODE1		PMODE0	

GLD_MSR_PM Register Bit Descriptions

Bit	Name	Description
63:35	RSVD (RO)	**Reserved (Read Only).** Reads as 0.
34:32	RSVD	**Reserved.** Reads as 0.
31:6	RSVD (RO)	**Reserved (Read Only).** Reads as 0.

GLPCI Register Descriptions (Continued)

GLD_MSR_PM Register Bit Descriptions (Continued)

Bit	Name	Description
5:4	PMODE2	**Power Mode 2 (Fast-PCI Clock).** Power mode for Fast-PCI clock domain. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
3:2	PMODE1	**Power Mode 1 (PCI Clock).** Power mode for PCI clock domain. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.
1:0	PMODE0	**Power Mode 0 (GLIU Clock).** Power mode for GLIU clock domain. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

5.6.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address 50002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

GLPCI Register Descriptions (Continued)

5.6.2 GLPCI Specific MSRs

5.6.2.1 GLPCI Global Control (CTRL)

MSR Address 50002010h
Type R/W
Reset Value 44000000_00000000h

CTRL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
FTH				RTH				SBRTH				RTL			DTL			WTO			SLTO	ILTO		LAT					0		
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PS_ERR_EN	BM_ERR_EN	TAR_ERR_EN	MAR_ERR_EN	PS_ASMI_EN	BM_ASMI_EN	TAR_ASMI_EN	MAR_ASMI_EN	SUS				IRFT			IRFC			IOD			ST	ER	RHE	LDE	RUPO	BZ	NI	ISO	OWC	IWC	RSVD	IE	ME

CTRL Register Bit Descriptions

Bit	Name	Description
63:60	FTH	**In-Bound Flush Threshold.** Controls the timing for requesting new read data while concurrently flushing previously prefetched, stale read data. If the number of prefetched 64-bit words reaches this level then a pending request is made.
59:56	RTH	**In-Bound Read Threshold.** Controls the timing for prefetching read data. If the number of prefetched 32-bit WORDs reaches this threshold, a subsequent GLIU request is generated to fetch the next cache line of read data.
55:52	SBRTH	**Southbridge In-Bound Read Threshold.** Controls the timing for prefetching read data for the Southbridge. If the number of prefetched 32-bit WORDs reaches this threshold, a subsequent GLIU request is generated to fetch the next cache-line of read data. The status of the southbridge's GNT# pin (GNT2#) is sampled to determine when the southbridge is generating an in-bound request. When configured to use an external arbiter the REQ2# pin is sampled as a discriminator.
51:49	RTL	**Retry Transaction Limit.** Limits the number of out-bound retries. If a target signals retry indefinitely the PCI interface may be configured to abort the failing out-bound request. 000: No limit 001: 8 retries 010: 16 retries 011: 32 retries 100: 64 retries 101: 128 retries 110: 256 retries 111: 512 retries
48:46	DTL	**Delayed Transaction Limit.** Limits the duration of delayed transactions. Once a read transaction is delayed (retried before the first data phase has completed) all other in-bound transactions are rejected until the original request is satisfied. If the original master stops retrying a livelock condition may occur. If the number of rejected transactions reaches the limit defined by this field, then the delayed transaction is forgotten. 000: No limit 001: 2 rejections 010: 4 rejections 011: 8 rejections 100: 16 rejections 101: 32 rejections 110: 64 rejections 111: 128 rejections

GLPCI Register Descriptions (Continued)

CTRL Register Bit Descriptions (Continued)

Bit	Name	Description
45:43	WTO	**In-Bound Write Timeout.** Controls the flushing of in-bound posted write data. When an in-bound write has completed on the PCI bus an internal counter is loaded with a value derived from this field. It then counts down on each PCI clock edge. When the counter reaches 0, the posted write data is flushed to memory. 000: 4 PCI clock edge 001: 8 PCI clock edges 010: 16 PCI clock edges 011: 32 PCI clock edges 100: 64 PCI clock edges 101: 128 PCI clock edges 110: 256 PCI clock edges 111: No timeout
42	SLTO	**Subsequent Latency Timeout Select.** Specifies the subsequent target latency timeout limit. If, within a burst, the GLPCI module does not respond with the configured number of clock edges, the PCI interface terminates the PCI bus cycle. 0: 8 PCI clock edges 1: 4 PCI clock edges
41:40	ILTO	**Initial Latency Timeout Select.** Specifies the initial target latency timeout limit for the PCI interface. If the GLPCI module does not respond with the first data phase within the configured number of clock edges, the PCI interface terminates the PCI bus cycle. AILTO (MSR 5000201Fh[6]) = 0: 00: 32 PCI clock edges 01: 16 PCI clock edges 10: 8 PCI clock edges 11: 4 PCI clock edges AILTO (MSR 5000201Fh[6]) = 1: 00: 64 PCI clock edges 01: 128 PCI clock edges 10: 256 PCI clock edges 11: No timeout
39:35	LAT	**PCI Latency Timer.** Latency timeout value for limiting bus tenure.
34:32	0 (RO)	**Constant 0 (Read Only).** The three least significant bits of the PCI latency timer field are fixed as zeros. These bits are not used as part of the PCI latency timer comparison.
31	PS_ERR_EN	**Parity/System Error.** Allow detection of either a parity error or a system error to be reported in the PARE_ERR_FLAG bit of GLD_MSR_ERROR (MSR 50002003h[21]). 0: Disable. 1: Enable.
30	BM_ERR_EN	**Broken Master Error.** Allow detection of a broken PCI bus master to be reported in the BME_ERR_FLAG bit of GLD_MSR_ERROR (MSR 50002003h[18]). 0: Disable. 1: Enable.
29	TAR_ERR_EN	**Target Abort Received Error.** Allow reception of a PCI bus target abort to be reported in the TARE_ERR_FLAG bit of GLD_MSR_ERROR (MSR 50002003h[17]). 0: Disable. 1: Enable.
28	MAR_ERR_EN	**Master Abort Received Error.** Allow reception of a PCI bus master abort to be reported in the MARE_ERR_FLAG bit of GLD_MSR_ERROR (MSR 50002003h[16]). 0: Disable. 1: Enable.
27	PS_ASMI_EN	**Parity/System ASMI Enable.** Allow detection of either a parity error or a system error to be reported in the PARE_ASMI_FLAG bit of GLD_MSR_SMI (MSR 50002002h[21]). 0: Disable. 1: Enable.
26	BM_ASMI_EN	**Broken Master ASMI Enable.** Allow detection of a broken PCI bus master to be reported in the BME_ASMI_FLAG bit of GLD_MSR_SMI (MSR 50002002h[18]). 0: Disable. 1: Enable.

GLPCI Register Descriptions (Continued)

CTRL Register Bit Descriptions (Continued)

Bit	Name	Description
25	TAR_ASMI_EN	**Target Abort Received ASMI Enable.** Allow reception of a PCI bus target abort to be reported in the TARE_ASMI_FLAG bit of GLD_MSR_SMI (MSR 50002002h[17]). 0: Disable. 1: Enable.
24	MAR_ASMI_EN	**Master Abort Receive Enable.** Allow reception of a PCI bus master abort to be reported in the TARE_ASMI_FLAG bit of GLD_MSR_SMI (MSR 50002002h[17]). 0: Disable. 1: Enable.
23:21	SUS	**Busy Sustain.** Controls the sustain time for keeping the clocks running after the internal busy signals indicate that the clocks may be gated: 000: No sustain 001: 4 clock cycles 010: 8 clock cycles 011: 16 clock cycles 100: 32 clock cycles 101: 64 clock cycles 110: 128 clock cycles 111: 256 clock cycles
20:18	IRFT	**In-Bound Read Flush Timeout.** Controls the flushing of in-bound prefetch read data. When an in-bound read has completed on the PCI bus an internal counter is loaded with a value derived from this field. It then counts down on each PCI clock edge. When the counter reaches 0, any remaining prefetched data is flushed. The counter stops counting down if a subsequent in-bound read is received. It continues to count down through an in-bound write and through any out-bound traffic: 000: 4 PCI clock edge 001: 8 PCI clock edges 010: 16 PCI clock edges 011: 32 PCI clock edges 100: 64 PCI clock edges 101: 128 PCI clock edges 110: 256 PCI clock edges 111: No timeout
17:16	IRFC	**In-Bound Read Flush Control.** Controls the policy for discarding stale data from in-bound read data FIFO: 00: Discard at end of in-bound read PCI transaction. 01: Discard upon timeout. 10: Discard at start of out-bound write or upon timeout. 11: Discard at start of out-bound write, at start of out-bound read or upon timeout. In addition to these policies in-bound read data is discarded whenever a non-contiguous in-bound read is accepted or when an in-bound write is received that affects the prefetched memory.
15:13	IOD	**I/O Delay.** Delay completion of out-bound I/O transactions for a configurable number of PCI clock cycles: 000: 0 PCI clock cycles 001: 1 PCI clock cycles 010: 2 PCI clock cycles 011: 4 PCI clock cycles 100: 8 PCI clock cycles 101: 16 PCI clock cycles 110: 32 PCI clock cycles 111: 64 PCI clock cycles
12	ST	**Short Timer.** When cleared to 0, delayed transactions are discarded after 2^{15} PCI clock cycles. When set to 1, delayed transactions are discarded after 2^{5} PCI clock cycles. For normal operation this bit should be cleared.
11	ER	**Early Read.** When cleared to 0, out-bound reads are stalled until there is enough FIFO space in the out-bound read FIFO to hold data for the entire transaction. When set to 1, out-bound reads start as soon as possible.
10	RHE	**Read Hints Enable.** When set to 0, all out-bound reads use PCI CMD = 6. When set to 1, the PCI CMD provides a hint about the size of the read request. 6 = 1, 2, or 4 DWORDs E = 8 DWORDs

GLPCI Register Descriptions (Continued)

CTRL Register Bit Descriptions (Continued)

Bit	Name	Description
9	LDE	**Latency Disconnect Enable.** When set to 1, causes the PCI interface to disconnect from a PCI bus master when a latency timer expiration occurs. This enforces the configured minimum latency upon PCI bus masters, where the GLPCI module is a target on the PCI bus. The latency timer must be greater than 0 when using this feature.
8	RUPO	**Relax Up-Stream Ordering.** Removes ordering restrictions for out-bound read response data with respect to in-bound write data. Setting this bit also causes the GLPCI to clear the SEND_RESPONSE flag for in-bound GLIU request packets. This bit should be cleared for normal operation.
7	BZ	**Bizarro Flag.** BIZARRO flag configuration to use on in-bound I/O reads and writes.)
6	NI	**No Invalidate Flag.** Force the INVALIDATE flag to be cleared for all in-bound writes.
5	ISO	**In-Bound Strong Ordering.** Disables the ability of in-bound reads to coherently pass posted in-bound writes. When set to 1, a PCI read request received by the host bridge target is not forwarded to the GLIU until all posted write data has been flushed to memory.
4	OWC	**Out-Bound Write Combining.** Enables concatenation of out-bound write bursts into a larger PCI burst. Setting this bit does NOT add any additional latency to out-bound writes.
3	IWC	**In-Bound Write Combining.** Enables combining of different in-bound PCI write transactions into a single GLIU host write transaction. When cleared to 0, PCI write data received from the host bridge target is NOT held in the posted write buffer; a GLIU transaction is generated immediately.
2	RSVD	**Reserved.** Always write 1.
1	IE	**I/O Enable.** Enable handling of in-bound I/O transactions from the PCI. When set to 1, the PCI interface accepts all in-bound I/O transactions from the PCI. This mode is only intended for design verification purposes. When cleared to 0, no in-bound I/O transactions are accepted.
0	ME	**Memory Enable.** Enable handling of in-bound memory access transaction from the PCI. When cleared to 0, the PCI interface does not accept any in-bound memory transactions from the PCI bus. The set to 1, the PCI interface accepts in-bound memory transactions for those address ranges defined in the region configuration registers.

GLPCI Register Descriptions (Continued)

5.6.2.2 PCI Arbiter Control (ARB)

MSR Address 50002011h
Type R/W
Reset Value 00000000_00000000h

ARB Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD														BM1	BM0	CPRE	RSVD				PRE2	PRE1	PRE0	CRME	RSVD				RME2	RME1	RME0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD					PRCM			RSVD					FPVEC			RSVD				SBCTR			IIE	RMT		CPCTR			EA	BMD	PARK

ARB Register Bit Definitions

Bit	Name	Description
63:50	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
49	BM1 (RO)	**Broken Master 1 (Read Only).** Indicates when a broken master is attached to REQ1#. This bit is set when the arbiter detects that the PCI bus master attached to REQ1# has not asserted FRAME# within 16 PCI clock edges after being granted the PCI bus. This bit is cleared by setting BMD (bit 1) to 1.
48	BM0 (RO)	**Broken Master 0 (Read Only).** Indicates when a broken master is attached to REQ[0]#. This bit is set when the arbiter detects that the PCI bus master attached to REQ[0]# has not asserted FRAME# within 16 PCI clock edges after being granted the PCI bus. This bit is cleared by setting BMD (bit 1) bit to 1.
47	CPRE	**CPU Preemption Enable.** When set to 1, the CPU's PCI grant may be de-asserted before the CPU's request is de-asserted.
46:43	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
42	PRE2	**Preemption Enable 2.** When set to 1, GNT2# may be de-asserted before REQ2# is de-asserted.
41	PRE1	**Preemption Enable 1.** When set to 1, GNT1# may be de-asserted before REQ1# is de-asserted.
40	PRE0	**Preemption Enable 0.** When set to 1, GNT0# may be de-asserted before REQ0# is de-asserted.
39	CRME	**CPU Retry Mask Enable.** When set to 1, CPU requests are masked following a retry termination of a PCI bus cycle initiated by the host PCI bridge master.
38:35	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
34	RME2	**Retry Mask Enable 2.** When set to 1, REQ2# is masked following a retry termination of a cycle initiated by that master.
33	RME1	**Retry Mask Enable 1.** When set to 1, REQ1# is masked following a retry termination of a cycle initiated by that master.
32	RME0	**Retry Mask Enable 0.** When set to 1, REQ0# is masked following a retry termination of a cycle initiated by that master.
31:27	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
26:24	PRCM	**Priority Rotation Control Mask.** When these bits are set to 000, all of the arbiter priority vector bits are allowed to rotate. When these bits are set to 111, all of the arbiter priority vector bits are fixed to the values in the Fixed Priority Vector (FPVEC) field (bits 18:16]). Any other value results in a hybrid priority scheme, where the arbiter priority vector bits corresponding to the mask bits set to 1 are fixed to the values in the FPVEC and all other bits are allowed to rotate.
23:19	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.

GLPCI Register Descriptions (Continued)

ARB Register Bit Definitions (Continued)

Bit	Name	Description
18:16	FPVEC	**Fixed Priority Vector.** This field is used to specify the fixed priority values for the PCI arbiter. This value is not used when the PRCM field (bits [26:24]) is cleared to 000.
15:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
11:9	SBCTR	**South Bridge Priority Counter.** Controls the frequency with which the south bridge is given top priority among the external PCI devices. This field specifies the number of external PCI grants that must occur before the south bridge is given top priority for the next arbitration cycle. Note that if this field is set to a value of N, N + 1 external PCI grants are allowed before the south bridge is given top priority.
8	IIE	**Insert Idle Enable.** When set to 1, where all GNT# pins are high, at least one idle cycle is inserted between each switch of granted PCI masters. When cleared to 0, grant may be simultaneously removed from one PCI master and granted to another PCI master in the same cycle; where allowed by the PCI specification.
7:6	RMT	**Retry Mask Timer.** Specifies the number of PCI clock edges that a master's request line masks off from arbitration following a retry termination of a cycle initiated by that master. 00: Mask for 8 PCI clock edges 01: Mask for 16 PCI clock edges 10: Mask for 32 PCI clock edges 11: Mask for 64 PCI clock edges
5:3	CPCTR	**CPU Priority Counter.** Controls the frequency with which the CPU is given top priority in the PCI arbiter. This field specifies the number of external PCI grants that must occur before the CPU is given top priority for the next arbitration cycle. Note that if this field is set to a value of N, N + 1 external PCI grants are allowed before the CPU is given top priority.
2	EA	**External Arbiter.** Enables use of an external arbiter instead of the internal arbiter. When set to 1, the CPU request signal is routed to the GNT0#/EXT_REQ# pin and the REQ0#/EXT_GNT# pin is routed to the CPU grant signal. If an external arbiter is used the clock for the Fast-PCI clock domain should not be gated.
1	BMD	**Broken Master Timer Disable.** Controls the operation of the broken master detector in the PCI arbiter. When set to 1, the arbiter does not recognize a broken master condition on the PCI bus. When cleared to 0, the arbiter detects a broken master condition when a granted PCI bus master takes 16 or more clock cycles before asserting FRAME#. The broken master is NOT allowed to gain access to the PCI bus. Software may restore any broken master's permission to use the PCI bus by clearing this bit and, optionally, setting it again.
0	PARK	**Parking Policy.** When cleared to 0, the arbiter always parks the PCI bus on the GX2. When set to 1, the arbiter parks the PCI bus on the last granted bus master. If this bit is set, the clock for the Fast-PCI clock domain should not be gated.

5.6.2.3 PCI VPH / PCI Configuration Cycle Control (PBUS)

MSR Address 50002012h
Type R/W
Reset Value 00FF0000_00000000h

The PBUS MSR is used to control the way that the GLPCI module generates (or does not generate) PCI configuration cycles onto the PCI bus. The SEC field (bits [39:32]) should be configured with the PCI bus number for the locally attached PCI bus. The SUB field (bits [55:48] should be configured with the PCI bus number for the highest numbered PCI bus that is accessible via this interface. The DEV field (bits [31:0]) should be configured to indicate which devices numbers do NOT generate PCI configuration cycles on the PCI bus.

GLPCI Register Descriptions (Continued)

PBUS Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD								SUB								RSVD								SEC							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DEV																															

PBUS Register Bit Descriptions

Bit	Name	Description
63:56	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
55:48	SUB	**Subordinate Bus Number.** Specifies the subordinate PCI bus number for all PCI buses reachable via this PCI interface.
47:40	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
39:32	SEC	**Secondary Bus Number.** Specifies the secondary PCI bus number for this PCI interface.
31:0	DEV	**Device Bitmap.** Specifies the virtualized PCI devices. Each bit position corresponds to a device number. A 0 instructs the GLPCI to allow PCI configuration cycles for the device to be generated on the PCI bus. A 1 tells the GLPCI to virtualize the device by generating an SSMI instead of a PCI configuration cycle.

5.6.2.4 Debug Packet Configuration (DEBUG)

MSR Address 50002013h
Type R/W
Reset Value 00000000_00000000h

Debug register, National internal use only.

DEBUG Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																															

DEBUG Register Bit Descriptions

Bit	Name	Description
63:0	RSVD	**Reserved.** These bits are reserved for internal testing only. These bits should not be written to.

GLPCI Register Descriptions (Continued)

5.6.2.5 Fixed Region Enables (REN)

MSR Address 50002014h
Type R/W
Reset Value 00000000_00000000h

REN Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
Spare																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								FC	F8	F4	F0	EC	E8	E4	E0	DC	D8	D4	D0	CC	C8	C4	C0	BC	B8	B4	B0	AC	A8	A4	A0

REN Register Bit Descriptions

Bit	Name	Description
63:32	Spare	**Spare Bits.** Extra bits available for future use. These bits may be set and cleared, but do not control anything.
31:24	RSVD (RO)	**Reserved (Read Only).** Reads return 0.
23	FC	**FC Enable.** Enables memory access to FC000 through FFFFF from PCI.
22	F8	**F8 Enable.** Enables memory access to F8000 through FBFFF from PCI.
21	F4	**F4 Enable.** Enables memory access to F4000 through F7FFF from PCI.
20	F0	**F0 Enable.** Enables memory access to F0000 through F3FFF from PCI.
19	EC	**EC Enable.** Enables memory access to EC000 through EFFFF from PCI.
18	E8	**E8 Enable.** Enables memory access to E8000 through EBFFF from PCI.
17	E4	**E4 Enable.** Enables memory access to E4000 through E7FFF from PCI.
16	E0	**E0 Enable.** Enables memory access to E0000 through E3FFF from PCI.
15	DC	**DC Enable.** Enables memory access to DC000 through DFFFF from PCI.
14	D8	**D8 Enable.** Enables memory access to D8000 through DBFFF from PCI.
13	D4	**D4 Enable.** Enables memory access to D4000 through D7FFF from PCI.
12	D0	**D0 Enable.** Enables memory access to D0000 through D3FFF from PCI.
11	CC	**CC Enable.** Enables memory access to CC000 through CFFFF from PCI.
10	C8	**C8 Enable.** Enables memory access to C8000 through CBFFF from PCI.
9	C4	**C4 Enable.** Enables memory access to C4000 through C7FFF from PCI.
8	C0	**C0 Enable.** Enables memory access to C0000 through C3FFF from PCI.
7	BC	**BC Enable.** Enables memory access to BC000 through BFFFF from PCI.
6	B8	**B8 Enable.** Enables memory access to B8000 through BBFFF from PCI.
5	B4	**B4 Enable.** Enables memory access to B4000 through B7FFF from PCI.
4	B0	**B0 Enable.** Enables memory access to B0000 through B3FFF from PCI.
3	AC	**AC Enable.** Enables memory access to AC000 through AFFFF from PCI.
2	A8	**A8 Enable.** Enables memory access to A8000 through ABFFF from PCI.
1	A4	**A4 Enable.** Enables memory access to A4000 through A7FFF from PCI.
0	A0	**A0 Enable.** Enables memory access to A0000 through A3FFF from PCI.

Table 5-37. Region Properties

Bit	Name	Description
7:6	RSVD	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

5.6.2.6 Fixed Region Configuration A0-BF (A0)

MSR Address 50002015h
Type R/W
Reset Value 00000000_00000000h

A0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
BC								B8								B4								B0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
AC								A8								A4								A0							

A0 Register Bit Descriptions

Bit	Name	Description (Note 1)
63:56	BC	**BC Properties.** Region properties for BC000 through BFFFF.
55:48	B8	**B8 Properties.** Region properties for B8000 through BBFFF.
47:40	B4	**B4 Properties.** Region Properties for B4000 through B7FFF.
39:32	B0	**B0 Properties.** Region properties for B0000 through B3FFF.
31:24	AC	**AC Properties.** Region properties for AC000 through AFFFF.
23:16	A8	**A8 Properties.** Region Properties for A8000 through ABFFF.
15:8	A4	**A4 Properties.** Region Properties for A4000 through A7FFF.
7:0	A0	**A0 Properties.** Region properties for A0000 through A3FFF.

Note1. See Table 5-37 for region properties bit decodes.

GLPCI Register Descriptions (Continued)

5.6.2.7 Fixed Region Configuration C0-DF (C0)

MSR Address 50002016h
Type R/W
Reset Value 00000000_00000000h

C0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
DC								D8								D4								D0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CC								C8								C4								C0							

C0 Register Bit Descriptions

Bit	Name	Description (Note 1)
63:56	DC	**DC Properties.** Region properties for DC000 through DFFFF.
55:48	D8	**D8 Properties.** Region properties for D8000 through DBFFF.
47:40	D4	**D4 Properties.** Region Properties for D4000 through D7FFF.
39:32	D0	**D0 Properties.** Region properties for D0000 through D3FFF.
31:24	CC	**CC Properties.** Region properties for CC000 through CFFFF.
23:16	C8	**C4 Properties.** Region Properties for C8000 through CBFFF.
15:8	C4	**C4 Properties.** Region Properties for C4000 through C3FFF.
7:0	C0	**C0 Properties.** Region properties for C0000 through C3FFF.

Note1. See Table 5-37 on page 362 for region properties bit decodes.

5.6.2.8 Fixed Region Configuration E0-FF (E0)

MSR Address 50002017h
Type R/W
Reset Value 00000000_00000000h

E0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
FC								F8								F4								F0							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EC								E8								E4								E0							

E0 Register Bit Descriptions

Bit	Name	Description (Note 1)
63:56	FC	**FC Properties.** Region properties for FC000 through FFFFF.
55:48	F8	**F8 Properties.** Region properties for F8000 through FBFFF.
47:40	F4	**F4 Properties.** Region Properties for F4000 through F7FFF.
39:32	F0	**F0 Properties.** Region properties for F0000 through F3FFF.
31:24	EC	**EC Properties.** Region properties for EC000 through EFFFF.
23:16	E8	**E4 Properties.** Region Properties for E8000 through EBFFF.
15:8	E4	**E4 Properties.** Region Properties for E4000 through E3FFF.

GLPCI Register Descriptions (Continued)

E0 Register Bit Descriptions

Bit	Name	Description (Note 1)
7:0	E0	**E0 Properties.** Region properties for E0000 through E3FFF.

Note1. See Table 5-37 on page 362 for region properties bit decodes.

5.6.2.9 Memory Region 0 Configuration (R0)

MSR Address 50002018h
Type R/W
Reset Value 00000000_00000000h

R0 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R0 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**PreFetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for NSC internal use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

GLPCI Register Descriptions (Continued)

5.6.2.10 Memory Region 1 Configuration (R1)

MSR Address 50002019h
Type R/W
Reset Value 00000000_00000000h

R1 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R1 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

5.6.2.11 Memory Region 2 Configuration (R2)

MSR Address 5000201Ah
Type R/W
Reset Value 00000000_00000000h

R2 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R2 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.

GLPCI Register Descriptions (Continued)

R2 Register Bit Descriptions(Continued)

Bit	Name	Description
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

5.6.2.12 Memory Region 3 Configuration (R3)

MSR Address 5000201Bh
Type R/W
Reset Value 00000000_00000000h

R3 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R3 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

GLPCI Register Descriptions (Continued)

5.6.2.13 Memory Region 4 Configuration (R4)

MSR Address 5000201Ch
Type R/W
Reset Value 00000000_00000000h

R4 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R4 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

GLPCI Register Descriptions (Continued)

5.6.2.14 Memory Region 5 Configuration (R5)

MSR Address 5000201Dh
Type R/W
Reset Value 00000000_00000000h

R5 Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
TOP																				RSVD											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BASE																				RSVD			EN	RSVD		PF	WC	RSVD	WP	RSVD	CD

R5 Register Bit Descriptions

Bit	Name	Description
63:44	TOP	**Top of Region.** 4 kB granularity, inclusive.
43:32	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
31:12	BASE	**Base of Region.** 4 kB granularity, inclusive.
11:9	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
8	EN	**Region Enable.** Set to 1 to enable access to this region.
7:6	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
5	PF	**Prefetchable.** Reads to this region have no side-effects.
4	WC	**Write Combine.** Writes to this region may be combined.
3	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
2	WP	**Write Protect.** When set to 1, only read accesses are allowed. Write accesses are ignored (master abort).
1	RSVD	**Reserved.** Reserved for internal National use. Always clear this bit to 0.
0	CD	**Cache Disable.** When set to 1, accesses are marked as non-coherent. When cleared to 0, accesses are marked as coherent.

GLPCI Register Descriptions (Continued)

5.6.2.15 External MSR Access Configuration (EXTMSR)

MSR Address 5000201Eh
Type R/W
Reset Value 00000000_00000000h

Note that MSR accesses addressed to Port 0 are handled directly by the GLPCI module.

EXTMSR

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD								FUNC-7			DEVICE-7					FUNC-6			DEVICE-6					FUNC-5			DEVICE-5				
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
FUNC-4			DEVICE-4					FUNC-3			DEVICE-3					FUNC-2			DEVICE-2					FUNC-1			DEVICE-1				

EXTMSR Register Bit Descriptions

Bit	Name	Description
63:56	RSVD (RO)	**Reserved (Read Only).** Reserved for future use.
55:53	FUNC-7	**Function Number 7.** PCI function number to use for MSR accesses addressed to Port 7.
52:48	DEVICE-7	**Device Number 7.** PCI device number to use for MSR accesses addressed to Port 7.
47:45	FUNC-6	**Function Number 6.** PCI function number to use for MSR accesses addressed to Port 6.
44:40	DEVICE-6	**Device Number 6.** PCI device number to use for MSR accesses addressed to Port 6.
39:37	FUNC-5	**Function Number 5.** PCI function number to use for MSR accesses addressed to Port 5.
36:32	DEVICE-5	**Device Number 5.** PCI device number to use for MSR accesses addressed to Port 5.
31:29	FUNC-4	**Function Number 4.** PCI function number to use for MSR accesses addressed to Port 4.
28:24	DEVICE-4	**Device Number 4.** PCI device number to use for MSR accesses addressed to Port 4.
23:21	FUNC-3	**Function Number 3.** PCI function number to use for MSR accesses addressed to Port 3.
20:16	DEVICE-3	**Device Number 3.** PCI device number to use for MSR accesses addressed to Port 3.
15:13	FUNC-2	**Function Number 2.** PCI function number to use for MSR accesses addressed to Port 2.
12:8	DEVICE-2	**Device Number 2.** PCI device number to use for MSR accesses addressed to Port 2.
7:5	FUNC-1	**Function Number 1.** PCI function number to use for MSR accesses addressed to Port 1.
4:0	DEVICE-1	**Device Number 1.** PCI device number to use for MSR accesses addressed to Port 1.

GLPCI Register Descriptions (Continued)

5.6.2.16 Spare

MSR Address 5000201Fh
Type R/W
Reset Value 00000000_00000003h

Spare

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
Spare																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Spare																									AILTO	PPD	PPC	MPC	MME	NSE	SUPO

Spare Register Bit Descriptions

Bit	Name	Description
63:7	Spare	**Spare Bits.** Extra bits available for future use. These bits may be set and cleared, but do not control anything.
6	AILTO	**Alternate Initial Latency Timeout.** Enables use of alternate timeout values for initial latency timeouts. See the description of the ILTO bit field (MSR 50002010h[40:41]) for more information.
5	PPD	**Post PIO Data.** Enables posting of I/O writes to addresses 170h and 1F0h.
4	PPC	**Post PIO Control.** Enables posting of I/O writes to addresses 171h, 172h, 173h, 174h, 175h, 176h, 177h, 1F1h, 1F2h, 1F3h, 1F4h, 1F5h, 1F6h, and 1F7h.
3	MPC	**Maximum Posted Count.** Controls the maximum number of PIO I/O writes that may be posted in the GLPCI. 0: One I/O write may be posted. 1: Two I/O writes may be posted.
2	MME	**Mask External MSR Exceptions:** Set to 1 to force the GLIU synchronous exception flag to be cleared for all external MSR transactions.
1	NSE	**No Synchronous Exceptions.** Controls when out-bound read data is written into the OBRD FIFO. When this bit is cleared, the GLPCI delays the writing of all out-bound read data into the FIFO by one clock cycle. This allows PCI transaction status to be sampled and included synchronously with the read data. When this bit is set, the GLPCI only delays read data for external MSR accesses and I/O read of the configuration data port (CFCh).
0	SUPO	**Strict Up-Stream Ordering.** Controls how out-bound reads get sorted with in-bound writes. When this bit is set, the ordering rules are strictly applied; meaning that all GLIU write responses associated with an in-bound PCI write transaction must complete before data from a subsequent out-bound PCI read may be placed onto the GLIU. When this bit is cleared, the out-bound read data may be placed onto the GLIU after the in-bound write data has been placed onto the GLIU.

5.7 GEODE I/O COMPANION REGISTER DESCRIPTIONS

All Geode I/O (GIO) Companion registers are Model Specific Registers (MSRs) and are accessed via the RDMSR and WRMSR instructions.

The registers associated with the GIO are the Standard GeodeLink Device MSRs and GIO Specific MSRs. Table 5-38 and Table 5-39 are register summary tables that include reset values and page references where the bit descriptions are provided.

Note: The MSR address is derived from the perspective of the CPU Core. See Section 3.1 "GX2 MSR Set" on page 54 for more details on MSR addressing.

Table 5-38. Standard GeodeLink Device MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
54002000h	RO	GeodeLink Device Capabilities MSR (GLD_MSR_CAP)	00000000_000F00xxh	Page 372
54002001h	R/W	GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG) - Not Used.	00000000_00000000h	Page 372
54002002h	R/W	GeodeLink Device SMI MSR (GLD_MSR_SMI)	00000000_00000000h	Page 373
54002003h	R/W	GeodeLink Device Error MSR (GLD_MSR_ERROR)	00000000_00000000h	Page 374
54002004h	R/W	GeodeLink Device Power Management MSR (GLD_MSR_PM)	00000000_00000000h	Page 375
54002005h	R/W	GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)	00000000_00000000h	Page 375

Table 5-39. GIO Specific MSRs Summary

MSR Address	Type	Register	Reset Value	Reference
54002010h	R/W	Geode I/O Companion Selection (GIO_MSR_SEL)	00000000_00000000h	Page 376

GIO Register Descriptions (Continued)

5.7.1 Standard GeodeLink Device MSRs

5.7.1.1 GeodeLink Device Capabilities MSR (GLD_MSR_CAP)

MSR Address 54002000h
Type RO
Reset Value 00000000_000F00xxh

GLD_MSR_CAP Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD								DEV_ID																REV_ID							

GLD_MSR_CAP Register Bit Descriptions

Bit	Name	Description
63:24	RSVD	**Reserved.**
23:8	DEV_ID	**Device ID.** Identifies device (0F00h).
7:0	REV_ID	**Revision ID.** Identifies device revision. See *Geode™ GX2 Processor Series Device Errata* document for value.

5.7.1.2 GeodeLink Device Master Configuration MSR (GLD_MSR_CONFIG)

MSR Address 54002001h
Type R/W
Reset Value 00000000_00000000h

This register is not used in the GIO module.

GIO Register Descriptions (Continued)

5.7.1.3 GeodeLink Device SMI MSR (GLD_MSR_SMI)

MSR Address 54002002h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_SMI Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																														GIO_ASMI_FLAG	UNEXP_TYPE_SSMI_FLAG
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														GIO_ASMI_EN	UNEXP_TYPE_SSMI_EN

GLD_MSR_SMI Register Bit Descriptions

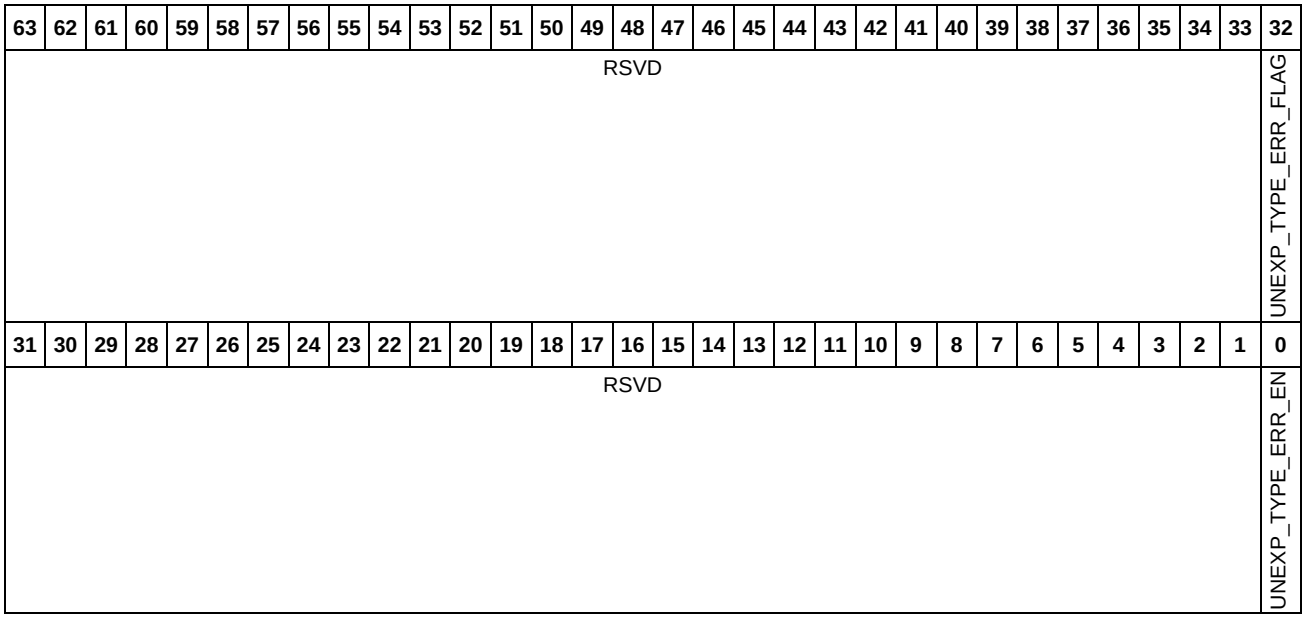
Bit	Name	Description
63:34	RSVD	**Reserved.** Write as read.
33	GIO_ASMI_ FLAG	**Geode I/O Companion Asynchronous SMI Flag.** If high, records that an ASMI was generated due to a Geode I/O Companion event. Write 1 to clear; writing 0 has no effect. GIO_ASMI_EN (bit 1) must be low to generate ASMI and set flag.
32	UNEXP_TYPE_ SSMI_FLAG	**Unexpected Type Synchronous SMI Flag.** If high, records that an SSMI was generated due to an unexpected type event. Write 1 to clear; writing 0 has no effect. UNEXP_TYPE_SSMI_EN (bit 0) must be low to generate SSMI and set flag.
31:2	RSVD	**Reserved.** Write as read.
1	GIO_ASMI_EN	**Geode I/O Companion Asynchronous SMI Flag.** Write 0 to allow a Geode I/O Companion event to generate an ASMI and set flag (bit 33).
0	UNEXP_TYPE_ SSMI_EN	**Unexpected Type Synchronous SMI Flag.** Write 0 to enable an unexpected type event to generate and SSMI and set flag (bit 32).

GIO Register Descriptions (Continued)

5.7.1.4 GeodeLink Device Error MSR (GLD_MSR_ERROR)

MSR Address 54002003h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_ERROR Register Map



GLD_MSR_ERROR Register Bit Descriptions

Bit	Name	Description
63:33	RSVD	**Reserved.** Write as read.
32	UNEXP_TYPE_ ERR_FLAG	**Unexpected Type Error Flag.** If high, records that an ERR was generated due to an unexpected type event. Write 1 to clear; writing 0 has no effect. UNEXP_TYPE_ERR_EN (bit 0) must be low to generate ERR and set flag.
31:1	RSVD	**Reserved.** Write as read.
0	UNEXP_TYPE_ ERR_EN	**Unexpected Type Error Enable.** Write 0 to allow an ERR to be generated due to an unexpected type event and set flag (bit 32).

GIO Register Descriptions (Continued)

5.7.1.5 GeodeLink Device Power Management MSR (GLD_MSR_PM)

MSR Address 54002004h
Type R/W
Reset Value 00000000_00000000h

GLD_MSR_PM Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														PMODE_0	

GLD_MSR_PM Register Bit Descriptions

Bit	Name	Description
63:33	RSVD	**Reserved.** Write as read.
32	RSVD	**Reserved.** Write as 0.
31:2	RSVD	**Reserved.** Write as read.
1:0	PMODE_0	**Power Mode 0.** Online GLIU logic. 00: Disable clock gating. Clocks are always on. 01: Enable active hardware clock gating. Clock goes off whenever this module's circuits are not busy. 10: Reserved. 11: Reserved.

5.7.1.6 GeodeLink Device Diagnostic MSR (GLD_MSR_DIAG)

MSR Address 54002005h
Type R/W
Reset Value 00000000_00000000h

This register is reserved for internal use by National and should not be written to.

GIO Register Descriptions (Continued)

5.7.2 GIO Specific MSRs

5.7.2.1 Geode I/O Companion Selection (GIO_MSR_SEL)

MSR Address 54002010h
Type R/W
Reset Value 00000000_00000000h

GIO_MSR_SEL Register Map

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
RSVD																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD																														MSR_IIOC	

GIO_MSR_SEL Register Bit Descriptions

Bit	Name	Description
63:2	RSVD	**Reserved.** Write as read.
1:0	MSR_IIOC	**IIOC Mode.** I/O companion mode. 00: Reserved. 01: CS5535. 10: Reserved. 11: Reserved for future expansion.

6.0 Electrical Specifications

This section provides information on electrical connections, absolute maximum ratings, operating conditions, and DC/AC characteristics for the Geode GX2 processor. All voltage values in the electrical specifications are with respect to V_{SS} unless otherwise noted.

6.1 ELECTRICAL CONNECTIONS

6.1.1 Power/Ground Connections and Decoupling

Testing and operating the GX2 processor requires the use of standard high frequency techniques to reduce parasitic effects. When using this device, the effects can be minimized by filtering the DC power leads with low-inductance decoupling capacitors, using low-impedance wiring, and by connecting all V_{CORE}, V_{IO}, and V_{MEM} balls to the appropriate voltage levels.

6.1.2 NC-Designated Balls

Balls designated as NC (No Connection) must be left disconnected. Connecting an NC ball to a pull-up/-down resistor, or an active signal could cause unexpected results and possible circuit malfunctions.

6.1.3 Unused Inputs

All inputs not used by the system designer must be kept at either ground or V_{IO}. To prevent possible spurious operation, connect active-high inputs to ground through a 20 kΩ (±10%) pull-down resistor and active-low inputs to V_{IO} through a 20 kΩ (±10%) pull-up resistor.

6.2 ABSOLUTE MAXIMUM RATINGS

Table 6-1 lists absolute maximum ratings for the GX2 processor. Stresses beyond the listed ratings may cause permanent damage to the device. Exposure to conditions beyond these limits may (1) reduce device reliability and (2) result in premature failure even when there is no immediately apparent sign of failure. Prolonged exposure to conditions at or near the absolute maximum ratings may also result in reduced useful life and reliability. These are stress ratings only and do not imply that operation under any conditions other than those listed in Table 6-2 "Operating Conditions" is possible.

6.3 OPERATING CONDITIONS

Table 6-2 lists the operating conditions for the GX2 processor.

Table 6-1. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit	Comments
$T_{STORAGE}$	Storage Temperature	-65	150	°C	No Bias
V_{CORE}	Core Supply Voltage		1.6	V	
V_{IO}	I/O Supply Voltage		3.6	V	
V_{MEM}	Memory Supply Voltage		3.6	V	
V_{MAX}	Voltage on any pin	-0.5	3.6	V	Except HSYNC, VSYNC
	Voltage on HSYNC, VSYNC	-0.5	5.5	V	
	ESD - Human Body Model		2000	V	
	ESD - Machine Model		200	V	

Table 6-2. Operating Conditions

Symbol	Parameter	Min	Max	Unit	Comments
T_C	Operating Case Temperature	0	85	°C	
V_{CORE}	Core Supply Voltage (1.5V Nominal)	1.42	1.58	V	Note 1
V_{IO}	I/O Supply Voltage (3.3V Nominal)	3.14	3.46	V	Filtered version of this supply also supplies PLL and DAC power. Note 1
V_{MEM}	GX2-DDR (2.5V)	2.38	2.62	V	Note 1
	GX2-SDR (3.3V)	3.14	3.46	V	Note 1
MVREF	GX2-DDR (1.25V Nominal)	1.19	1.31	V	Note 1
	GX2-SDR (1.65V Nominal)	1.57	1.73	V	Note 1

Note 1. This parameter is specified as nominal ±5%.

Electrical Specifications (Continued)

6.4 DC CURRENT

DC current is not a simple measurement. Three of the GX2 power states (On, Active Idle, and Sleep) were selected for measurement. For each power state measured, two functional characteristics (Typical Average and Absolute Maximum) are used to determine how much current the GX2 uses.

6.4.1 Power State Parameter Definitions

The DC current tables in this section list Core and I/O current for three of the power states.

- **On (S0/C0)**: All internal and external clocks with respect to the GX2 are running and all functional blocks (CPU Core, Memory Controller, Display Controller, etc.) are actively generating cycles. This is equivalent to the ACPI specification's "S0/C0" state.
- **Active Idle (S0/C1)**: The CPU Core has been halted, all other functional blocks (including the Display Controller for refreshing the display) are actively generating cycles. This state is entered when a HLT instruction is executed by the CPU Core. From a user's perspective, this state is indistinguishable from the On state and is equivalent to the ACPI specification's "S0/C1" state.
- **Sleep (S1)**: This is the lowest power state the GX2 can be in with voltage still applied to the device's core and I/O supply pins. This is equivalent to the ACPI specification's "S1" state.

6.4.2 Definition and Measurement Techniques of GX2 Current Parameters

The following two parameters describe the GX2 current while in the On state:

Typical Average

Typical Average (Typ Avg) indicates the average current used by the GX2 while in the On state. This is measured by running typical Microsoft Windows applications in a typical display mode with a background of vertical stripes (4-pixel wide) alternating between black and white with power management disabled (to guarantee that the GX2 never goes into the Active Idle state). The resolution of 1024x768x16 bpp, 85 Hz refresh is used for CRT and 800x600x16 bpp, 60 Hz refresh is used for TFT. The measurements are broken out separately for DDR and SDR SDRAM configurations. This number is provided for reference only since it can vary greatly depending on the usage model of the system.

Note: This Typ Avg should not be confused with the typical power numbers. Typical power is based on a combination of On (Typ Avg) and Active Idle states.

Absolute Maximum

Absolute Maximum (Abs Max) indicates the maximum instantaneous current used by the GX2. CPU Core current is measured by running the Landmark Speed 200 benchmark test (with power management disabled) and measuring the peak current at any given instant during the test. I/O current is measured by running Microsoft Windows 98 with a background image of vertical stripes (1-pixel wide) alternating between black and white. The resolution of 1600x1200x16 bpp, 85 Hz refresh is used for CRT and 1600x1200x16 bpp, 60 Hz refresh is used for TFT. The measurements are broken out separately for DDR and SDR SDRAM configurations.

6.4.3 Definition of System Conditions for Measuring On Parameters

The GX2's current is highly dependent on two functional characteristics, DOTCLK (Dot Clock) frequency and SDRAM type/frequency (DDR or SDR). Table 6-3 on page 379 shows how these factors are controlled when measuring the Typ Avg and Abs Max processor current parameters.

6.4.4 DC Current Measurements

Table 6-4 on page 379 through Table 6-8 show the DC current measurements of the GX2. The GX2 supports CRT or flat panel (FP) display (different part NSIDs). Power consumed by the GX2 varies with the different display and SDRAM type.

The CRT DACs require current; while the FP interface, even though it has no DAC to power, also draws current while it is active. The CRT DACs and the FP interface currents are separated so they can be matched to the part selected.

SDR SDRAM has a typical CMOS interface that only consumes power when switching. The data bus on the DDR SDRAM has a low voltage swing actively terminated interface. While this interface supports higher data transfer rates, it consumes more power.

6.4.5 DDR SDRAM Interface Power Consumption

Power delivered into the V_{MEM} pins on the GX2 is only partially consumed by the GX2. Most of the power is consumed by the resistors used to create the low voltage swing active termination for the data bus. Calculations show that only $((I_{MEM} \times V_{MEM}) - 75mW) \times 22\% + 75mW$ of the power delivered into the V_{MEM} pins is consumed by the GX2. DDR consumes more system power than SDR, but the GX2 consumes less power using DDR than SDR.

Electrical Specifications (Continued)

Table 6-3. System Conditions for Measuring GX2 Current Used During On State

CPU Current Measurement	V_{CORE} (Note 1)	V_{IO} (Note 1)	DOTCLK Freq. (Note 2)	SDRAM Freq.		
				333 MHz Core	366 MHz Core	400 MHz Core
Typical Average CRT	Nominal	Nominal	94.5 MHz	133 MHz	122 MHz	133 MHz
Typical Average TFT			40 MHz			
Absolute Maximum CRT	Max	Max	230 MHz			
Absolute Maximum TFT			162 MHz			

Note 1. See Table 6-2 "Operating Conditions" on page 377 for nominal and maximum voltages.

Note 2. 1600x1200x16 bpp, 85 Hz refresh = 230 MHz DOTCLK, 1600x1200x16 bpp, 60 Hz refresh = 162 MHz DOTCLK, 1024x768x16 bpp, 85 Hz refresh = 94.5 MHz DOTCLK, 800x600x16 bpp, 60 Hz refresh = 40 MHz DOTCLK.

Table 6-4. GX2-CRT-DDR DC Currents

Symbol	Parameter	333 MHz (Note 1)		366 MHz (Note 1)		400 MHz (Note 1)		Unit	Comments
		Typ Avg	Abs Max	Typ Avg	Abs Max	Typ Avg	Abs Max		
I_{CC3ON}	Power State: On (S0/C0)	100	140	100	140	100	140	mA	I_{CC} for V_{IO}
I_{COREON}		910	1650	1000	1780	1075	1900	mA	I_{CC} for V_{CORE}
I_{MEMON}		540	675	540	710	540	710	mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2
I_{SBON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	Note 3
I_{SBLON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	
$I_{CC3IDLE}$	Power State: Active Idle (S0/C1)	100		100		100		mA	I_{CC} for V_{IO}, Note 4
$I_{COREIDLE}$		470		510		545		mA	I_{CC} for V_{CORE}
$I_{MEMIDLE}$		420		420		420		mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2
I_{CC3SLP}	Power State: Sleep (S1)	TBD		TBD		TBD		mA	I_{CC} for V_{IO}
$I_{CORESLP}$		TBD		TBD		TBD		mA	I_{CC} for V_{CORE}
I_{MEMSLP}		TBD		TBD		TBD		mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2

Note 1. f_{CLK} ratings refer to internal clock frequency.

Note 2. Memory power consumption is split between the GX2 device and the memory interface. See Section 6.4.5 on page 378 for an explanation.

Note 3. All V_{SBL} supplied inputs are at 0.2V or V_{SBL} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Note 4. All inputs are at 0.2V or V_{IO} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Electrical Specifications (Continued)

Table 6-5. GX2-CRT-SDR DC Currents

Symbol	Parameter	333 MHz (Note 1)		366 MHz (Note 1)		400 MHz (Note 1)		Unit	Comments
		Typ Avg	Abs Max	Typ Avg	Abs Max	Typ Avg	Abs Max		
I_{CC3ON}	Power State: On (S0/C0)	80	110	80	110	80	110	mA	I_{CC} for V_{IO}
I_{COREON}		830	1560	890	1640	960	1720	mA	I_{CC} for V_{CORE}
I_{MEMON}		255	420	230	400	255	420	mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3V
I_{SBON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	Note 2
I_{SBLON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	
$I_{CC3IDLE}$	Power State: Active Idle (S0/C1)	80		80		80		mA	I_{CC} for V_{IO}, Note 3
$I_{COREIDLE}$		330		355		380		mA	I_{CC} for V_{CORE}
$I_{MEMIDLE}$		185		165		185		mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3V
I_{CC3SLP}	Power State: Sleep (S1)	TBD		TBD		TBD		mA	I_{CC} for V_{IO}
$I_{CORESLP}$		TBD		TBD		TBD		mA	I_{CC} for V_{CORE}
I_{MEMSLP}		TBD		TBD		TBD		mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3V

Note 1. f_{CLK} ratings refer to internal clock frequency.

Note 2. All V_{SBL} supplied inputs are at 0.2V or V_{SBL} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Note 3. All inputs are at 0.2V or V_{IO} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Electrical Specifications (Continued)

Table 6-6. GX2-FP-DDR DC Currents

Symbol	Parameter	333 MHz (Note 1)		366 MHz (Note 1)		400 MHz (Note 1)		Unit	Comments
		Typ Avg	Abs Max	Typ Avg	Abs Max	Typ Avg	Abs Max		
I_{CC3ON}	Power State: On (S0/C0)	90	290	90	290	90	290	mA	I_{CC} for V_{IO}
I_{COREON}		910	1600	1020	1720	1100	1850	mA	I_{CC} for V_{CORE}
I_{MEMON}		550	690	550	720	550	750	mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2
I_{SBON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	Note 3
I_{SBLON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	
$I_{CC3IDLE}$	Power State: Active Idle (S0/C1)	90		90		90		mA	I_{CC} for V_{IO}, Note 4
$I_{COREIDLE}$		465		510		555		mA	I_{CC} for V_{CORE}
$I_{MEMIDLE}$		400		400		400		mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2
I_{CC3SLP}	Power State: Sleep (S1)	TBD		TBD		TBD		mA	I_{CC} for V_{IO}
$I_{CORESLP}$		TBD		TBD		TBD		mA	I_{CC} for V_{CORE}
I_{MEMSLP}		TBD		TBD		TBD		mA	I_{CC} for V_{MEM}, V_{MEM} = 2.5V, Note 2

Note 1. f_{CLK} ratings refer to internal clock frequency.

Note 2. Memory power consumption is split between the GX2 device and the memory interface. See Section 6.4.5 on page 378 for an explanation.

Note 3. All V_{SBL} supplied inputs are at 0.2V or V_{SBL} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Note 4. All inputs are at 0.2V or V_{IO} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Electrical Specifications (Continued)

Table 6-7. GX2-FP-SDR DC Currents

Symbol	Parameter	333 MHz (Note 1)		366 MH (Note 1)		400 MHz (Note 1)		Unit	Comments
		Typ Avg	Abs Max	Typ Avg	Abs Max	Typ Avg	Abs Max		
I_{CC3ON}	Power State: On (S0/C0)	85	280	85	280	85	280	mA	I_{CC} for V_{IO}
I_{COREON}		900	1530	950	1630	990	1750	mA	I_{CC} for V_{CORE}
I_{MEMON}		270	290	240	260	270	290	mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3V
I_{SBON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	Note 2
I_{SBLON}		TBD	TBD	TBD	TBD	TBD	TBD	mA	
$I_{CC3IDLE}$	Power State: Active Idle (S0/C1)	85		85		85		mA	I_{CC} for V_{IO}, Note 3
$I_{COREIDLE}$		330		345		370		mA	I_{CC} for V_{CORE}
$I_{MEMIDLE}$		170		155		170		mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3V
I_{CC3SLP}	Power State: Sleep (S1)	TBD		TBD		TBD		mA	I_{CC} for V_{IO}
$I_{CORESLP}$		TBD		TBD		TBD		mA	I_{CC} for V_{CORE}
I_{MEMSLP}		TBD		TBD		TBD		mA	I_{CC} for V_{MEM}, V_{MEM} = 3.3

Note 1. f_{CLK} ratings refer to internal clock frequency.

Note 2. All V_{SBL} supplied inputs are at 0.2V or V_{SBL} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Note 3. All inputs are at 0.2V or V_{IO} – 0.2 (CMOS levels). All inputs are held static, and all outputs are unloaded (static I_{OUT} = 0 mA).

Electrical Specifications (Continued)

6.5 DC CHARACTERISTICS

All DC parameters and current specifications in this section are specified under the operating conditions listed in Table 6-2 on page 377, unless otherwise noted. There are seven buffer types on GX2; the signals associated with each type are shown as comments in the V_{IL} section of Table 6-8 and in Section 2.1 "Ball Assignments" starting on page 20.

Table 6-8. DC Characteristics

Symbol	Parameter	Min	Max	Units	Comments
V_{IL}	Low Level Input Voltage				
	PCI	-0.5	$0.3*V_{IO}$	V	AD[26:0], C/BE[3:0]#, PAR, STOP#, FRAME#, IRDY#, TRDY#, DEVSEL#, REQ#, GNT#
	RST	-0.5	0.5	V	RST#
	24/Q3	-0.5	$0.3*V_{IO}$	V	SYSREF, DOTREF, DOTCLK, TDBGO
	24/Q5	-0.5	$0.3*V_{IO}$	V	IRQ13, SUSPA#, DRGB[23:0], DISP_EN, FP_VDDEN, FP_VCONEN, FP_LDE_MOD, TDO
	24/Q7	-0.5	$0.3*V_{IO}$	V	INTR, SMI#, SUSP#, SD_WR_CLK, TCLK, TMS, TDI, TDBGI
	5V/4	-0.5	$0.3*V_{IO}$	V	HSYNC, VSYNC
	SDRAM				
	GX2-SDR	-0.3	MVREF-0.40	V	SD_FB_CLK, MD[63:0], CKE[1:0], CS[3:0]#, RAS[1:0]#, CAS1:0]#, WE[1:0]#, BA[1:0], MA[12:0], DQS[7:0], DQM[7:0]
	GX2-DDR	-0.3	MVREF-0.40	V	
	SDCLK				
	GX2-SDR	-0.3	0.8	V	SDCLK[7:0]
	GX2-DDR	N/A	N/A	V	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
V_{IH}	High Level Input Voltage				
	PCI	$0.5*V_{IO}$	$V_{IO}+0.5$	V	
	RST	$0.5*V_{IO}$	$V_{IO}+0.5$	V	
	24/Q3	$0.7*V_{IO}$	$V_{IO}+0.5$	V	
	24/Q5	$0.7*V_{IO}$	$V_{IO}+0.5$	V	
	24/Q7	$0.7*V_{IO}$	$V_{IO}+0.5$	V	
	5V/4	$0.7*V_{IO}$	$V_{IO}+0.5$	V	
	SDRAM				
	GX2-SDR	MVREF+0.40	$V_{MEM}+0.3$	V	
	GX2-DDR	MVREF+0.40	$V_{MEM}+0.3$	V	
	SDCLK				
	GX2-SDR	2.2	$V_{MEM}+0.3$	V	
	GX2-DDR	N/A	N/A	V	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.

Electrical Specifications (Continued)

Table 6-8. DC Characteristics (Continued)

Symbol	Parameter	Min	Max	Units	Comments
V_{OL}	Low Level Output Voltage				
	PCI		$0.1*V_{IO}$	V	
	24/Q3		0.4	V	
	24/Q5		0.4	V	
	24/Q7		0.4	V	
	5V/4		0.4	V	
	SDRAM				
	GX2-SDR		0.4	V	
	GX2-DDR		0.35	V	
	SDCLK				
	GX2-SDR		0.4	V	
	GX2-DDR		MVREF-0.4		
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
V_{OH}	High Level Output Voltage				
	PCI	$0.8*V_{IO}$		V	
	24/Q3	2.4		V	
	24/Q5	2.4		V	
	24/Q7	2.4		V	
	5V/4	2.4		V	
	SDRAM				
	GX2-SDR	2.4		V	
	GX2-DDR	V_{MEM}-0.43		V	
	SDCLK				
	GX2-SDR	2.4		V	
	GX2-DDR	MVREF+0.4		V	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
I_{LEAK}	Input Leakage Current Including Hi-Z Output Leakage				
	PCI	-3.0	3.0	µA	
	RST	-3.0	3.0	µA	
	24/Q3	-3.0	3.0	µA	
	24/Q5	-3.0	3.0	µA	
	24/Q7	-3.0	3.0	µA	
	5V/4	-5.0		µA	
	SDRAM				
	GX2-SDR	-5.0	5.0	µA	
	GX2-DDR	-3.0	3.0	µA	
	SDCLK				
	GX2-SDR	-5.0	5.0	µA	
	GX2-DDR	-5.0	5.0	µA	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.

Electrical Specifications (Continued)

Table 6-8. DC Characteristics (Continued)

Symbol	Parameter	Min	Max	Units	Comments
I_{PD}	Weak Pull-Down Current				These PDs are activated only during the power management sequence if they are configured to do so in MSR 4C00000Bh (see Section 5.5.2.4 on page 332).
	PCI	N/A		- - -	GLCP_GLB_PM
	24/Q3	25	150	µA	DOTCLK, TDBGO
	24/Q5	25	150	µA	DISP_EN, FP_LDE_MOD, FP_VCONEN, IRQ13, DRGB, FP_VDDEN
	24/Q7	N/A	N/A	µA	
	5V/4	25	150	µA	HSYNC, VSYNC
	SDRAM				
	GX2-SDR	N/A		- - -	
	GX2-DDR	N/A		- - -	
	SDCLK				
	GX2-SDR	N/A		- - -	
	GX2-DDR	N/A		- - -	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
I_{OH}	Output High Current				$V_O = V_{OH}$ (Min)
	PCI	-12		mA	
	24/Q3	-24.0		mA	
	24/Q5	-24.0		mA	
	24/Q7	-24.0		mA	
	5V/4	-4.0		mA	
	SDRAM				
	GX2-SDR	-2.0		mA	
	GX2-DDR	-15.2		mA	
	SDCLK				
	GX2-SDR	-2.0		mA	
	GX2-DDR	-2.0		mA	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.

Electrical Specifications (Continued)

Table 6-8. DC Characteristics (Continued)

Symbol	Parameter	Min	Max	Units	Comments
I_{OL}	Output Low Current				$V_O = V_{OL}$ (Max)
	PCI	12		mA	
	24/Q3	24.0		mA	
	24/Q5	24.0		mA	
	24/Q7	24.0		mA	
	5V/4	4.0		mA	
	SDRAM				
	GX2-SDR	2.0		mA	
	GX2-DDR	15.2		mA	
	SDCLK				
	GX2-SDR	2.0		mA	
	GX2-DDR	2.0		mA	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
C_{IN}	Input Capacitance				
	PCI		8.0	pF	
	RST		8.0	pF	
	24/Q3		8.0	pF	
	24/Q5		8.0	pF	
	24/Q7		8.0	pF	
	5V/4		8.0	pF	
	SDRAM				
	GX2-SDR		8.0	pF	
	GX2-DDR		8.0	pF	
	SDCLK				
	GX2-SDR		8.0	pF	
	GX2-DDR		8.0	pF	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.
C_{OUT}	Output Capacitance				The tester used to verify all these measurements presents a 50 pF load to all outputs.
	PCI		8.0	pF	
	24/Q3		8.0	pF	
	24/Q5		8.0	pF	
	24/Q7		8.0	pF	
	5V/4		8.0	pF	
	SDRAM				
	GX2-SDR		8.0	pF	
	GX2-DDR		8.0	pF	
	SDCLK				
	GX2-SDR		8.0	pF	
	GX2-DDR		8.0	pF	
	Wire	N/A	N/A		Wire connection does not have an I/O buffer.

6.6 AC LEVELS CHARACTERISTICS

The AC Levels Characteristics are the voltage levels used to measure the AC timing parameters.These characteristics are shown in Table 6-9.

Table 6-9. AC Levels Characteristics

Symbol	Parameter	Value	Units	Comments
V_{ILAC}	Low Level Input Voltage			
	PCI	$0.3*V_{IO}$	V	AD[26:0], C/BE[3:0]#, PAR, STOP#, FRAME#, IRDY#, TRDY#, DEVSEL#, REQ#, GNT#
	RST	0.6	V	RST#
	24/Q3	$0.3*V_{IO}$	V	SYSREF, DOTREF, DOTCLK, TDBGO
	24/Q5	$0.3*V_{IO}$	V	IRQ13, SUSPA#, DRGB[23:0], DISP_EN, FP_VDDEN, FP_VCONEN, FP_LDE_MOD, TDO
	24/Q7	$0.3*V_{IO}$	V	INTR, SMI#, SUSP#, SD_WR_CLK, TCLK, TMS, TDI, TDBGI
	5V/4	$0.3*V_{IO}$	V	HSYNC, VSYNC
	SDRAM			
	GX2-SDR	MVREF-0.75	V	SD_FB_CLK, MD[63:0], CKE[1:0], CS[3:0]#, RAS[1:0]#, CAS1:0]#, WE[1:0]#, BA[1:0], MA[12:0], DQS[7:0], DQM[7:0]
	GX2-DDR	MVREF-0.75	V	
	SDCLK			
	GX2-SDR	0.8	V	SDCLK[7:0]
	GX2-DDR	N/A	V	
	Wire	N/A		Wire connection does not have an I/O buffer.
V_{IHAC}	High Level Input Voltage			
	PCI	$0.5*V_{IO}$	V	
	RST	$0.5*V_{IO}$	V	
	24/Q3	$0.7*V_{IO}$	V	
	24/Q5	$0.7*V_{IO}$	V	
	24/Q7	$0.7*V_{IO}$	V	
	5V/4	$0.7*V_{IO}$	V	
	SDRAM			
	GX2-SDR	MVREF+0.75	V	
	GX2-DDR	MVREF+0.75	V	
	SDCLK			
	GX2-SDR	2.2	V	
	GX2-DDR	N/A	V	
	Wire	N/A		Wire connection does not have an I/O buffer.

Electrical Specifications (Continued)

Table 6-9. AC Levels Characteristics (Continued)

Symbol	Parameter	Value	Units	Comments
V_{OLAC}	Low Level Output Voltage			
	PCI	$0.1*V_{IO}$	V	
	24/Q3	0.4	V	
	24/Q5	0.4	V	
	24/Q7	0.4	V	
	5V/4	0.4	V	
	SDRAM			
	GX2-SDR	0.4	V	
	GX2-DDR	0.35	V	
	SDCLK			
	GX2-SDR	0.4	V	
	GX2-DDR	MVREF-0.4		
	Wire	N/A		Wire connection does not have an I/O buffer.
V_{OHAC}	High Level Output Voltage			
	PCI	$0.8*V_{IO}$	V	
	24/Q3	2.4	V	
	24/Q5	2.4	V	
	24/Q7	2.4	V	
	5V/4	2.4	V	
	SDRAM			
	GX2-SDR	2.4	V	
	GX2-DDR	V_{MEM}-0.43	V	
	SDCLK			
	GX2-SDR	2.4	V	
	GX2-DDR	MVREF+0.4	V	
	Wire	N/A		Wire connection does not have an I/O buffer.

Electrical Specifications (Continued)

6.7 AC CHARACTERISTICS

The following tables list the AC characteristics including output delays, input setup requirements, input hold requirements, and output float delays. The rising-clock-edge reference level V_{REF}, and other reference levels are shown in Table 6-10 on page 390. Input or output signals must cross these levels during testing.

Input setup and hold times are specified minimums that define the smallest acceptable sampling window for which a synchronous input signal must be stable for correct operation.

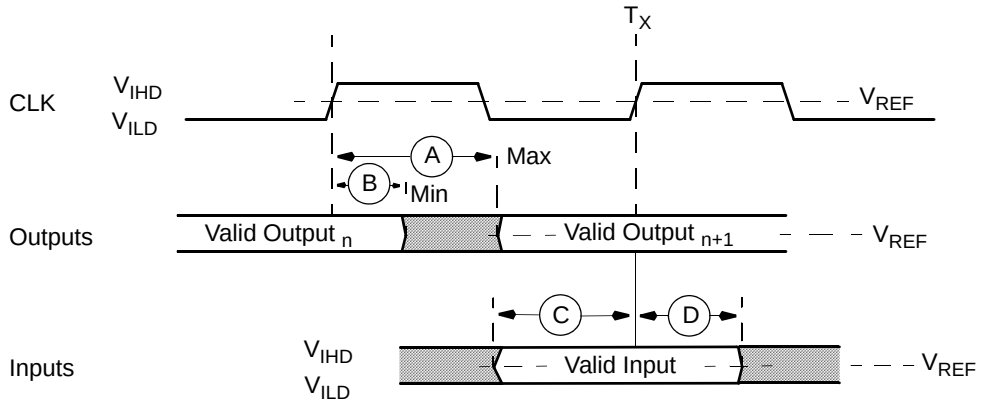
All AC tests are performed at the following parameters using the timing diagram shown in Figure 6-1 unless otherwise specified:

V_{CORE}: 1.42V to 1.58V (1.5V Nominal)
V_{IO}: 3.14V to 3.46V (3.3V Nominal)
V_{MEM}: DDR: 2.5V; SDR: 3.3V
MVREF: DDR = 1.25V (Nominal); SDR = 1.65V (Nominal)
T_C: 0^oC to 85^oC
R_L: 50 Ω
C_L: 50 pF

While most minimum, maximum, and typical AC characteristics are only shown as a single value, they are tested and guaranteed across the entire processor core voltage range. AC characteristics that are affected significantly by the core voltage or speed grade are documented accordingly.

All AC timing measurements are taken at 50% crossing points for both input times and output times.

All AC timing specifications are tested with the recommended software boot values in MSR 4C00000Fh in the GLCP (see Section 5.5.2.8 "GLCP I/O Delay Controls (GLCP_DELAY_CONTROLS)" on page 335.



Legend: A = Maximum Output or Float Delay Specification
B = Minimum Output or Float Delay Specification
C = Minimum Input Setup Specification
D = Minimum Input Hold Specification

Figure 6-1. Drive Level and Measurement Points for Switching Characteristics

Electrical Specifications (Continued)

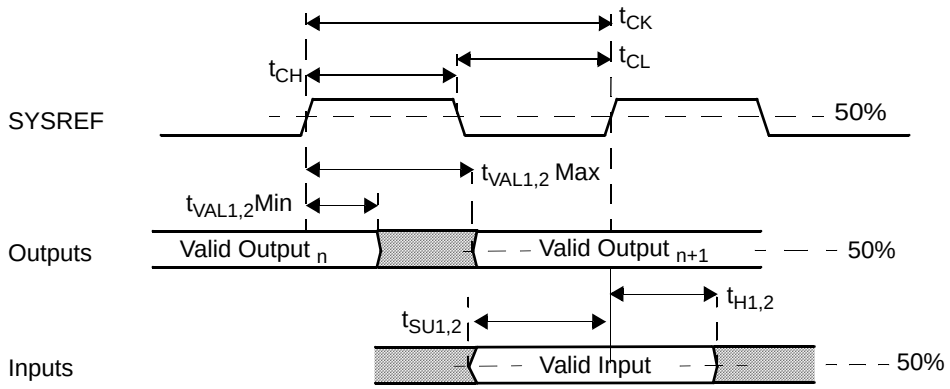
Table 6-10. System Interface Signals

Symbol	Parameter	Min	Max	Unit	Comments
t_{CK}	SYSREF Cycle time	15.0	INF	ns	66 MHz
t_{CH}	SYSREF High time	6.0		ns	
t_{CL}	SYSREF Low time	6.0		ns	
t_{SU1}	RST# Setup time to SYSREF	4.0		ns	Note 1
t_{H1}	RST# Hold time from SYSREF	1.0		ns	Note 1
t_{SU2}	SMI#, SUSP#, INTR Setup time to SYSREF	3.0		ns	Note 1
t_{H2}	SMI#, SUSP#, INTR Hold time from SYSREF	0		ns	Note 1
t_{VAL1}	IRQ13 Valid Delay time from SYSREF	2.0	6.0	ns	
t_{VAL2}	SUSPA# Valid Delay time from SYSREF	2.0	6.0	ns	
t_{ON_CRT}	V_{IO} power on after V_{CORE}	-100	100	ms	Note 2
t_{ON_FP}	V_{IO} power on after V_{CORE}	0	100	ms	Note 2
t_{MEM}	V_{MEM} power on after V_{CORE}	-100	100	ms	
t_{MVON}	MVREF power on after V_{MEM}	0	100	ms	
$t_{RST\#}$	Reset active time after SYSREF clock stable	50		µs	For PLL lock
t_Z	Output drive delay after RST# released	3.0	10	ns	

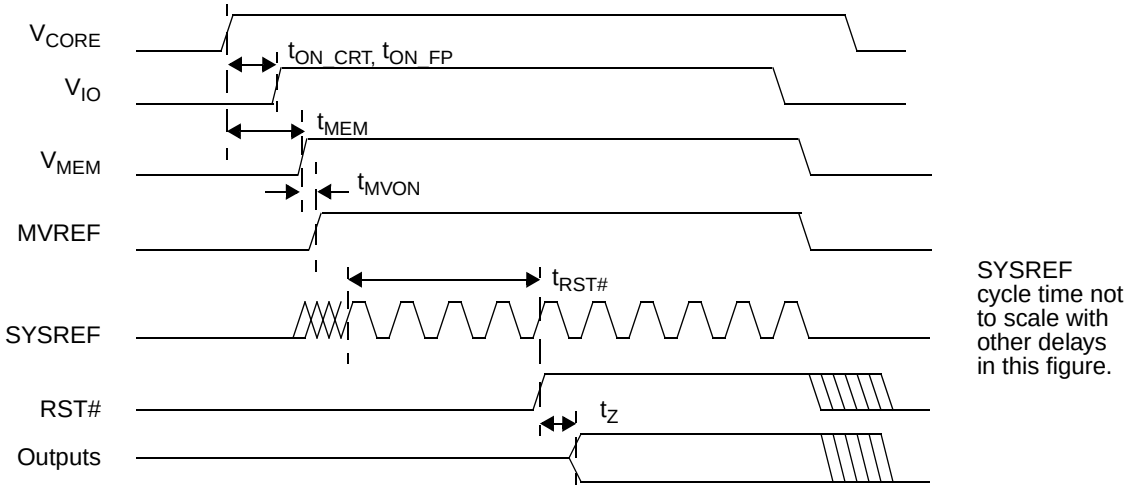
Note 1. The system signals are asynchronous. The setup/hold times stated here are for testing purposes that require sequential repeatability.

Note 2. For proper power-up of DRGB and flat panel controls, V_{IO} must power up after V_{CORE}. Otherwise, V_{CORE} can be last.

Electrical Specifications (Continued)



Drive Level and Measurement Points for Switching Characteristics



Power Up Sequencing

Figure 6-2. System Interface Signals

Electrical Specifications (Continued)

Table 6-11. PCI Interface Signals

Symbol	Parameter	Min	Max	Unit	Comments
t_{SU1}	Bused signals Input Setup time to SYSREF	3.0		ns	
t_{SU2}	REQ[2:0]# Input Setup time to SYSREF	4.5		ns	
t_H	Input Hold time from SYSREF for all PCI inputs	0		ns	Note 1
t_{VAL1}	Bused signals Valid Delay time from SYSREF	2.0	6.0	ns	Note 2
t_{VAL2}	GNT[2:0]# Valid Delay time from SYSREF	2.0	6.0	ns	Note 1

Note 1. The GNT#, IRQ13, and SUSPA# signals are only inputs during RST# active. They must be stable between five and two PCI clocks before RST# inactive.

Note 2. Output delay includes TRISTATE-to-valid transitions and valid-to-TRISTATE timing.

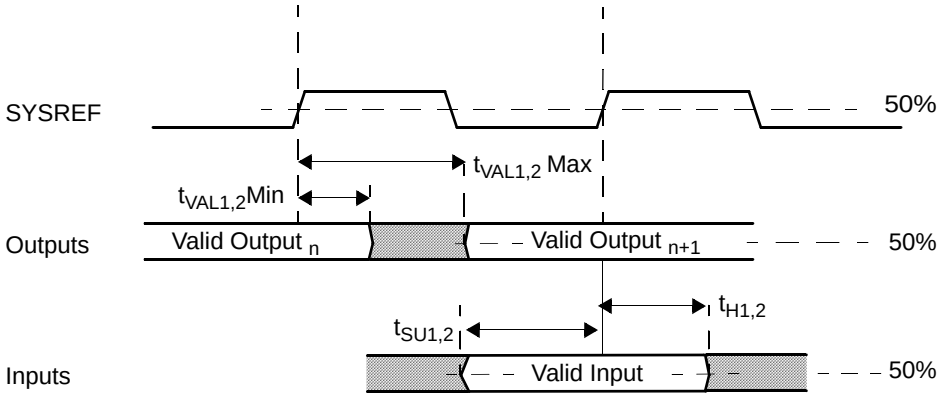


Figure 6-3. PCI Interface Signals

Electrical Specifications (Continued)

Table 6-12. GX2-FP Interface Signals

Symbol	Parameter	Min	Max	Unit	Comments
t_{CK}	DOTCLK period	23.5		ns	42.5 MHz
	DOTCLK Duty Cycle	45/55		%	
	DOTCLK long term output jitter		15%	t_{CK}	
t_{VAL1}	DRGB[23:0] Output Valid Delay time from DOTCLK	0.5	5.0	ns	
t_{VAL2}	FP_LDE_MOD Output Valid Delay time from DOTCLK	0.1	5.0	ns	
t_{VAL3}	HSYNC and VSYNC Output Valid Delay time from falling edge of DOTCLK	-2.0	2.0	ns	

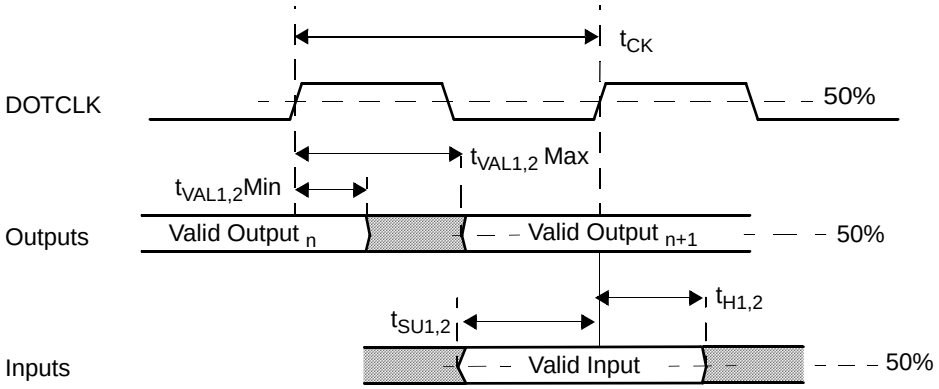


Figure 6-4. GX2-FP Interface Signals

Electrical Specifications (Continued)

Table 6-13. GX2-CRT Interface Signals

Symbol	Parameter	Min	Max	Unit	Comments
t_{CK}	DOTCLK Period	4.3		ns	
	DOTCLK Duty Cycle	45/55		%	
	DOTCLK long term output jitter		15%	t_{CK}	
t_{skew}	Skew between RED, GREEN, BLUE Output Valid.		1.0	ns	Between any two signals. Note 1

Note 1. HSYNC and VSYNC for CRT timing are generated from the same on-chip clock that is used to generate the RED, GREEN, and BLUE signals.

Table 6-14. CRT Display Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Units	Comments
AV_{DD}	Power Supply	3.14	3.3	3.46	V	
R_L	Output Load on each of the pins RED, GREEN, and BLUE		37.5 (Note1)		Ω	R1, R2, and R3 as shown in Figure 6-5 on page 396.
I_{OUT}	Output Current on each of the pins RED, GREEN, and BLUE			21	mA	
R_{SET}	Value of the full-scale adjust resistor connected to SETRES		464		Ω	This resistor must have a 1% tolerance.
$VEXT_{REF}$	External voltage reference connected to the VREF pin		1.235		V	

Note 1. There is a 75 Ω resistor on the motherboard and a 75 Ω resistor in the CRT monitor to create the effective 37.5 Ω typical resistance.

Electrical Specifications (Continued)

Table 6-15. CRT Display Analog (DAC) Characteristics

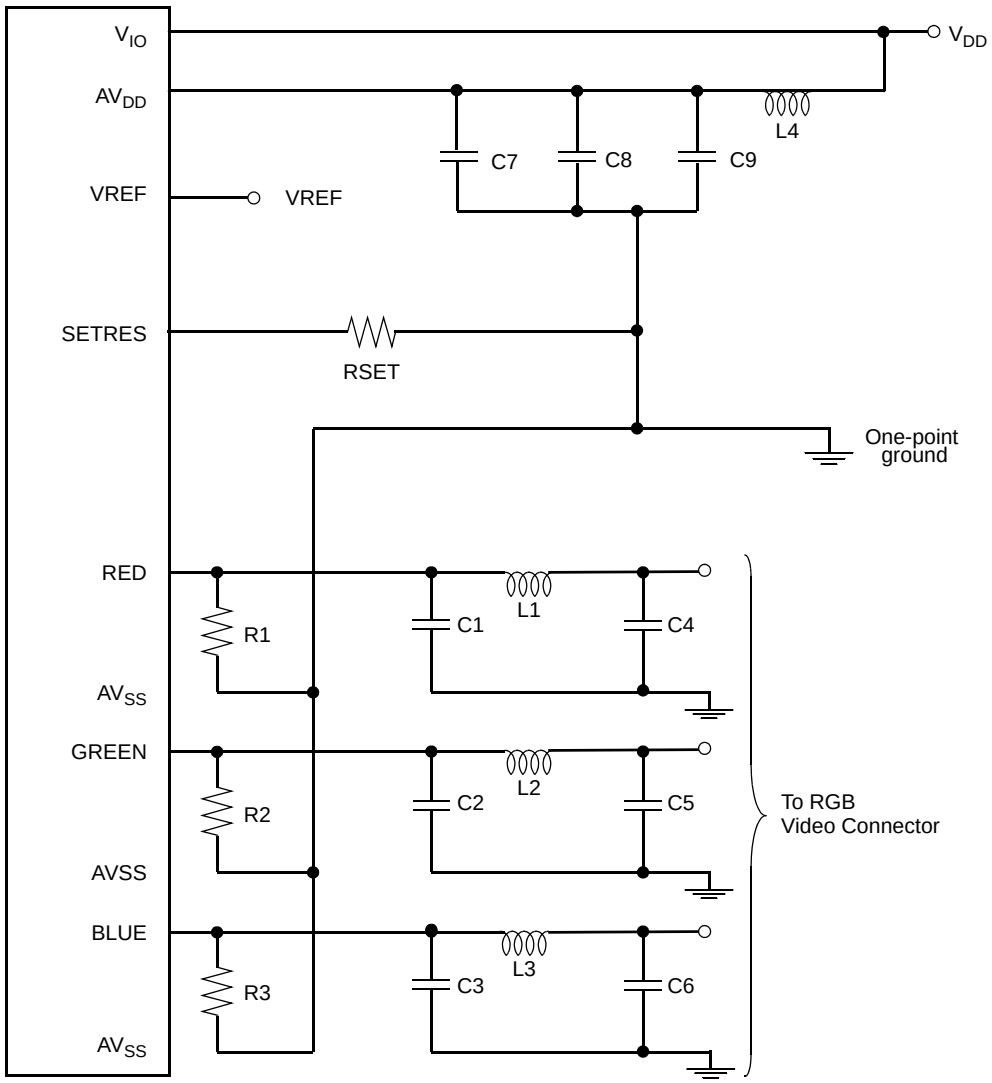
Symbol	Parameter	Min	Typ	Max	Units	Comments
V_{OM}	Output Voltage			0.735	V	
V_{OC}	Output Current			20	mA	
INL	Integral Linearity Error			+/-1	LSB	
DNL	Differential Linearity Error			+/-1	LSB	
t_{FS}	Full Scale Settling Time			2.5	ns	
--	DAC-to-DAC matching			5	%	
--	Power Supply Rejection			0.7	%	@ 1 kHz
t_{RISE}	Output Rise Time			3.8	ns	Note 1 and Note 2
t_{FALL}	Output Fall Time			3.8	ns	Note 1 and Note 3

Note 1. Timing measurements are made with a 75 Ω doubly-terminated load, with $VEXT_{REF}$ = 1.235V and R_{SET} = 464 Ω.

Note 2. 10% to 90% of full-scale transition.

Note 3. Full-scale transition: time from output minimum to maximum, not including clock and data feedthrough.

Electrical Specifications (Continued)



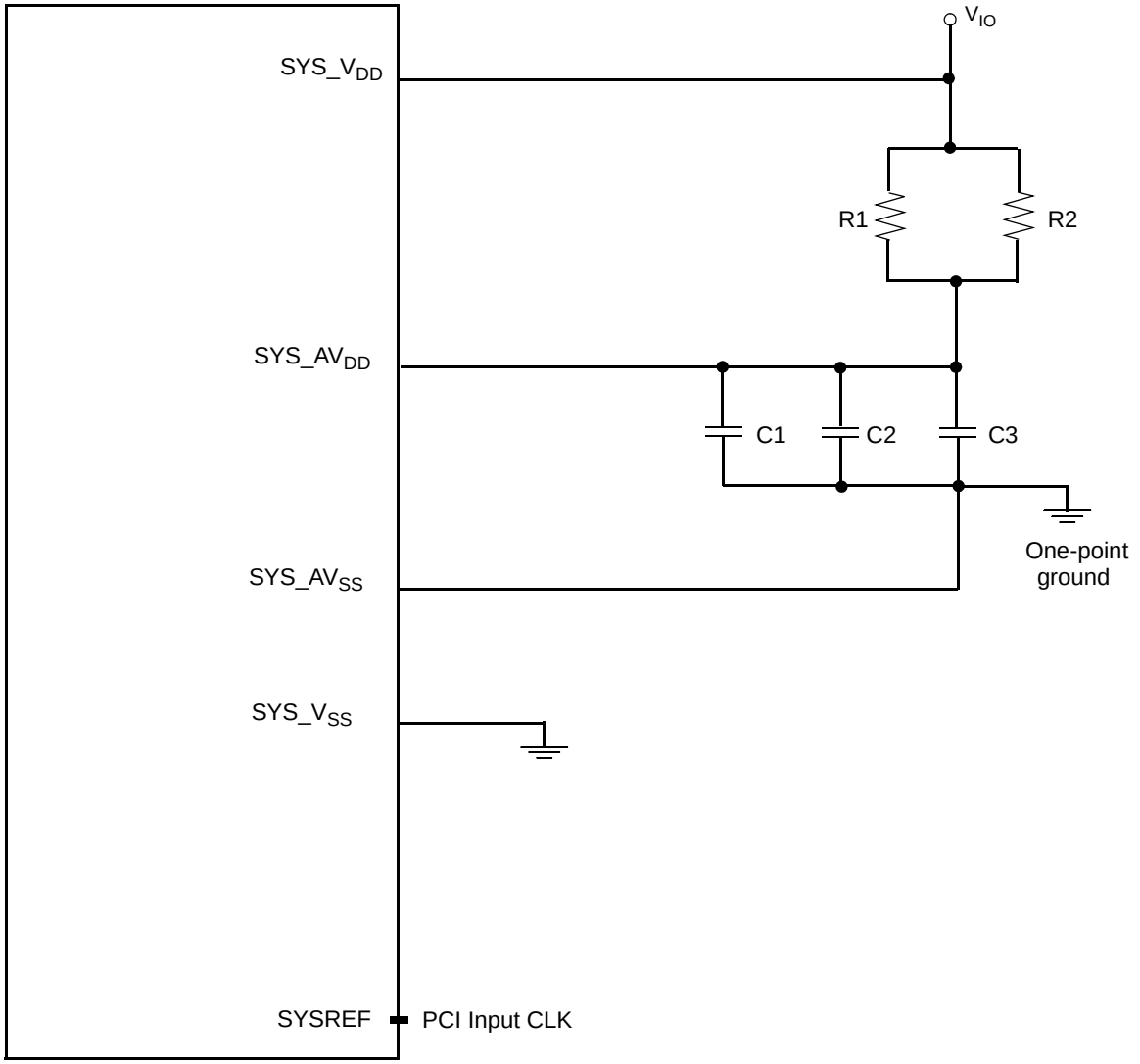
Legend

Part Designator	Value
R1-R3	75 Ω, 1%
RSET	464 Ω, 1%
C1-C6	4.7 pF Ceramic
C7	100 µF
C8, C9	0.1 µF, Ceramic
L1-L3	22 nH Inductor
L4	600 Ω Ferrite Bead

Note: RGB filters may change based on display resolution requirements.

Figure 6-5. Typical Video Connection Diagram

Electrical Specifications (Continued)

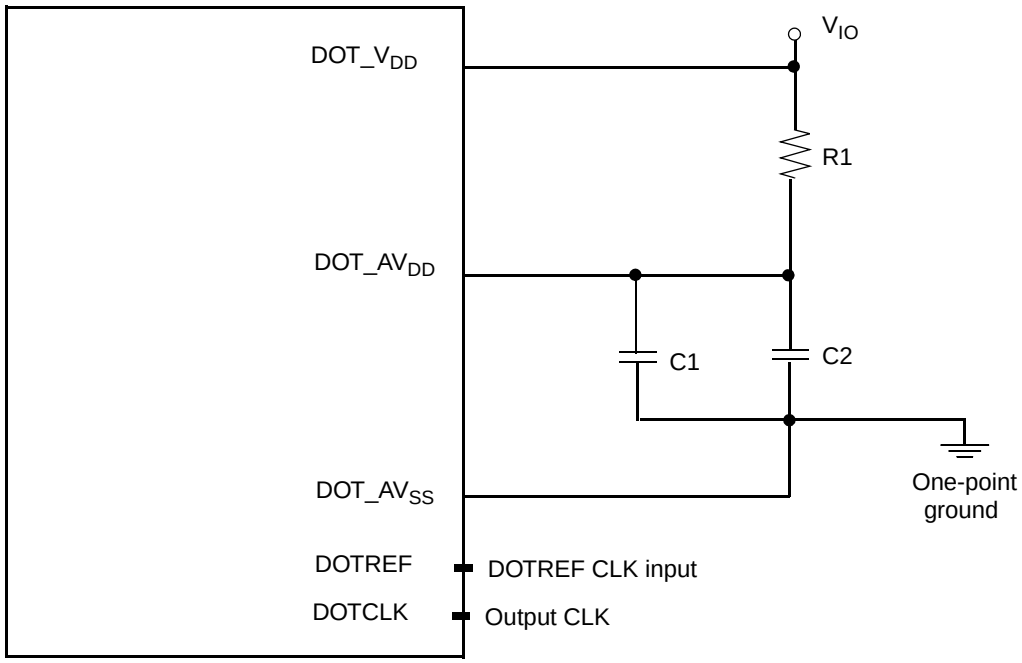


Legend

Part Designator	Value
R1, R2	10 Ω
C1, C2	0.1 µF, Ceramic
C3	10 µF

Figure 6-6. Typical System PLL Connection Diagram

Electrical Specifications (Continued)



Legend

Part Designator	Value
R1	10 Ω
C1	0.1 µF, Ceramic
C2	10 µF

Figure 6-7. Typical DOTPLL Connection Diagram

Electrical Specifications (Continued)

Table 6-16. GX2-DDR Interface Signals

Symbol (Note 1)	Parameter	Min	Max	Unit	Comments
t_{CK}	SD_FB_CLK Output clock period	7.5		ns	
	SD_FB_CLK Output Duty Cycle	45/55		%	
	SDCLK[5:0], SDCLK[5:0]# period	7.5		ns	Note 2
	SDCLK[5:0], SDCLK[5:0]# Duty Cycle	45/55		%	Note 2
t_{SKEW1}	SDCLK[n] to SDCLK[n]x skew (n = 0.5)		0.1	ns	Guaranteed by design
t_{DEL1}	SDCLK[5:0], SDCLK[5:0]# Edge Delay from SD_FB_CLK	-0.7	0.5	ns	Note 3, Note 4
	DQS[7:0] Input and output period	7.5		ns	
	DQS[7:0] Input and output Duty Cycle	45/55		%	
t_{DQSCK}	DQS[7:0] Input delay relative to SD_FB_CLK	-2	4	ns	
t_{SKEW2}	DQS-to-DQS Input skew		3	ns	
t_{DEL2}	DQS[7:0] Output edge delay from SD_FB_CLK	-0.5	0.7	ns	Note 5
t_{RPRE}	DQS Input preamble before first DQS rising edge	0.5		t_{CK}	
t_{RPST}	DQS Input postamble after last DQS	0.35		t_{CK}	
t_{WPRE}	DQS Output write preamble valid time before DQS rising edge	$0.5*t_{CK}-1.75$	$0.5*t_{CK}+1$	ns	Note 6
t_{WPST}	DQS Output write postamble after last DQS falling edge	$0.5*t_{CK}-1$	$0.5*t_{CK}+1.75$	ns	Note 6
t_{DQSQs}	MD[63:0] Input setup time before DQS edge	-1.0		ns	Note 7
t_{DQSQh}	MD[63:0] Input hold time after DQS edge	$0.25*t_{CK}+0.35$		ns	, Note 7
t_{VAL1}	MD[63:0], DQM[7:0] Output Data Valid Delay time from DQS rising or falling edge	0.9	$0.5*t_{CK}-1.25$	ns	Note 7
t_{VAL2}	MA[12:0], BA[1:0], CAS[1:0]#, RAS[1:0]#, CKE[1:0], CS[3:0]#, WE[1:0] Output Valid Delay time from SD_FB_CLK	1.0	4.5	ns	Note 3, Note 4

Note 1. Refer to Figure 6-8 "DDR Write Timing Measurement Points" on page 400 and Figure 6-9 "DDR Read Timing Measurement Points" on page 400.

Note 2. The even and odd clocks are an inversion of each other (differential clocking).

Note 3. 0.5 ns max t_{DEL1} does not occur under same conditions as 1.6 ns min t_{VAL2}.

Note 4. 1.3 ns < t_{VAL2} - t_{DEL1} < 4.5 ns

Note 5. -0.7 ns < t_{DEL2} - t_{DEL1} < 0.7 ns

Note 6. DQS output preamble and postamble timings are affected by the SD_FB_CLK duty cycle.

Note 7. The MD timing relative to DQS are on a per-byte basis only. MD[7:0] and DQM[0] must be measured against DQS[0], and MD[15:8] and DQM[1] must be measured against DQS[1], etc.

Electrical Specifications (Continued)

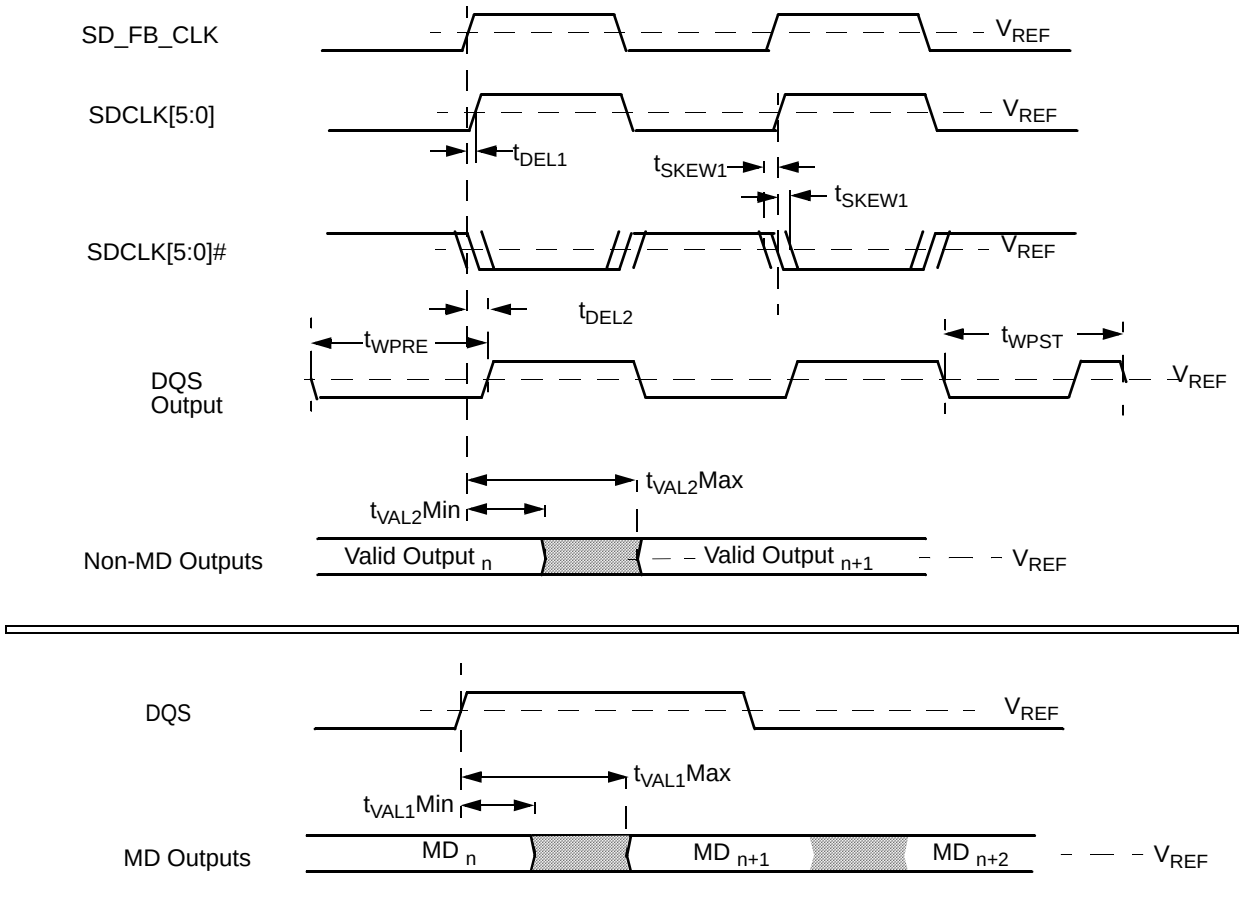


Figure 6-8. DDR Write Timing Measurement Points

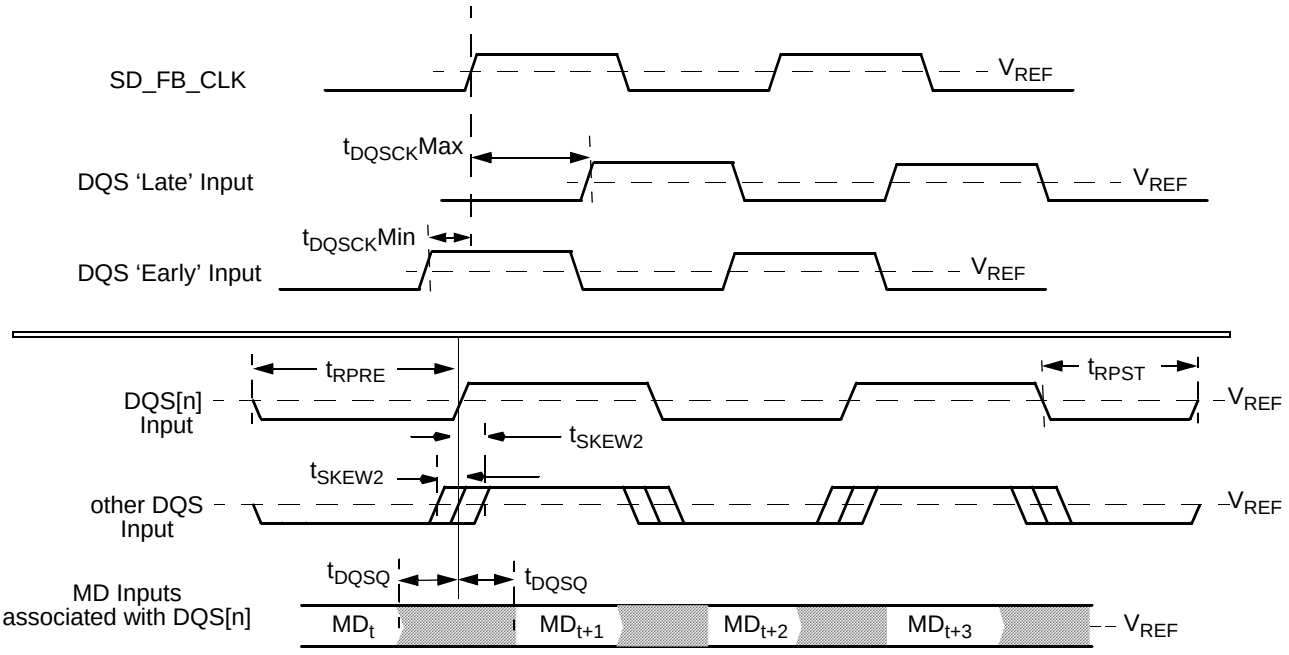


Figure 6-9. DDR Read Timing Measurement Points

Electrical Specifications (Continued)

Table 6-17. GX2-SDR Interface Signals

Symbol	Parameter (Note 1)	Min	Max	Unit	Comments
t_{CK}	SD_FB_CLK output clock period	7.5		ns	133 MHz
	SD_FB_CLK Duty Cycle	45/55		%	
	SDCLK[7:0], SD_RD_OUT_CLK[11] period	7.5		ns	
	SDCLK[7:0], SD_RD_OUT_CLK[11] Duty Cycle	45/55		%	
t_{SKEW}	SDCLK[7:0], SD_RD_OUT_CLK[11] skew from SD_FB_CLK		0.5	ns	
	SD_WR_CLK period	7.5		ns	
	SD_WR_CLK Duty Cycle	40/60		%	
	SD_RD_IN_CLK period (SDCLK[8])	7.5		MHz	
	SD_RD_IN_CLK Duty Cycle (SDCLK[8])	40/60		%	
t_{DEL}	SD_RD_IN_CLK input delay from SDCLK11 output	0.5	2	ns	Note 2
t_{SU}	MD[63:0] Input Setup time to SD_RD_IN_CLK	0.0		ns	
t_{H}	MD[63:0] Input Hold time from SD_RD_IN_CLK	2.0		ns	
t_{VAL1}	MD[63:0], DQM[7:0] Output Data Valid Delay time from SD_FB_CLK	1.6	4.5	ns	
t_{VAL2}	MA[12:0], BA[1:0], CAS[1:0]#, RAS[1:0]#, CKE[1:0], CS[3:0]#, WE[1:0] Output Valid Delay time from SD_FB_CLK	1.6	4.5	ns	

Note 1. The delays in this table assume the GLCP_DELAY_CONTROLS (MSR 4C00000Fh) register. Alternate delay control settings affect these numbers.

Note 2. t_{DEL} is shown for functional board design. On a tester, t_{DEL} can have a minimum of -2 ns (SD_RD_IN_CLK can precede SD_RD_OUT_CLK11) and a maximum of t_{CK} - 4.5 ns (3.0 ns if t_{CK} is 7.5 ns).

Electrical Specifications (Continued)

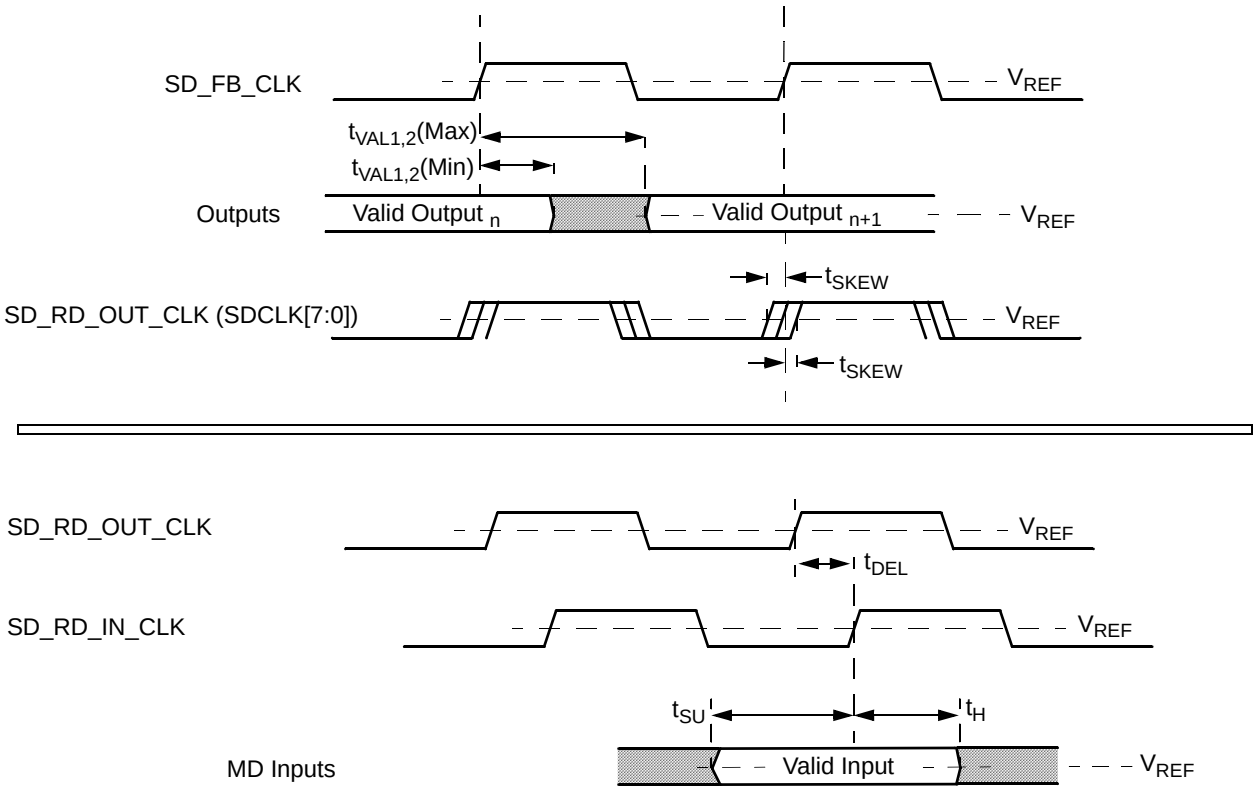


Figure 6-10. Drive Level and Measurement Points for SDR Memory Timing

Electrical Specifications (Continued)

Table 6-18. JTAG Interface Signals

Symbol	Parameter	Min	Max	Unit	Comments
	TCK period - Boundary scan	200		ns	
	TCK period - Functional	T_C			Note 1
	TCK Duty Cycle	40/60		%	
	TDI, TMS Setup time to TCK rising edge	1.0		ns	
	TMS Hold time from TCK rising edge	3.0		ns	
	TDI Hold time from TCK rising edge - Boundary scan	60.0		ns	
	TDI Hold time from TCK rising edge - Functional	1/2 T_C		ns	Note 1
	TDO Output Valid Delay time from TCK falling edge when running boundary scan test	3.0	20	ns	
	TDO Output Valid Delay time from TCK falling edge in normal functional mode	3.0	6.0	ns	
	All chip I/O Setup time to TCK rise - boundary scan	1.0		ns	
	All chip I/O Hold time from TCK rise - boundary scan	60		ns	
	All chip I/O Output Valid Delay time from TCK fall-ing edge - boundary scan test	2.0	40.0	ns	

Note 1. For DDR mode: T_C = 4 SDCLK periods. For SDR mode: T_C = 2 SDCLK periods.

7.0 Instruction Set

This chapter provides the general instruction set format and detailed information on the Geode GX2 processor's instructions/instruction encodings. The instruction set is divided into three categories:

- CPUID Instruction Set - listed in Section 7.2 on page 409.
- Processor Core Instruction Set - listed in Section 7.3 on page 415.
- MMX, FPU, and 3DNow! Instruction Sets (including extensions) - listed in Section 7.4 on page 428.

In the above listed sections are tables that provide information on the instruction encoding, and the instruction clock counts for each instruction. The clock count values for these tables are based on the following assumptions:

1) All clock counts refer to the internal processor core clock frequency.
2) The instruction has been prefetched, decoded, and is ready for execution.
3) Any needed memory operands are in the cache in the last accessed way (i.e., Way0, Way1, Way2, or Way3). Add two clocks if not in last accessed way.
4) No exceptions are detected during instruction execution.
5) If an effective address is calculated, it does not use two general register components. One register, scaling, and a displacement value can be used within the clock count shown. However, if the effective address calculation uses a base register, an index register, and a displacement value, a cycle must be added to the count.
6) All clock counts assume an 8-byte span of 32-bit memory/IO operands.
7) If instructions access a 32-bit operand not within an 8-byte block, add one clock for read or write and add two clocks for read and write.
8) For non-cached memory accesses, add several clocks. Cache miss accesses are approximately an additional 25 clocks, the exact number depends upon the cycle/operation running.
9) Locked cycles are not cacheable. Therefore, using the LOCK prefix with an instruction adds additional clocks as specified in item 8 above.

7.1 GENERAL INSTRUCTION SET FORMAT

Depending on the instruction, the GX2 processor core instructions follow the general instruction format shown in Table 7-1. These instructions vary in length and can start at any byte address. An instruction consists of one or more bytes that can include prefix bytes, at least one opcode byte, a mod r/m byte, an s-i-b byte, address displacement, and immediate data. An instruction can be as short as one byte and as long as 15 bytes. If there are more than 15 bytes in the instruction, a general protection fault (error code 0) is generated.

The fields in the general instruction format at the byte level are summarized in Table 7-2 and detailed in the following subsections.

Table 7-1. General Instruction Set Format

		Register and Address Mode Specifier							
		mod r/m Byte			s-i-b Byte			Address Displacement	Immediate Data
Prefix (Optional)	Opcode	mod	reg	r/m	ss	index	base		
0 or More Bytes	1 or 2 Bytes	7:6	5:3	2:0	7:6	5:3	2:0	0, 8, 16, or 32 Bits	0, 8, 16, or 32 Bits

Table 7-2. Instruction Fields

Field Name	Description
Prefix (optional)	Prefix Field(s): One or more optional fields that are used to specify segment register override, address and operand size, repeat elements in string instruction, and LOCK# assertion.
Opcode	Opcode Field: Identifies instruction operation.
mod	Address Mode Specifier: Used with the r/m field to select addressing mode.
reg	General Register Specifier: Uses reg, sreg3, or sreg2 encoding depending on opcode field.
r/m	Address Mode Specifier: Used with mod field to select addressing mode.
ss	Scale factor: Determines scaled-index address mode.
index	Index: Determines general register to be used as index register.
base	Base: Determines general register to be used as base register.
Address Displacement	Displacement: Determines address displacement.
Immediate Data	Immediate Data: Immediate data operand used by instruction.

Instruction Set (Continued)

7.1.1 Prefix (Optional)

Prefix bytes can be placed in front of any instruction to modify the operation of that instruction. When more than one prefix is used, the order is not important. There are five types of prefixes that can be used:

1) Segment Override explicitly specifies which segment register the instruction will use for effective address calculation.
2) Address Size switches between 16-bit and 32-bit addressing by selecting the non-default address size.
3) Operand Size switches between 16-bit and 32-bit operand size by selecting the non-default operand size.
4) Repeat is used with a string instruction to cause the instruction to be repeated for each element of the string.

Table 7-3 lists the encoding for different types of prefix bytes.

Table 7-3. Instruction Prefix Summary

Prefix	Encoding	Description
ES:	26h	Override segment default, use ES for memory operand.
CS:	2Eh	Override segment default, use CS for memory operand.
SS:	36h	Override segment default, use SS for memory operand.
DS:	3Eh	Override segment default, use DS for memory operand.
FS:	64h	Override segment default, use FS for memory operand.
GS:	65h	Override segment default, use GS for memory operand.
Operand Size	66h	Make operand size attribute the inverse of the default.
Address Size	67h	Make address size attribute the inverse of the default.
LOCK	F0h	Assert LOCK# hardware signal.
REPNE	F2h	Repeat the following string instruction.
REP/REPE	F3h	Repeat the following string instruction.

7.1.2 Opcode

The opcode field specifies the operation to be performed by the instruction. The opcode field is either one or two bytes in length and may be further defined by additional bits in the mod r/m byte. Some operations have more than one opcode, each specifying a different form of the operation. Certain opcodes name instruction groups. For example, opcode 80h names a group of operations that have an immediate operand and a register or memory operand. The reg field may appear in the second opcode byte or in the mod r/m byte.

The opcode may contain w, d, s, and eee opcode fields, for example, as shown in Table 7-27 on page 416.

7.1.2.1 w Field (Operand Size)

When used, the 1-bit w field selects the operand size during 16-bit and 32-bit data operations. See Table 7-4.

Table 7-4. w Field Encoding

w Field	Operand Size	
	16-Bit Data Operations	32-Bit Data Operations
0	8 bits	8 bits
1	16 bits	32 bits

7.1.2.2 d Field (Operand Direction)

When used, the 1-bit d field determines which operand is taken as the source operand and which operand is taken as the destination. See Table 7-5.

Table 7-5. d Field Encoding

d Field	Direction of Operation	Source Operand	Destination Operand
0	Register-to-Register or Register-to-Memory	reg	mod r/m or mod ss-index-base
1	Register-to-Register or Memory-to-Register	mod r/m or mod ss-index-base	reg

Instruction Set (Continued)

7.1.2.3 s Field (Immediate Data Field Size)

When used, the 1-bit s field determines the size of the immediate data field. If the s bit is set, the immediate field of the opcode is 8 bits wide and is sign-extended to match the operand size of the opcode. See Table 7-6.

Table 7-6. s Field Encoding

s Field	Immediate Field Size		
	8-Bit Operand Size	16-Bit Operand Size	32-Bit Operand Size
0 (or not present)	8 bits	16 bits	32 bits
1	8 bits	8 bits (sign-extended)	8 bits (sign-extended)

7.1.2.4 eee Field (MOV-Instruction Register Selection)

The eee field (bits [5:3]) is used to select the control, debug, and test registers in the MOV instructions. The type of register and base registers selected by the eee field are listed in Table 7-7. The values shown in Table 7-7 are the only valid encodings for the eee bits.

Table 7-7. eee Field Encoding

eee Field	Register Type	Base Register
000	Control Register	CR0
010	Control Register	CR2
011	Control Register	CR3
100	Control Register	CR4
000	Debug Register	DR0
001	Debug Register	DR1
010	Debug Register	DR2
011	Debug Register	DR3
110	Debug Register	DR6
111	Debug Register	DR7
000	Test Register	TR0
001	Test Register	TR1
010	Test Register	TR2
011	Test Register	TR3
100	Test Register	TR4
101	Test Register	TR5
110	Test Register	TR6
111	Test Register	TR7

7.1.3 mod and r/m Byte (Memory Addressing)

The mod and r/m fields within the mod r/m byte select the type of memory addressing to be used. Some instructions use a fixed addressing mode (e.g., PUSH or POP) and therefore, these fields are not present. Table 7-8 lists the addressing method when 16-bit addressing is used and a mod r/m byte is present. Some mod r/m field encodings are dependent on the w field and are shown in Table 7-9 on page 407.

Table 7-8. mod r/m Field Encoding

mod Field	r/m Field	16-Bit Address Mode with mod r/m ByteNote 1	32-Bit Address Mode with mod r/m Byte and No s-i-b Byte Present[Note 1]
00	000	DS:[BX+SI]	DS:[EAX]
00	001	DS:[BX+DI]	DS:[ECX]
00	010	SS:[BP+SI]	DS:[EDX]
00	011	SS:[BP+DI]	DS:[EBX]
00	100	DS:[SI]	s-i-b is present (See Table 7-15)
00	101	DS:[DI]	DS:[d32]
00	110	DS:[d16]	DS:[ESI]
00	111	DS:[BX]	DS:[EDI]
01	000	DS:[BX+SI+d8]	DS:[EAX+d8]
01	001	DS:[BX+DI+d8]	DS:[ECX+d8]
01	010	SS:[BP+SI+d8]	DS:[EDX+d8]
01	011	SS:[BP+DI+d8]	DS:[EBX+d8]
01	100	DS:[SI+d8]	s-i-b is present (See Table 7-15)
01	101	DS:[DI+d8]	SS:[EBP+d8]
01	110	SS:[BP+d8]	DS:[ESI+d8]
01	111	DS:[BX+d8]	DS:[EDI+d8]
10	000	DS:[BX+SI+d16]	DS:[EAX+d32]
10	001	DS:[BX+DI+d16]	DS:[ECX+d32]
10	010	SS:[BP+SI+d16]	DS:[EDX+d32]
10	011	SS:[BP+DI+d16]	DS:[EBX+d32]
10	100	DS:[SI+d16]	s-i-b is present (See Table 7-15)
10	101	DS:[DI+d16]	SS:[EBP+d32]
10	110	SS:[BP+d16]	DS:[ESI+d32]
10	111	DS:[BX+d16]	DS:[EDI+d32]
11	xxx	See Table 7-9.	See Table 7-9

Note 1.d8 refers to 8-bit displacement, d16 refers to 16-bit displacement, and d32 refers to a 32-bit displacement.

Table 7-9. General Registers Selected by mod r/m Fields and w Field

mod	r/m	16-Bit Operation		32-Bit Operation	
		w = 0	w = 1	w = 0	w = 1
11	000	AL	AX	AL	EAX
11	001	CL	CX	CL	ECX
11	010	DL	DX	DL	EDX
11	011	BL	BX	BL	EBX
11	100	AH	SP	AH	ESP
11	101	CH	BP	CH	EBP
11	110	DH	SI	DH	ESI
11	111	BH	DI	BH	EDI

7.1.4 reg Field

The reg field (Table 7-10) determines which general registers are to be used. The selected register is dependent on whether a 16-bit or 32-bit operation is current and on the status of the w bit.

Table 7-10. General Registers Selected by reg Field

reg	16-Bit Operation		32-Bit Operation	
	w = 0	w = 1	w = 0	w = 1
000	AL	AX	AL	EAX
001	CL	CX	CL	ECX
010	DL	DX	DL	EDX
011	BL	BX	BL	EBX
100	AH	SP	AH	ESP
101	CH	BP	CH	EBP
110	DH	SI	DH	ESI
111	BH	DI	BH	EDI

7.1.4.1 sreg2 Field (ES, CS, SS, DS Register Selection)

The sreg2 field (Table 7-11) is a 2-bit field that allows one of the four 286-type segment registers to be specified.

Table 7-11. sreg2 Field Encoding

sreg2 Field	Segment Register Selected
00	ES
01	CS
10	SS
11	DS

7.1.4.2 sreg3 Field (FS and GS Segment Register Selection)

The sreg3 field (Table 7-12) is 3-bit field that is similar to the sreg2 field, but allows use of the FS and GS segment registers.

Table 7-12. sreg3 Field Encoding

sreg3 Field	Segment Register Selected
000	ES
001	CS
010	SS
011	DS
100	FS
101	GS
110	Undefined
111	Undefined

Instruction Set (Continued)

7.1.5 s-i-b Byte (Scale, Indexing, Base)

The s-i-b fields provide scale factor, indexing, and a base field for address selection. The ss, index, and base fields are described next.

7.1.5.1 ss Field (Scale Selection)

The ss field (Table 7-13) specifies the scale factor used in the offset mechanism for address calculation. The scale factor multiplies the index value to provide one of the components used to calculate the offset address.

Table 7-13. ss Field Encoding

ss Field	Scale Factor
00	x1
01	x2
01	x4
11	x8

7.1.5.2 Index Field (Index Selection)

The index field (Table 7-14) specifies the index register used by the offset mechanism for offset address calculation. When no index register is used (index field = 100), the ss value must be 00 or the effective address is undefined.

Table 7-14. index Field Encoding

Index Field	Index Register
000	EAX
001	ECX
010	EDX
011	EBX
100	none
101	EBP
110	ESI
111	EDI

7.1.5.3 Base Field (s-i-b Present)

In Table 7-8, the note “s-i-b is present” for certain entries forces the use of the mod and base field as listed in Table 7-15. The first two digits in the first column of Table 7-15 identify the mod bits in the mod r/m byte. The last three digits in the first column of this table identify the base fields in the s-i-b byte.

Table 7-15. mod base Field Encoding

mod Field within mode/rm Byte (bits 7:6)	base Field within s-i-b Byte (bits 2:0)	32-Bit Address Mode with mod r/m and s-i-b Bytes Present
00	000	DS:[EAX+(scaled index)]
00	001	DS:[ECX+(scaled index)]
00	010	DS:[EDX+(scaled index)]
00	011	DS:[EBX+(scaled index)]
00	100	SS:[ESP+(scaled index)]
00	101	DS:[d32+(scaled index)]
00	110	DS:[ESI+(scaled index)]
00	111	DS:[EDI+(scaled index)]
01	000	DS:[EAX+(scaled index)+d8]
01	001	DS:[ECX+(scaled index)+d8]
01	010	DS:[EDX+(scaled index)+d8]
01	011	DS:[EBX+(scaled index)+d8]
01	100	SS:[ESP+(scaled index)+d8]
01	101	SS:[EBP+(scaled index)+d8]
01	110	DS:[ESI+(scaled index)+d8]
01	111	DS:[EDI+(scaled index)+d8]
10	000	DS:[EAX+(scaled index)+d32]
10	001	DS:[ECX+(scaled index)+d32]
10	010	DS:[EDX+(scaled index)+d32]
10	011	DS:[EBX+(scaled index)+d32]
10	100	SS:[ESP+(scaled index)+d32]
10	101	SS:[EBP+(scaled index)+d32]
10	110	DS:[ESI+(scaled index)+d32]
10	111	DS:[EDI+(scaled index)+d32]

Instruction Set (Continued)

7.2 CPUID INSTRUCTION SET

The CPUID instruction (opcode 0FA2) allows software to make processor inquiries as to the vendor, family, model, stepping, features, and specific cache organization information. The presence of support for the CPUID instruction is indicated by the ability to change the value of the ID flag, bit 21, in the EFLAGS register.

The CPUID level allows the CPUID instruction to return different information in EAX, EBX, ECX, and EDX registers. The level is determined by the initialized value of the EAX register prior to execution of the CPUID instruction.

The CPUID information can also be determined by reading the MSRs directly. See Table 7-16.

Table 7-16. CPUID MRS Address Map

MSR Address	Description		Reset Value
00003000h	Standard Levels & Vendor ID String 1	(cpuid[00000000] EBX/EAX)	646F6547_00000001h
00003001h	Vendor ID Strings 2 and 3	(cpuid[00000000] EDX/ECX)	79622065_43534E20h
00003002h	Type/Family/Model/Step	(cpuid[00000001] EBX/EAX)	00000000_0000055xh
00003003h	Feature Flags	(cpuid[00000001] EDX/ECX)	0080A93D_00000000h
00003004h-00003005h	Reserved (Not used)		00000000_00000000h
00003006h	CPUID Max Extended Levels 1	(cpuid[80000000] EBX/EAX)	646F6547_80000006h
00003007h	CPUID Max Extended Levels 2	(cpuid[80000000] EDX/ECX)	79622065_43534E20h
00003008h	Extended Type/Family/Model/Stepping	(cpuid[80000001] EBX/EAX)	00000000_0000055xh
00003009h	Extended Feature Flags	(cpuid[80000001] EDX/ECX)	C0C0A13D_00000000h
0000300Ah	CPU Marketing Name 1	(cpuid[80000002] EBX/EAX)	4D542865_646F6547h
0000300Bh	CPU Marketing Name 2	(cpuid[80000002] EDX/ECX)	72676574_6E492029h
0000300Ch	CPU Marketing Name 3	(cpuid[80000003] EBX/EAX)	6F725020_64657461h
0000300Dh	CPU Marketing Name 4	(cpuid[80000003] EDX/ECX)	6220726F_73736563h
0000300Eh	CPU Marketing Name 5	(cpuid[80000004] EBX/EAX)	6E6F6974_614E2079h
0000300Fh	CPU Marketing Name 6	(cpuid[80000004] EDX/ECX)	00696D65_53206C61h
00003010h	L1 TLB Information	(cpuid[80000005] EBX/EAX)	FF08FF08_00000000h
00003011h	L1 Cache Information	(cpuid[80000005] EDX/ECX)	10040120_10040120h
00003012h	L2 TLB Information	(cpuid[80000006] EBX/EAX)	00002040_0000F004h
00003013h	L2 TLB Information	(cpuid[80000006] EDX/ECX)	00000000_00000000h

Instruction Set (Continued)

7.2.1 Standard CPUID Levels

The standard CPUID levels are part of the standard x86 instruction set.

7.2.1.1 CPUID Instruction with EAX = 00000000h

Standard function 00000000h (EAX = 00000000h) of the CPUID instruction returns the maximum standard CPUID levels, as well as the processor vendor string.

After the instruction is executed, the EAX register contains the maximum standard CPUID levels supported. The maximum standard CPUID level is the highest acceptable value for the EAX register input. This does not include the extended CPUID levels.

The EBX through EDX registers contain the vendor string of the processor as shown in Table 7-17.

7.2.1.2 CPUID Instruction with EAX = 00000001h

Standard function 00000001h (EAX = 00000001h) of the CPUID instruction returns the processor type, family, model, stepping information in the EAX register, and the supported standard feature flags in the EDX register. The EBX and ECX registers are reserved. Table 7-18 provides a register map.

In the EDX register, each flag refers to a specific feature. Some of these features have protection control in CR4. Before using any of these features, the software should check the corresponding feature flag. Attempting to execute an unavailable feature can cause exceptions and unexpected behavior. For example, software must check EDX[4] before attempting to use the Time Stamp Counter instruction.Table 7-19 shows the EAX and EDX bit field formats when EAX = 00000001h and indicates if a feature is not supported.

Table 7-17. CPUID Instruction with EAX = 00000000h

Register Note 1	Returned Contents		Description	Comment
EAX	00000001h		Maximum Standard Level	
EBX	646F6547h	{doeG}	Vendor ID String 1	Vendor ID string is: Geode by NSC.
EDX	79622065h	{yb e}	Vendor ID String 2	
ECX	43534E20h	{CSN}	Vendor ID String 3	

Note 1.The “Register” column is intentionally out of order.

Table 7-18. CPUID Instruction with EAX = 00000001h

Register	Returned Contents	Description	Comment
EAX	0000055xh	Type/Family/Model/Step	
EBX	00000000h	Reserved	
ECX	00000000h	Reserved	
EDX	0080A93Dh	Standard Feature Flags	

Instruction Set (Continued)

Table 7-19. CPUID Instruction Codes with EAX = 00000001h

Register	Reset Value	Description	Comment
EAX[31:16]	0x0000	Reserved	
EAX[15:12]	0x0	Type	
EAX[11:8]	0x5	Family	
EAX[7:4]	0x5	Model	
EAX[3:0]	0x1	Step	May change with CPU revision
EDX[31:26]	000000	Reserved	
EDX[25]	0	XMM. Streaming SIMD Extensions	Not supported
EDX[24]	0	FXSR. Fast FP Save and Restore	Not supported
EDX[23]	1	MMX. MMX Instruction Set and Architecture	
EDX[22:19]	000	Reserved	
EDX[18]	0	PN. 96-Bit Serial Number Feature	Not supported
EDX[17]	0	PSE36. 36-Bit Page Size Extensions	Not supported
EDX[16]	0	PAT. Page Attribute Table	Not supported
EDX[15]	1	CMOV. Conditional Move Instruction	
EDX[14]	0	MCA. Machine Check Architecture	Not supported
EDX[13]	1	PGE. Page Global Enable Feature	
EDX[12]	0	MTRR. Memory Type Range Registers	Not supported
EDX[11]	1	SEP. Sysenter/Sysexit Instruction	
EDX[10]	0	Reserved	
EDX[9]	0	APIC. Advanced Programmable Interrupt	Not supported
EDX[8]	1	CX8. Compare Exchange (CMPXCHG8B) Instruction	
EDX[7]	0	MCE. Machine Check Exception	Not supported
EDX[6]	0	PAE. Page Address Extension	Not supported
EDX[5]	1	MSR. Model Specific Registers via RDMSR/WRMSR Instructions	
EDX[4]	1	TSC. Time Stamp Counter and RDTSC Instruction	
EDX[3]	1	PSE. 4 MB Page Size Extension	
EDX[2]	1	DE. Debugging Extension	
EDX[1]	0	VME. Virtual Interrupt Flag in VM86	Not supported
EDX[0]	1	FPU. Floating Point Unit On Chip	

Instruction Set (Continued)

7.2.2 Extended CPUID Levels

Testing for extended CPUID instruction support can be accomplished by executing a CPUID instruction with the EAX register initialized to 80000000h. If a value greater than or equal to 80000000h is returned to the EAX register by the CPUID instruction, the processor supports extended CPUID levels.

7.2.2.1 CPUID Instruction with EAX = 80000000h

Extended function 80000000h (EAX = 80000000h) of the CPUID instruction returns the maximum extended CPUID supported levels as well as the processor vendor string.

After the instruction is executed, the EAX register contains the maximum extended CPUID levels supported. The maximum extended standard CPUID level is the highest acceptable value for the EAX register input.

The EBX through EDX registers contain the vendor string of the processor as shown in Table 7-20.

7.2.2.2 CPUID Instruction with EAX = 80000001h

Extended function 80000001h (EAX = 80000001h) of the CPUID instruction returns the processor type, family, model, stepping information in the EAX register, and the supported extended feature flags in the EDX register. The EBX and ECX registers are reserved. Table 7-21 provides a register map.

In the EDX register, each flag refers to a specific extended feature. Some of these features have protection control in CR4. Before using any of these extended features, the software should check the corresponding flag. Attempting to execute an unavailable extended feature can cause exceptions and unexpected behavior.

Table 7-22 shows the EAX and EDX bit field formats when EAX = 80000001h and indicates if a feature is not supported.

Table 7-20. CPUID Instruction with EAX = 80000000h

Register Note 1	Returned Contents	Description	Comment
EAX	80000006h	Maximum Extended CPUID Level	
EBX	646F6547h {doeG}	Vendor ID String 1	Vendor ID string is: Geode by NSC.
EDX	79622065h {yb e}	Vendor ID String 2	
ECX	43534E20h {CSN}	Vendor ID String 3	

Note 1.The “Register” column is intentionally out of order.

.

Table 7-21. CPUID Instruction with EAX = 80000001h

Register	Returned Contents	Description	Comment
EAX	0000055xh	Type/Family/Model/Step	
EBX	00000000h	Reserved	
ECX	00000000h	Reserved	
EDX	0080A93Dh	Feature Flags	

Instruction Set (Continued)

Table 7-22. CPUID Instruction Codes with EAX = 80000001h

Register	Reset Value	Description	Comment
EAX[31:16]	0x0000	Reserved	
EAX[15:12]	0x0	Type	
EAX[11:8]	0x5	Family	
EAX[7:4]	0x5	Model	
EAX[3:0]	0x1	Step	May change with CPU revision
EDX[31]	1	3DN. 3DNow! Instruction Set	
EDX[30]	1	3DE. 3DNow! Instruction Set Extension	
EDX[29:25]	00000	Reserved	
EDX[25]	0	XMM. Streaming SIMD Extensions	Not supported
EDX[24]	0	FXSR/FXRSTOR. Fast FP Save and Restore	Not supported
EDX[23]	1	MMX. MMX Instruction Set and Architecture	
EDX[22]	1	AMMX. AMD MMX Instruction Extension	
EDX[21:18]	0000	Reserved	
EDX[17]	0	PSE36. 36-Bit Page Size Extensions	Not supported
EDX[16]	0	PAT. Page Attribute Table	Not supported
EDX[15]	1	CMOV. Conditional Move Instruction (CMOV, FCMOV, FCOMI)	
EDX[14]	0	MCA. Machine Check Architecture	Not supported
EDX[13]	1	PGE. Page Global Enable Feature	
EDX[12]	0	MTRR. Memory Type Range Registers	Not supported
EDX[11]	0	ASEP. Syscall/Sysret Instruction	
EDX[10]	0	Reserved	
EDX[9]	0	APIC. Advanced Programmable Interrupt Controller	Not supported
EDX[8]	1	CX8. Compare Exchange (CMPXCHG8B) Instruction	
EDX[7]	0	MCE. Machine Check Exception	Not supported
EDX[6]	0	PAE. Page Address Extension	Not supported
EDX[5]	1	MSR. Model Specific Registers via RDMSR/WRMSR Instructions	
EDX[4]	1	TSC. Time Stamp Counter and RDTSC Instruction	
EDX[3]	1	PSE. 4MB Page Size Extension	
EDX[2]	1	DE. Debugging Extension	
EDX[1]	0	VME. Virtual Interrupt Flag in VM86	Not supported
EDX[0]	1	FPU. Floating Point Unit On Chip	

Instruction Set (Continued)

7.2.2.3 CPUID Instruction with EAX = 80000002h, 80000003h, or 80000004h

Extended functions 80000002h through 80000004h (EAX = 80000002h, EAX = 80000003h, and EAX = 80000004h) of the CPUID instruction returns an ASCII string containing the CPU marketing name, as shown in Table 7-23. These functions eliminate the need to look up the processor name in a lookup table. Software can simply call these functions to obtain the name of the processor. The string may be 48 ASCII characters long, and is returned in little endian format. If the name is shorter than 48 characters long, the remaining bytes are filled with ASCII NUL characters (00h).

7.2.2.4 CPUID Instruction with EAX = 80000005h

Extended function 80000005h (EAX = 80000005h) of the CPUID instruction returns information on the internal L1 cache and TLB structures. They are used for reporting purposes only. See Table 7-24 for returned contents.

7.2.2.5 CPUID Instruction with EAX = 80000006h

Extended function 80000006h (EAX = 80000006h) of the CPUID instruction returns information on the internal L2 cache and TLB structures.

Table 7-23. CPUID Instruction with EAX = 80000002h, 80000003h, or 80000004h

Register	Returned Contents		Description	Comment
EAX = 80000002h				CPU Marketing Name: Geode™ Integrated Processor by National Semiconductor
EAX	646F6547h	{doeG}	CPU Marketing Name 1a	
EBX	4D542865h	{MT)e}	CPU Marketing Name 1b	
ECX	6E492029	{nI (}	CPU Marketing Name 2a	
EDX	72676574	{rget}	CPU Marketing Name 2b	
EAX = 80000003h				
EAX	64657461h	{deta}	CPU Marketing Name 3a	
EBX	6F725020h	{orP}	CPU Marketing Name 3b	
ECX	73736563h	{ssec}	CPU Marketing Name 4a	
EDX	6220726Fh	{b ro}	CPU Marketing Name 4b	
EAX = 80000004h				
EAX	614E2079h	{aN y}	CPU Marketing Name 5a	
EBX	6E6F6974h	{noit}	CPU Marketing Name 5b	
ECX	53206C61h	{S la}	CPU Marketing Name 6a	
EDX	00696D65h	{ime}	CPU Marketing Name 6b	

Table 7-24. CPUID Instruction with EAX = 80000005h

Register	Returned Contents	Description	Comment
EAX	00000000h	4 MB L1 TLB Information	Indicates no 4MB L1 TLB.
EBX	FF08FF08h	4 KB L1 TLB Information	Decodes to eight fully associative code TLB and eight fully associative data TLB entries.
ECX	10040120h	L1 Code Cache Information	Indicates 16 KB four-way associative with 32 byte lines for code cache. These encodings follow the AMD reporting method.
EDX	10040120h	L1 Data Cache Information	Indicates 16 KB four-way associative with 32 byte lines for data cache. These encodings follow the AMD reporting method.

.

Table 7-25. CPUID Instruction with EAX = 80000006h

Register	Returned Contents	Description	Comment
EAX	0000F004h	L2 TLB Information	Two-way associative 64 entry code and data combined TLB.
EBX	00002040h	L2 TLB Information	
EDX	00000000h	L2 Code Cache Information	Indicates no L2 cache.
ECX	00000000h	L2 Data Cache Information	

Instruction Set (Continued)

7.3 PROCESSOR CORE INSTRUCTION SET

The instruction set for the GX2 processor core is summarized in Table 7-27. The table uses several symbols and abbreviations that are described next and listed in Table 7-26.

7.3.1 Opcodes

Opcodes are given as hex values except when they appear within brackets as binary values.

7.3.2 Clock Counts

The clock counts listed in the instruction set summary table (Table 7-27) are grouped by operating mode (real and protected) and whether there is a register/cache hit or a cache miss. In some cases, more than one clock count is shown in a column for a given instruction, or a variable is used in the clock count.

7.3.3 Flags

There are nine flags that are affected by the execution of instructions. The flag names have been abbreviated and various conventions used to indicate what effect the instruction has on the particular flag.

Table 7-26. Processor Core Instruction Set Table Legend

Symbol or Abbreviation	Description
Opcode	
#	Immediate 8-bit data.
##	Immediate 16-bit data.
###	Full immediate 32-bit data (8, 16, or 32 bits).
+	8-bit signed displacement.
+++	Full signed displacement (16 or 32 bits).
Clock Count	
/	Register operand/memory operand.
n	Number of times operation is repeated.
L	Level of the stack frame.
|	Conditional jump taken | Conditional jump not taken. (e.g., “4|1” = four clocks if jump taken, one clock if jump not taken).
\	CPL ≤ IOPL \ CPL > IOPL (where CPL = Current Privilege Level, IOPL = I/O Privilege Level).
Flags	
OF	Overflow Flag.
DF	Direction Flag.
IF	Interrupt Enable Flag.
TF	Trap Flag.
SF	Sign Flag.
ZF	Zero Flag.
AF	Auxiliary Flag.
PF	Parity Flag.
CF	Carry Flag.
x	Flag is modified by the instruction.
-	Flag is not changed by the instruction.
0	Flag is reset to “0.”
1	Flag is set to “1.”
u	Flag is undefined following execution of the instruction.

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags										Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF		Real Mode	Prot'd Mode
AAA *ASCII Adjust AL after Addition*	37	3	3	u	-	-	-	u	u	x	u	x			
AAD *ASCII Adjust AX before Divide*	D5 0A	4	4	u	-	-	-	x	x	u	x	u			
AAM *ASCII Adjust AX after Multiply*	D4 0A			u	-	-	-	x	x	u	x	u			
Divide by non-zero		15	15												
Divide by zero		18	18												
AAS *ASCII Adjust AL after Subtract*	3F	3	3	u	-	-	-	u	u	x	u	x			
ADC *Add with Carry*				x	-	-	-	x	x	x	x	x		b	h
Register to Register	1 [00dw] [11 reg r/m]	1	1												
Register to Memory	1 [000w] [mod reg r/m]	1	1												
Memory to Register	1 [001w] [mod reg r/m]	1	1												
Immediate to Register/Memory	8 [00sw] [mod 010 r/m]###	1	1												
Immediate to Accumulator	1 [010w] ###	1	1												
ADD *Integer Add*				x	-	-	-	x	x	x	x	x		b	h
Register to Register	0 [00dw] [11 reg r/m]	1	1												
Register to Memory	0 [000w] [mod reg r/m]	1	1												
Memory to Register	0 [001w] [mod reg r/m]	1	1												
Immediate to Register/Memory	8 [00sw] [mod 000 r/m]###	1	1												
Immediate to Accumulator	0 [010w] ###	1	1												
AND *Boolean AND*				0	-	-	-	x	x	u	x	0		b	h
Register to Register	2 [00dw] [11 reg r/m]	1	1												
Register to Memory	2 [000w] [mod reg r/m]	1	1												
Memory to Register	2 [001w] [mod reg r/m]	1	1												
Immediate to Register/Memory	8 [00sw] [mod 100 r/m]###	1	1												
Immediate to Accumulator	2 [010w] ###	1	1												
ARPL *Adjust Requested Privilege Level*	63 [mod reg r/m]			-	-	-	-	-	x	-	-	-		a	h
To Memory DST[1:0] < SRC[1:0]			6												
To Memory DST[1:0] >= SRC[1:0]			4												
To Register DST[1:0] < SRC[1:0]			4												
To Register DST[1:0] >= SRC[1:0]			4												
BOUND *Check Array Boundaries*	62 [mod reg r/m]			-	-	-	-	-	-	-	-	-		b, e	g,h,j,k, r
If Below Range (Interrupt #5)		8+INT	8+INT												
If Above Range (Interrupt #5)		8+INT	8+INT												
If In Range		6	6												
BSF *Scan Bit Forward*	0F BC [mod reg r/m]	2	2	-	-	-	-	-	x	-	-	-		b	h
Register, Register/Memory															
BSR *Scan Bit Reverse*	0F BD [mod reg r/m]	2	2	-	-	-	-	-	x	-	-	-		b	h
Register, Register/Memory															
BSWAP *Byte Swap*	0F C[1 reg]	1	1	-	-	-	-	-	-	-	-	-			
BT *Test Bit*				-	-	-	-	-	-	-	-	x		b	h
Register/Memory, Immediate	0F BA [mod 100 r/m]#	1	1												
Register, Register	0F A3 [mod reg r/m]	1	1												
Memory, Register	0F A3 [mod reg r/m]	7	7												
BTC *Test Bit and Complement*				-	-	-	-	-	-	-	-	x		b	h
Register/Memory, Immediate	0F BA [mod 111 r/m]#	2	2												
Register, Register	0F BB [mod reg r/m]	2	2												
Memory, Register	0F BB [mod reg r/m]	8	8												
BTR *Test Bit and Reset*				-	-	-	-	-	-	-	-	x		b	h
Register/Memory, Immediate	0F BA [mod 110 r/m]#	2	2												
Register, register	0F B3 [mod reg r/m]	2	2												
Memory, Register	0F B3 [mod reg r/m	8	8												

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
BTS *Test Bit and Set*				-	-	-	-	-	-	-	-	x	b	h
Register/Memory, Immediate	0F BA [mod 101 r/m] #	2	2											
Register, Register	0F AB [mod reg r/m]	2	2											
Memory, Register	0F AB [mod reg r/m]	8	8											
CALL *Subroutine Call*				-	-	-	-	-	-	-	-	-	b	h,j,k,r
Direct Within Segment	E8 +++	2	2											
Register/Memory Indirect Within Segment	FF [mod 010 r/m]	2/4	2/4											
Direct Intersegment -Call Gate to Same Privilege -Call Gate to Different Privilege No Pars -Call Gate to Different Privilege m Pars -16-bit Task to 16-bit TSS -16-bit Task to 32-bit TSS -16-bit Task to V86 Task -32-bit Task to 16-bit TSS -32-bit Task to 32-bit TSS -32-bit Task to V86 Task	9A [unsigned full offset, selector]	7	14 24 45 51+2m 183 189 123 186 192 126											
Indirect Intersegment -Call Gate to Same Privilege -Call Gate to Different Privilege No Pars -Call Gate to Different Privilege m Pars -16-bit Task to 16-bit TSS -16-bit Task to 32-bit TSS -16-bit Task to V86 Task -32-bit Task to 16-bit TSS -32-bit Task to 32-bit TSS -32-bit Task to V86 Task	FF [mod 011 r/m]	9	15 25 46 52+2m 184 190 124 187 193 127											
CBW *Convert Byte to Word*	98	1	1	-	-	-	-	-	-	-	-	-		
CDQ *Convert Doubleword to Quadword*	99	2	2	-	-	-	-	-	-	-	-	-		
CLC *Clear Carry Flag*	F8	1	1	-	-	-	-	-	-	-	-	0		
CLD *Clear Direction Flag*	FC	2	2	-	0	-	-	-	-	-	-	-		
CLI *Clear Interrupt Flag*	FA	4	4	-	-	0	-	-	-	-	-	-		m
CLTS *Clear Task Switched Flag*	0F 06	3	3	-	-	-	-	-	-	-	-	-	c	l
CMC *Complement the Carry Flag*	F5	2	2	-	-	-	-	-	-	-	-	x		
CMOVA/CMOVNBE *Move if Above/Not Below or Equal*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 47 [mod reg r/m]													
CMOVBE/CMOVNA *Move if Below or Equal/Not Above*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 46 [mod reg r/m]													
CMOVAE/CMOVNB/CMOVNC *Move if Above or Equal/Not Below/Not Carry*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 43 [mod reg r/m]													
CMOVB/CMOVC/CMOVNAE *Move if Below/Carry/Not Above or Equal*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 42 [mod reg r/m]													
CMOVE/CMOVZ *Move if Equal/Zero*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 44 [mod reg r/m]													
CMOVNE/CMOVNZ *Move if Not Equal/Not Zero*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 45 [mod reg r/m]													
CMOVG/CMOVNLE *Move if Greater/Not Less or Equal*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 4F [mod reg r/m]													
CMOVLE/CMOVNG *Move if Less or Equal/Not Greater*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 4E [mod reg r/m]													
CMOVL/CMOVNGE *Move if Less/Not Greater or Equal*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 4C [mod reg r/m]													
CMOVGE/CMOVNL *Move if Greater or Equal/Not Less*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 4D [mod reg r/m]													
CMOVO *Move if Overflow*		1	1	-	-	-	-	-	-	-	-	-		r
Register, Register/Memory	0F 40 [mod reg r/m]													

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags										Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF		Real Mode	Prot'd Mode
CMOVNO *Move if No Overflow*	0F 41 [mod reg r/m]	1	1	-	-	-	-	-	-	-	-	-			r
Register, Register/Memory															
CMOVP/CMOVPE *Move if Parity/Parity Even*	0F 4A [mod reg r/m]	1	1	-	-	-	-	-	-	-	-	-			r
Register, Register/Memory															
CMOVNP/CMOVPO *Move if Not Parity/Parity Odd*	0F 4B [mod reg r/m]	1	1	-	-	-	-	-	-	-	-	-			r
Register, Register/Memory															
CMOVS *Move if Sign*	0F 48 [mod reg r/m]	1	1	-	-	-	-	-	-	-	-	-			r
Register, Register/Memory															
CMOVNS *Move if Not Sign*	0F 49 [mod reg r/m]	1	1	-	-	-	-	-	-	-	-	-			r
Register, Register/Memory															
CMP *Compare Integers*				x	-	-	-	x	x	x	x	x		b	h
Register to Register	3 [10dw] [11 reg r/m]	1	1												
Register to Memory	3 [101w] [mod reg r/m]	1	1												
Memory to Register	3 [100w] [mod reg r/m]	1	1												
Immediate to Register/Memory	8 [00sw] [mod 111 r/m] ###	1	1												
Immediate to Accumulator	3 [110w] ###	1	1												
CMPS *Compare String*	A [011w]	6	6	x	-	-	-	x	x	x	x	x		b	h
CMPXCHG *Compare and Exchange*				x	-	-	-	x	x	x	x	x			
Register1, Register2	0F B [000w] [11 reg2 reg1]	5	5												
Memory, Register	0F B [000w] [mod reg r/m]	5	5												
CMPXCHG8B *Compare and Exchange 8 Bytes*	0F C7 [mod 001 r/m]			-	-	-	-	-	-	-	-	-			
If {EDX,EAX} == DST		10	10												
If {EDX,EAX} != DST		12	12												
CPUID *CPU Identification*	0F A2			-	-	-	-	-	-	-	-	-			
If EAX <= 1		13	13												
If 1 < EAX < 2^{31}		10	10												
If 2^{31} <= EAX <= (2^{31}+6)		14	14												
If EAX > (2^{31}+6)		11	11												
CWD *Convert Word to Doubleword*	99	2	2	-	-	-	-	-	-	-	-	-			
CWDE *Convert Word to Doubleword Extended*	98	3	3	-	-	-	-	-	-	-	-	-			
DAA *Decimal Adjust AL after Addition*	27	2	2	-	-	-	-	x	x	x	x	x			
DAS *Decimal Adjust AL after Subtraction*	2F	2	2	-	-	-	-	x	x	x	x	x			
DEC *Decrement by 1*				x	-	-	-	x	x	x	x	-		b	h
Register/Memory Byte	FE [mod 001 r/m]	1	1												
Register/Memory Word/DWord	FF [mod 001 r/m]	1	1												
Register (short form)	4 [1 reg]	1	1												
DIV *Unsigned Divide*				-	-	-	-	x	x	u	u	-			
Accumulator by Register/Memory	F [011w] [mod 110 r/m]													b,e	e,h
Divisor: Byte		15	15												
Word		23	23												
Doubleword		39	39												
DMINT *Enter Debug Management Mode*	0F 39	51-53	51-53	0	0	0	0	0	0	0	0	0		s	s
ENTER *Enter New Stack Frame*	C8 ##,#			-	-	-	-	-	-	-	-	-			
Level = 0		7	7											b	h
Level = 1		13	13												
Level (L) > 1		15+2*L	15+2*L												
HLT *Halt*	F4	13	13	-	-	-	-	-	-	-	-	-			l
ICEBP *Call Debug Exception Handler*	F1	30	45-82	-	-	x	0	-	-	-	-	-			

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags										Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF		Real Mode	Prot'd Mode
IDIV *Integer (Signed) Divide*	F [011w] [mod 111 r/m]			-	-	-	-	x	x	u	u	-		b,e	e,h
Accumulator by Register/Memory															
Divisor: Byte		16	16												
Word		24	24												
Doubleword		40	40												
IMUL *Integer (Signed) Multiply*				x	-	-	-	x	x	u	u	x		b	h
Accumulator by Register/Memory	F [011w] [mod 101 r/m]														
Multiplier: Byte		3	3												
Word		4	4												
Doubleword		7	7												
Register with Register/Memory	0F AF [mod reg r/m]														
Multiplier: Word		4	4												
Doubleword		7	7												
Register/Memory with Immediate to Register2	6 [10s1] [mod reg r/m] ###														
Multiplier: Byte		4	4												
Word		4	4												
Doubleword		7	7												
IN *Input from I/O Port*				-	-	-	-	-	-	-	-	-			m
Fixed Port	E [010w] #	7	7/21												
Variable Port	E [110w]	7	7/21												
INC *Increment by 1*				x	-	-	-	x	x	x	x	-		b	h
Register/Memory	F [111w] [mod 000 r/m]	1	1												
Register (short form)	4 [0 reg]	1	1												
INS *Input String from I/O Port*	6 [110w]	10	10/24	-	-	-	-	-	-	-	-	-		b	h,m
INT i *Software Interrupt*	CD #			-	-	x	0	-	-	-	-	-		b,e	g,j,k,r
		23													
Protected Mode:															
-Interrupt or Trap to Same Privilege			33												
-Interrupt or Trap to Different Privilege			55												
-16-bit Task to 16-bit TSS by Task Gate			184												
-16-bit Task to 32-bit TSS by Task Gate			190												
-16-bit Task to V86 by Task Gate			124												
-16-bit Task to 16-bit TSS by Task Gate			187												
-32-bit Task to 32-bit TSS by Task Gate			193												
-32-bit Task to V86 by Task Gate			127												
-V86 to 16-bit TSS by Task Gate			187												
-V86 to 32-bit TSS by Task Gate			193												
-V86 to Privilege 0 by Trap Gate/Int Gate			64												
INT 3 *Breakpoint Software Interrupt*	CC	21	37-215											b,c	g,i,k,r
INTO *Overflow Software Interrupt*	CE													b,c	g,i,k,r
If OF==0		4	4												
If OF==1 (INT 4)		INT	INT												
INVD *Invalidate Cache*	0F 08	10	10	-	-	-	-	-	-	-	-	-		t	t
INVLPG *Invalidate TLB Entry*	0F 01 [mod 111 r/m]	7	7	-	-	-	-	-	-	-	-	-			
IRET *Interrupt Return*	CF			x	x	x	x	x	x	x	x	x			
Real Mode		9													g,h,j,k,r
Protected Mode:															
-Within Task to Same Privilege			20												
-Within Task to Different Privilege			39												
-16-bit Task to 16-bit Task			169												
-16-bit Task to 32-bit TSS			175												
-16-bit Task to V86 Task			109												
-32-bit Task to 16-bit TSS			172												
-32-bit Task to 32-bit TSS			178												
-32-bit Task to V86 Task			112												
JB/JNAE/JC *Jump on Below/Not Above or Equal/Carry*				-	-	-	-	-	-	-	-	-			r
8-bit Displacement	72 +	1	1												
Full Displacement	0F 82 +++	1	1												
JBE/JNA *Jump on Below or Equal/Not Above*				-	-	-	-	-	-	-	-				r
8-bit Displacement	76 +	1	1												
Full Displacement	0F 86 +++	1	1												
JCXZ/JECXZ *Jump on CX/ECX Zero*	E3 +	2	2	-	-	-	-	-	-	-	-	-			r

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
JE/JZ *Jump on Equal/Zero*				-	-	-	-	-	-	-	-			r
8-bit Displacement	74 +	1	1											
Full Displacement	0F 84 +++	1	1											
JL/JNGE *Jump on Less/Not Greater or Equal*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7C +	1	1											
Full Displacement	0F 8C +++	1	1											
JLE/JNG *Jump on Less or Equal/Not Greater*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7E +	1	1											
Full Displacement	0F 8E +++	1	1											
JMP *Unconditional Jump*				-	-	-	-	-	-	-	-		b	h,j,k,r
8-bit Displacement	EB +	1	1											
Full Displacement	E9 +++	1	1											
Register/Memory Indirect Within Segment	FF [mod 100 r/m]	1/3	1/3											
Direct Intersegment	EA [unsigned full offset, selector]	6	12											
-Call Gate Same Privilege Level			22											
-16-bit Task to 16-bit TSS			186											
-16-bit Task to 32-bit TSS			192											
-16-bit Task to V86 Task			126											
-32-bit Task to 16-bit TSS			189											
-32-bit Task to 32-bit TSS			195											
-32-bit Task to V86 Task			129											
Indirect Intersegment	FF [mod 101 r/m]	8	13											
-Call Gate Same Privilege Level			23											
-16-bit Task to 16-bit TSS			187											
-16-bit Task to 32-bit TSS			193											
-16-bit Task to V86 Task			127											
-32-bit Task to 16-bit TSS			190											
-32-bit Task to 32-bit TSS			196											
-32-bit Task to V86 Task			130											
JNB/JAE/JNC *Jump on Not Below/Above or Equal/Not Carry*				-	-	-	-	-	-	-	-			r
8-bit Displacement	73 +	1	1											
Full Displacement	0F 83 +++	1	1											
JNBE/JA *Jump on Not Below or Equal/Above*				-	-	-	-	-	-	-	-			r
8-bit Displacement	77 +	1	1											
Full Displacement	0F 87 +++	1	1											
JNE/JNZ *Jump on Not Equal/Not Zero*				-	-	-	-	-	-	-	-			r
8-bit Displacement	75 +	1	1											
Full Displacement	0F 85 +++	1	1											
JNL/JGE *Jump on Not Less/Greater or Equal*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7D +	1	1											
Full Displacement	0F 8D +++	1	1											
JNLE/JG *Jump on Not Less or Equal/Greater*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7F +	1	1											
Full Displacement	0F 8F +++	1	1											
JNO *Jump on Not Overflow*				-	-	-	-	-	-	-	-			r
8-bit Displacement	71 +	1	1											
Full Displacement	0F 81 +++	1	1											
JNP/JPO *Jump on Not Parity/Parity Odd*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7B +	1	1											
Full Displacement	0F 8B +++	1	1											
JNS *Jump on Not Sign*				-	-	-	-	-	-	-	-			r
8-bit Displacement	79 +	1	1											
Full Displacement	0F 89 +++	1	1											

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
JO *Jump on Overflow*				-	-	-	-	-	-	-	-			r
8-bit Displacement	70 +	1	1											
Full Displacement	0F 80 +++	1	1											
JP/JPE *Jump on Parity/Parity Even*				-	-	-	-	-	-	-	-			r
8-bit Displacement	7A +	1	1											
Full Displacement	0F 8A +++	1	1											
JS *Jump on Sign*				-	-	-	-	-	-	-	-			r
8-bit Displacement	78 +	1	1											
Full Displacement	0F 88 +++	1	1											
LAHF *Load AH with Flags*	9F	2	2	-	-	-	-	-	-	-	-	-		
LAR *Load Access Rights*	0F 02 [mod reg r/m]			-	-	-	-	-	x	-	-	-	a	g,h,j,p
From Register/Memory			9											
LDS *Load Pointer to DS*	C5 [mod reg r/m]	4	9/15	-	-	-	-	-	-	-	-	-	b	h,i,j
LEA *Load Effective Address*				-	-	-	-	-	-	-	-	-		
No Index Register	8D [mod reg r/m]	1	1											
With Index Register		1	1											
LES *Load Pointer to ES*	C4 [mod reg r/m]	4	9/15	-	-	-	-	-	-	-	-	-	b	h,i,j
LFS *Load Pointer to FS*	0F B4 [mod reg r/m]	4	9/15	-	-	-	-	-	-	-	-	-	b	h,i,j
LGDT *Load GDT Register*	0F 01 [mod 010 r/m]	8-9	8-9	-	-	-	-	-	-	-	-	-	b,c	h,l
LGS *Load Pointer to GS*	0F B5 [mod reg r/m]	4	9/15	-	-	-	-	-	-	-	-	-	b	h,i,j
LIDT *Load IDT Register*	0F 01 [mod 011 r/m]	8-9	8-9	-	-	-	-	-	-	-	-	-	b,c	h,l
LLDT *Load LDT Register*	0F 00 [mod 010 r/m]			-	-	-	-	-	-	-	-	-	a	g,h,j,l
From Register/Memory			8											
LMSW *Load Machine Status Word*				-	-	-	-	-	-	-	-	-		
From Register/Memory	0F 01 [mod 110 r/m]	8	8										b,c	h,l
LODS *Load String*	A [110 w]	2	2	-	-	-	-	-	-	-	-	-	b	h
LOOP *Offset Loop/No Loop*	E2 +	2	2	-	-	-	-	-	-	-	-	-		r
LOOPNZ/LOOPNE *Offset*	E0 +	2	2	-	-	-	-	-	-	-	-	-		r
LOOPZ/LOOPE *Offset*	E1 +	2	2	-	-	-	-	-	-	-	-	-		r
LSL *Load Segment Limit*				-	-	-	-	-	x	-	-	-		
From Register/Memory	0F 03 [mod reg r/m]		9										a	g,h,j,p
LSS *Load Pointer to SS*	0F B2 [mod reg r/m]	4	10/15	-	-	-	-	-	-	-	-	-	a	h,i,j
LTR *Load Task Register*				-	-	-	-	-	-	-	-	-		
From Register/Memory	0F 00 [mod 011 r/m]		9										a	g,h,j,l
LEAVE *Leave Current Stack Frame*	C9	2	2	-	-	-	-	-	-	-	-	-	b	h
MOV *Move Data*				-	-	-	-	-	-	-	-	-	b	h
Register to Register	8 [10dw] [11 reg r/m]	1	1											
Register to Memory	8 [100w] [mod reg r/m]	1	1											
Register/Memory to Register	8 [101w] [mod reg r/m]	1	1											
Immediate to Register/Memory	C [011w] [mod 000 r/m] ###	1	1											
Immediate to Register (short form)	B [w reg] ###	1	1											
Memory to Accumulator (short form)	A [000w] +++	1	1											
Accumulator to Memory (short form)	A [001w] +++	1	1											
MOV *Move to/from Segment Registers*				-	-	-	-	-	-	-	-	-		i,j
Register/Memory to Segment Register	8E [mod sreg3 r/m]	1	7/13											
Segment Register to Register/Memory	8C [mod sreg3 r/m]	1	1											
MOV *Move to/from Control Registers*				-	-	-	-	-	-	-	-	-		l
Register to CR	0F 22 [11 eee reg]	7-12	7-12											
CR to Register	0F 20 [11 eee reg]	2-5	2-5											

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
MOV *Move To/From Debug Registers*				-	-	-	-	-	-	-	-	-		l
Register to DR	0F 23 [11 eee reg]	8	8											
DR to Register	0F 21 [11 eee reg]	5	5											
MOV *Move To/From Test Registers*				-	-	-	-	-	-	-	-	-		l
Register to TR	0F 26 [11 eee reg]	2	2											
TR to Register	0F 24 [11 eee reg]	3	3											
MOVS *Move String*	A [010w]	4	4	-	-	-	-	-	-	-	-	-	b	h
MOVSX *Move with Sign Extension*				-	-	-	-	-	-	-	-	-	b	h
Register from Register/Memory	0F B[111w] [mod reg r/m]	1	1											
MOVZX *Move with Zero Extension*				-	-	-	-	-	-	-	-	-	b	h
Register from Register/Memory	0F B[011w] [mod reg r/m]	1	1											
MUL *Unsigned Multiply*				x	-	-	-	x	x	u	u	x	b	h
Accumulator with Register/Memory	F [011w] [mod 100 r/m]													
Multiplier: Byte		3	3											
Word		4	4											
Doubleword		7	7											
NEG *Negate Integer*	F [011w] [mod 011 r/m]	1	1	x	-	-	-	x	x	x	x	x	b	h
NOP *No Operation*	90	1	1	-	-	-	-	-	-	-	-	-		
NOT *Boolean Complement*	F [011w] [mod 010 r/m]	1	1	-	-	-	-	-	-	-	-	-	b	h
OIO *Official Invalid Opcode*	0F FF	1	8-125	-	-	x	0	-	-	-	-	-		
OR *Boolean OR*				0	-	-	-	x	x	u	x	0	b	h
Register to Register	0 [10dw] [11 reg r/m]	1	1											
Register to Memory	0 [100w] [mod reg r/m]	1	1											
Memory to Register	0 [101w] [mod reg r/m]	1	1											
Immediate to Register/Memory	8 [00sw] [mod 001 r/m] ###	1	1											
Immediate to Accumulator	0 [110w] ###	1	1											
OUT *Output to Port*				-	-	-	-	-	-	-	-	-		m
Fixed Port	E [011w] #	12	14/28											
Variable Port	E [111w]	12	14/28											
OUTS *Output String*	6 [111w]	13	15/29	-	-	-	-	-	-	-	-	-	b	h,m
POP *Pop Value off Stack*				-	-	-	-	-	-	-	-	-	b	h,i,j
Register	8F [mod 000 r/m]	1	1											
Memory	8F [mod 000 r/m]	3	3											
Register (short form)	5 [1 reg]	1	1											
DS	1F	1	6/13											
ES	07	1	6/13											
SS	17	1	8/13											
FS	0F A1	1	6/13											
GS	0F 9A	1	6/13											
POPA *Pop All General Registers*	61	8	8	-	-	-	-	-	-	-	-	-	b	h
POPF *Pop Stack into FLAGS*	9D	2	2	x	x	x	x	x	x	x	x	x	b	h,n
PREFIX BYTES				-	-	-	-	-	-	-	-	-		m
Assert Hardware LOCK Prefix	F0													
Address Size Prefix	67													
Operand Size Prefix	66													
Segment Override Prefix														
-CS	2E													
-DS	3E													
-ES	26													
-FS	64													
-GS	65													
-SS	36													

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
PUSH *Push Value onto Stack*				-	-	-	-	-	-	-	-	-	b	h
Register/Memory	FF [mod 110 r/m]	1/3	1/3											
Register (short form)	5 [0 reg]	1	1											
CS	0E	1	1											
SS	16	1	1											
DS	1E	1	1											
ES	06	1	1											
FS	0F A0	1	1											
GS	0F A8	1	1											
Immediate	6 [10s0] ###	1	1											
PUSHA *Push All General Registers*	60	8	8	-	-	-	-	-	-	-	-	-	b	h
PUSHF *Push FLAGS Register*	9C	2	2	-	-	-	-	-	-	-	-	-	b	h
RCL *Rotate Through Carry Left*														
Register/Memory by 1	D [000w] [mod 010 r/m]	2	2	x	-	-	-	-	-	-	-	x	b	h
Register/Memory by CL	D [001w] [mod 010 r/m]	4-9	4-9	u	-	-	-	-	-	-	-	x		
Register/Memory by Immediate	C [000w] [mod 010 r/m] #	4-9	4-9	u	-	-	-	-	-	-	-	x		
RCR *Rotate Through Carry Right*													b	h
Register/Memory by 1	D [000w] [mod 011 r/m]	3-5	305	x	-	-	-	-	-	-	-	x		
Register/Memory by CL	D [001w] [mod 011 r/m]	4-7	4-7	u	-	-	-	-	-	-	-	x		
Register/Memory by Immediate	C [000w] [mod 011 r/m] #	4-7	4-7	u	-	-	-	-	-	-	-	x		
RDM *Leave Debug Management Mode*	0F 3A	36-44	36-44	x	x	x	x	x	x	x	x	x	s	s
RDMSR *Read Tmodel Specific Register*	0F 32	5+	5+	-	-	-	-	-	-	-	-	-		
RDTSC *Read Time Stamp Counter*	0F 31	5+	5+	-	-	-	-	-	-	-	-	-		
REP INS *Input String*	F3 6[110w]	15+Cn	15+5n\ 30+5n	-	-	-	-	-	-	-	-	-	b	h,m
REP LODS *Load String*	F3 A[110w]	8+2n	8+2n	-	-	-	-	-	-	-	-	-	b	h
REP MOVS *Move String*	F3 A[010w]	11+2n	11+2n	-	-	-	-	-	-	-	-	-	b	h
REP OUTS *Output String*	F3 6[111w]	16+10 n	16+10 n\ 31+10 n	-	-	-	-	-	-	-	-	-	b	h,m
REP STOS *Store String*	F3 A[101w]	9+2n	9+2n	-	-	-	-	-	-	-	-	-	b	h
REPE CMPS *Compare String*														
Find non-match	F3 A[011w]	11+4n	11+4n	x	-	-	-	x	x	x	x	x	b	h
REPE SCAS *Scan String*														
Find non-AL/AX/EAX	F3 A[111w]	9+3n	9+3n	x	-	-	-	x	x	x	x	x	b	h
REPNE CMPS *Compare String*														
Find match	F2 A[011w]	10+4n	10+4n	x	-	-	-	x	x	x	x	x	b	h
REPNE SCAS *Scan String*														
Find AL/AX/EAX	F2 A[111w]	7+3n	7+3n	x	-	-	-	x	x	x	x	x	b	h
RET *Return from Subroutine*				-	-	-	-	-	-	-	-	-		
Within Segment	C3	3	3										b	g,h,j,k, r
Within Segment Adding Immediate to SP	C2 ##	3	3											
Intersegment	CB	6	13											
Intersegment Adding Immediate to SP	CA ##	7	13											
Protected Mode: Different Privilege Level -Intersegment -Intersegment Adding Immediate to SP			 35 35											
ROL *Rotate Left*														
Register/Memory by 1	D[000w] [mod 000 r/m]	2	2	x	-	-	-	-	-	-	-	x	b	h
Register/Memory by CL	D[001w] [mod 000 r/m]	2	2	u	-	-	-	-	-	-	-	x		
Register/Memory by Immediate	C[000w] [mod 000 r/m] #	2	2	u	-	-	-	-	-	-	-	x		

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
ROR *Rotate Right*														
Register/Memory by 1	D[000w] [mod 001 r/m]	2	2	x	-	-	-	-	-	-	-	x	b	h
Register/Memory by CL	D[001w] [mod 001 r/m]	2	2	u	-	-	-	-	-	-	-	x		
Register/Memory by Immediate	C[000w] [mod 001 r/m] #	2	2	u	-	-	-	-	-	-	-	x		
RSDC *Restore Segment Register and Descriptor*	0F 79 [mod sreg3 r/m]	11	11	-	-	-	-	-	-	-	-	-	s	s
RSLDT *Restore LDTR and Descriptor*	0F 7B [mod 000 r/m]	9	9	-	-	-	-	-	-	-	-	-	s	s
RSTS *Restore TSR and Descriptor*	0F 7D [mod 000 r/m]	10	10	-	-	-	-	-	-	-	-	-	s	s
RSM *Resume from SMM Mode*	0F AA	36	36	x	x	x	x	x	x	x	x	x	s	s
SAHF *Store AH in FLAGS*	9E	1	1	-	-	-	-	x	x	x	x	x		
SAL *Shift Left Arithmetic*													b	h
Register/Memory by 1	D[000w] [mod 100 r/m]	1	1	x	-	-	-	x	x	u	x	x		
Register/Memory by CL	D[001w] [mod 100 r/m]	2	2	u	-	-	-	x	x	u	x	x		
Register/Memory by Immediate	C[000w] [mod 100 r/m] #	1	1	u	-	-	-	x	x	u	x	x		
SAR *Shift Right Arithmetic*													b	h
Register/Memory by 1	D[000w] [mod 111 r/m]	2	2	x	-	-	-	x	x	u	x	x		
Register/Memory by CL	D[001w] [mod 111 r/m]	2	2	u	-	-	-	x	x	u	x	x		
Register/Memory by Immediate	C[000w] [mod 111 r/m] #	2	2	u	-	-	-	x	x	u	x	x		
SBB *Integer Subtract with Borrow*													b	h
Register to Register	1[10dw] [11 reg r/m]	1	1	x	-	-	-	x	x	x	x	x		
Register to Memory	1[100w] [mod reg r/m]	1	1											
Memory to Register	1[101w] [mod reg r/m]	1	1											
Immediate to Register/Memory	8[00sw] [mod 011 r/m] ###	1	1											
Immediate to Accumulator (short form)	1[110w] ###	1	1											
SCAS *Scan String*	A [111w]	2	2	x	-	-	-	x	x	x	x	x	b	h
SETB/SETNAE/SETC *Set Byte on Below/Not Above or Equal/Carry*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 92 [mod 000 r/m]	1	1											
SETBE/SETNA *Set Byte on Below or Equal/Not Above*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 96 [mod 000 r/m]	1	1											
SETE/SETZ *Set Byte on Equal/Zero*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 94 [mod 000 r/m]	1	1											
SETL/SETNGE *Set Byte on Less/Not Greater or Equal*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9C [mod 000 r/m]	1	1											
SETLE/SETNG *Set Byte on Less or Equal/Not Greater*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9E [mod 000 r/m]	1	1											
SETNB/SETAE/SETNC *Set Byte on Not Below/Above or Equal/Not Carry*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 93 [mod 000 r/m]	1	1											
SETNBE/SETA *Set Byte on Not Below or Equal/Above*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 97 [mod 000 r/m]	1	1											
SETNE/SETNZ *Set Byte on Not Equal/Not Zero*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 95 [mod 000 r/m]	1	1											
SETNL/SETGE *Set Byte on Not Less/Greater or Equal*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9D [mod 000 r/m]	1	1											
SETNLE/SETG *Set Byte on Not Less or Equal/Greater*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9F [mod 000 r/m]	1	1											
SETNO *Set Byte on Not Overflow*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 91 [mod 000 r/m]	1	1											
SETNP/SETPO *Set Byte on Not Parity/Parity Odd*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9B [mod 000 r/m]	1	1											
SETNS *Set Byte on Not Sign*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 99 [mod 000 r/m]	1	1											

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
SETO *Set Byte on Overflow*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 90 [mod 000 r/m]	1	1											
SETP/SETPE *Set Byte on Parity/Parity Even*				-	-	-	-	-	-	-	-	-		h
To Register/Memory	0F 9A [mod 000 r/m]	1	1											
SETS *Set Byte on Sign*														h
To Register/Memory	0F 98 [mod 000 r/m]	1	1	-	-	-	-	-	-	-	-	-		
SGDT *Store GDT Register*													b,c	h
To Register/Memory	0F 01 [mod 000 r/m]	6	6	-	-	-	-	-	-	-	-	-		
SIDT *Store IDT Register*													b,c	h
To Register/Memory	0F 01 [mod 001 r/m]	6	6	-	-	-	-	-	-	-	-	-		
SLDT *Store LDT Register*													a	h
To Register/Memory	0F 00 [mod 000 r/m]		1	-	-	-	-	-	-	-	-	-		
STR *Store Task Register*													a	h
To Register/Memory	0F 00 [mod 001 r/m]		3	-	-	-	-	-	-	-	-	-		
SMSW *Store Machine Status Word*	0F 01 [mod 100 r/m]	2	2	-	-	-	-	-	-	-	-	-	b,c	h
STOS *Store String*	A [101w]	2	2	-	-	-	-	-	-	-	-	-	b	h
SHL *Shift Left Logical*													b	h
Register/Memory by 1	D [000w] [mod 100 r/m]	1	1	x	-	-	-	x	x	u	x	x		
Register/Memory by CL	D [001w] [mod 100 r/m]	2	2	u	-	-	-	x	x	u	x	x		
Register/Memory by Immediate	C [000w] [mod 100 r/m] #	1	1	u	-	-	-	x	x	u	x	x		
SHLD *Shift Left Double*				u	-	-	-	x	x	u	x	x	b	h
Register/Memory by Immediate	0F A4 [mod reg r/m] #	2	2											
Register/Memory by CL	0F A5 [mod reg r/m]	2	2											
SHR *Shift Right Logical*													b	h
Register/Memory by 1	D [000w] [mod 101 r/m]	2	2	x	-	-	-	x	x	u	x	x		
Register/Memory by CL	D [001w] [mod 101 r/m]	2	2	u	-	-	-	x	x	u	x	x		
Register/Memory by Immediate	C [000w] [mod 101 r/m] #	2	2	u	-	-	-	x	x	u	x	x		
SHRD *Shift Right Double*				u	-	-	-	x	x	u	x	x	b	h
Register/Memory by Immediate	0F AC [mod reg r/m] #	2	2											
Register/Memory by CL	0F AD [mod reg r/m]	2	2											
SMINT *Software SMM Entry*	0F 38	57-58	57-58	-	-	-	-	-	-	-	-	-	s	s
STC *Set Carry Flag*	F9	1	1	-	-	-	-	-	-	-	-	1		
STD *Set Direction Flag*	FD	2	2	-	1	-	-	-	-	-	-	-		
STI *Set Interrupt Flag*	FB	4	4	-	-	1	-	-	-	-	-	-		m
SUB *Integer Subtract*				x	-	-	-	x	x	x	x	x	b	h
Register to Register	2 [10dw] [11 reg r/m]	1	1											
Register to Memory	2 [100w] [mod reg r/m]	1	1											
Memory to Register	2 [101w] [mod reg r/m]	1	1											
Immediate to Register/Memory	8 [00sw] [mod 101 r/m] ###	1	1											
Immediate to Accumulator (short form)	2 [110w] ###	1	1											
SVDC *Save Segment Register and Descriptor*	0F 78 [mod sreg3 r/m]	7	7	-	-	-	-	-	-	-	-	-	s	s
SVLDT *Save LDTR and Descriptor*	0F 7A [mod 000 r/m]	7	7	-	-	-	-	-	-	-	-	-	s	s
SVTS *Save TSR and Descriptor*	0F 7C [mod 000 r/m]	8	8	-	-	-	-	-	-	-	-	-	s	s
SYSENTER *Fast System Call Entry*	0F 34	10	10	-	-	-	-	-	-	-	-	-		
SYSEXIT *Fast System Call Exit*	0F 35	11	11	-	-	-	-	-	-	-	-	-		
TEST *Test Bits*				0	-	-	-	x	x	u	x	0	b	h
Register/Memory and Register	8 [010w] [mod reg r/m]	1	1											
Immediate Data and Register/Memory	F [011w] [mod 000 r/m] ###	1	1											
Immediate Data and Accumulator	A [100w] ###	1	1											
VERR *Verify Read Access*				-	-	-	-	-	x	-	-	-	a	g,h,j,p
To Register/Memory	0F 00 [mod 100 r/m]		8											

Instruction Set (Continued)

Table 7-27. Processor Core Instruction Set (Continued)

Instruction	Opcode	Clock Count (Reg/Cache Hit)		Flags								Notes	
		Real Mode	Prot'd Mode	OF	DF	IF	TF	SF	ZF	AF	PF	CF	Real Mode	Prot'd Mode
VERW *Verify Write Access*				-	-	-	-	-	x	-	-	-	a	g,h,j,p
To Register/Memory	0F 00 [mod 101 r/m]		8											
WAIT *Wait Until FPU Not Busy*	9B	1	1	-	-	-	-	-	-	-	-	-		
WBINVD *Writeback and Invalidate Cache*	0F 09	23	23	-	-	-	-	-	-	-	-	-	t	t
WRMSR *Write to Model Specific Register*	0F 30	10	10	-	-	-	-	-	-	-	-	-		
XADD *Exchange and Add*				x	-	-	-	x	x	x	x	x		
Register1, Register2	0F C[000w] [11 reg2 reg1]	2	2											
Memory, Register	0F C[000w] [mod reg r/m]	2	2											
XCHG *Exchange*				-	-	-	-	-	-	-	-	-	b,f	f,h
Register/Memory with Register	8[011w] [mod reg r/m]	2	2											
Register with Accumulator	9[0 reg]	2	2											
XLAT *Translate Byte*	D7	4	4	-	-	-	-	-	-	-	-	-		h
XOR *Boolean Exclusive OR*				0	-	-	-	x	x	u	x	0	b	h
Register to Register	3 [00dw] [11 reg r/m]	1	1											
Register to Memory	3 [000w] [mod reg r/m]	1	1											
Memory to Register	3 [001w] [mod reg r/m]	1	1											
Immediate to Register/Memory	8 [00sw] [mod 110 r/m] ###	1	1											
Immediate to Accumulator (short form)	3 [010w] ###	1	1											

Instruction Notes for Instruction Set Summary

Notes a through c apply to real address mode only:

a. This is a protected mode instruction. Attempted execution in real mode results in exception 6 (invalid opcode).

b. Exception 13 fault (general protection) occurs in real mode if an operand reference is made that partially or fully extends beyond the maximum CS, DS, ES, FS, or GS segment limit. Exception 12 fault (stack segment limit violation or not present) occurs in real mode if an operand reference is made that partially or fully extends beyond the maximum SS limit.

c. This instruction may be executed in real mode. In real mode, its purpose is primarily to initialize the CPU for protected mode.

d. -

Notes e through g apply to real address mode and protected virtual address mode:

e. An exception may occur, depending on the value of the operand.

f. LOCK# is automatically asserted, regardless of the presence or absence of the LOCK prefix.

g. LOCK# is asserted during descriptor table accesses.

Notes h through r apply to protected virtual address mode only:

h. Exception 13 fault occurs if the memory operand in CS, DS, ES, FS, or GS cannot be used due to either a segment limit violation or an access rights violation. If a stack limit is violated, an exception 12 occurs.

i. For segment load operations, the CPL, RPL, and DPL must agree with the privilege rules to avoid an exception 13 fault. The segment's descriptor must indicate "present" or exception 11 (CS, DS, ES, FS, or GS not present). If the SS register is loaded, and a stack segment not present is detected, an exception 12 occurs.

j. All segment descriptor accesses in the GDT or LDT made by this instruction automatically assert LOCK# to maintain descriptor integrity in multiprocessor systems.

k. JMP, CALL, INT, RET, and IRET instructions referring to another code segment cause an exception 13, if an applicable privilege rule is violated.

l. An exception 13 fault occurs if CPL is greater than 0 (0 is the most privileged level).

m. An exception 13 fault occurs if CPL is greater than IOPL.

Instruction Set (Continued)

n. The IF bit of the Flags register is not updated if CPL is greater than IOPL. The IOPL and VM fields of the Flags register are updated only if CPL = 0.

o. The PE bit of the MSW (CR0) cannot be reset by this instruction. Use MOV into CR0 if you need to reset the PE bit.

p. Any violation of privilege rules as they apply to the selector operand do not cause a Protection exception; rather, the zero flag is cleared.

q. If the processor's memory operand violates a segment limit or segment access rights, an exception 13 fault occurs before the ESC instruction is executed. An exception 12 fault occurs if the stack limit is violated by the operand's starting address.

r. The destination of a JMP, CALL, INT, RET, or IRET must be in the defined limit of a code segment or an exception 13 fault occurs.

Issue s applies to National Semiconductor-specific SMM and DMM instructions:

s. An invalid opcode exception 6 occurs unless the current privilege level is zero (most privileged) and either the instruction is enabled in SMM_CTL, the instruction is enabled in DMM_CTL, the processor is in system management mode, or the processor is in debug management mode.

Issue t applies to the cache invalidation instruction with the cache operating in writeback mode:

t. The total clock count is the clock count shown plus the number of clocks required to write all "modified" cache lines to external memory.

Instruction Set (Continued)

7.4 MMX, FPU, AND 3DNOW! INSTRUCTIONS SETS

The CPU is functionally divided into the FPU unit and the Integer Unit. The FPU has been extended to process both MMX, 3DNow!, and floating point instructions in parallel with the Integer Unit.

When the Integer Unit detects an MMX instruction, the instruction is passed to the FPU unit for execution. The Integer Unit continues to execute instructions while the FPU unit executes the MMX instruction. If another MMX instruction is encountered, the second MMX instruction is placed in the MMX queue. Up to six MMX instructions can be queued.

When the Integer Unit detects a floating point instruction without memory operands, after two clock cycles the instruction passes to the FPU for execution. The Integer Unit continues to execute instructions while the FPU executes the floating point instruction. If another FPU instruction is encountered, the second FPU instruction is placed in the FPU queue. Up to four FPU instructions can be queued. In the event of an FPU exception, while other FPU instructions are queued, the state of the CPU is saved to ensure recovery.

The MMX instruction set (including extensions) is summarized in Table 7-29. The FPU instruction set is summarized in Table 7-30. The 3DNow! instruction set (including extensions) is summarized in Table 7-31. The abbreviations used in the instruction sets are listed in Table 7-28.

Note: The following opcodes are reserved: D9D7, D9E2, D9E7, DDFC, DED8, DEDA, DEDC, DEDD, DEDE, and DFFC. If a reserved opcode is executed, unpredictable results may occur (exceptions are not generated).

Table 7-28. MMX, FPU, and 3DNow! Instruction Set Table Legend

Abbreviation	Description
<---	Result written.
[11 mm reg]	Binary or binary groups of digits.
mm	One of eight 64-bit MMX registers.
reg	A general purpose register.
<--- sat ---	If required, the resultant data is saturated to remain in the associated data range.
<--- move ---	Source data is moved to result location.
[byte]	Eight 8-bit BYTEs are processed in parallel.
[word]	Four 16-bit WORDs are processed in parallel.
[dword]	Two 32-bit DWORDs are processed in parallel.
[qword]	One 64-bit QWORD is processed.
[sign xxx]	The BYTE, WORD, DWORD, or QWORD most significant bit is a sign bit.
mm1, mm2	MMX Register 1, MMX Register 2.
mod r/m	Mod and r/m byte encoding (Table 7-8 on page 406).
pack	Source data is truncated or saturated to next smaller data size, then concatenated.
packdw	Pack two DWORDs from source and two DWORDs from destination into four WORDs in the destination register.
packwb	Pack four WORDs from source and four WORDs from destination into eight BYTEs in the destination register.
imm8	One-byte of immediate value.
memory64	64 bits in memory located in eight consecutive bytes.
memory32	32 bits in memory located in four consecutive bytes.
index 0 (imm8)	The value imm8 [1:0] *16.
index 1 (imm8)	The value imm8 [3:2] *16.
index 2 (imm8)	The value imm8 [5:4] *16.
index 3 (imm8)	The value imm8 [7:6] *16.
windex 0 (imm8)	The range given by [index0 (imm8) + 15: index0 (imm8)].
windex 1 (imm8)	The range given by [index1 (imm8) + 15: index1 (imm8)].

Instruction Set (Continued)

Table 7-28. MMX, FPU, and 3DNow! Instruction Set Table Legend (Continued)

Abbreviation	Description
windex 2 (imm8)	The range given by [index2 (imm8) + 15: index2 (imm8)].
windex 3 (imm8)	The range given by [index3 (imm8) r15: indes3 (imm8)].
windexall (imm8)	The four different index # (imm8) ordered in the same way as word.
msb [bytes]	The most significant bits of the different eight bytes in QWORD, ordered from higher to lower bytes.
msb [words]	The most significant bits (sign bit) of the different four WORDs in a QWORD ordered from higher to lower.
trun	If required, the resultant data is truncated to remain within the associated range.
n	Stack register number.
TOSNote 1	Top of stack register pointed to by SSS in the status register.
ST(1)Note 1	FPU register next to TOS.
ST(n)Note 1	A specific FPU register, relative to TOS.
M.WI	16-bit integer operand from memory.
M.SI	32-bit integer operand from memory.
M.LI	64-bit integer operand from memory.
M.SR	32-bit real operand from memory.
M.DR	64-bit real operand from memory.
M.XR	80-bit real operand from memory.
M.BCD	18-digit BCD integer operand from memory.
CC	FPU condition code.
Env Regs	Status, Mode Control and Tag registers, Instruction Pointer and Operand Pointer.

Note 1.All references to TOS and ST(n) refer to stack layout prior to execution. Values popped off the stack are discarded. A POP from the stack increments the top of the stack pointer. A PUSH to the stack decrements the top of the stack pointer.

Table 7-29. MMX Instruction Set

MMX Instructions	Opcode	Operation	Clock Ct	Notes
EMMS *Empty MMX State*	0F77	Tag Word <--- FFFFh (empties the floating point tag word)	1	1
MASKMOVQ *Streaming (Cache Bypass) Store Using Byte Mask (Using EDI Register)*			2	
MMX Register1with MMX Register2	0FF7 [11 mm1 mm2]	memory [edi] [byte] <--- MMX reg 2 [Sign byte] ? MMX reg 1 [byte] : memory [edi] [byte]		
MOVD *Move Doubleword*				
Register to MMX Register	0F6E [11 mm reg]	MMX reg [qword] <--- zero extend --- reg [dword]	1	
MMX Register to Register	0F7E [11 mm reg]	reg [qword] <--- MMX reg [low dword]	1	
Memory to MMX Register	0F6E [mod mm r/m]	MMX regr [qword] <--- zero extend --- memory [dword]	1	
MMX Register to Memory	0F7E [mod mm r/m]	Memory [dword] <--- MMX reg [low dword]	1	
MOVNTQ *Streaming (Cache Bypass) Store*			1	
MMX Register to Memory64	0FE7 [mod mm r/m]	Memory64 [qword] <--- MMX reg [qword]		
MOVQ *Move Quardword*				
MMX Register 2 to MMX Register 1	0F6F [11 mm1 mm2]	MMX reg 1 [qword] <--- MMX reg 2 [qword]	1	
MMX Register 1 to MMX Register 2	0F7F [11 mm1 mm2]	MMX reg 2 [qword] <--- MMX reg 1 [qword]	1	
Memory to MMX Register	0F6F [mod mm r/m]	MMX reg [qword] <--- memory[qword]	1	
MMX Register to Memory	0F7F [mod mm r/m]	Memory [qword] <--- MMX reg [qword]	1	

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PACKSSDW *Pack Dword with Signed Saturation*				
MMX Register 2 to MMX Register 1	0F6B [11 mm1 mm2]	MMX reg 1 [qword] <--- packdw, signed sat --- MMX reg 2, MMX reg 1	2	
Memory to MMX Register	0F6B [mod mm r/m]	MMX reg [qword] <--- packdw, signed sat --- memory, MMX reg	2	
PACKSSWB *Pack Word with Signed Saturation*				
MMX Register 2 to MMX Register 1	0F63 [11 mm1 mm2]	MMX reg 1 [qword] <--- packwb, signed sat --- MMX reg 2, MMX reg 1	2	
Memory to MMX Register	0F63 [mod mm r/m]	MMX reg [qword] <--- packwb, signed sat --- memory, MMX reg	2	
PACKUSWB *Pack Word with Unsigned Saturation*				
MMX Register 2 to MMX Register 1	0F67 [11 mm1 mm2]	MMX reg 1 [qword] <--- packwb, unsigned sat --- MMX reg 2, MMX reg 1	2	
Memory to MMX Register	0F67 [mod mm r/m]	MMX reg [qword] <--- packwb, unsigned sat --- memory, MMX reg	2	
PADDB *Packed Add Byte with Wrap-Around*				
MMX Register 2 to MMX Register 1	0FFC [11 mm1 mm2]	MMX reg 1 [byte] <--- MMX reg 1 [byte] + MMX reg 2 [byte]	2	
Memory to MMX Register	0FFC [mod mm r/m]	MMX reg[byte] <--- memory [byte] + MMX reg [byte]	2	
PADDD *Packed Add Dword with Wrap-Around*				
MMX Register 2 to MMX Register 1	0FFE [11 mm1 mm2]	MMX reg 1 [sign dword] <--- MMX reg 1 [sign dword] + MMX reg 2 [sign dword]	2	
Memory to MMX Register	0FFE [mod mm r/m]	MMX reg [sign dword] <--- memory [sign dword] + MMX reg [sign dword]	2	
PADDSB *Packed Add Signed Byte with Saturation*				
MMX Register 2 to MMX Register 1	0FEC [11 mm1 mm2]	MMX reg 1 [sign byte] <--- sat --- (MMX reg 1 [sign byte] + MMX reg 2 [sign byte])	2	
Memory to Register	0FEC [mod mm r/m]	MMX reg [sign byte] <--- sat --- (memory [sign byte] + MMX reg [sign byte])	2	
PADDSW *Packed Add Signed Word with Saturation*				
MMX Register 2 to MMX Register 1	0FED [11 mm1 mm2]	MMX reg 1 [sign word] <--- sat --- (MMX reg 1 [sign word] + MMX reg 2 [sign word])	2	
Memory to Register	0FED [mod mm r/m]	MMX reg [sign word] <--- sat --- (memory [sign word] + MMX reg [sign word])	2	
PADDUSB *Add Unsigned Byte with Saturation*				
MMX Register 2 to MMX Register 1	0FDC [11 mm1 mm2]	MMX reg 1 [byte] <--- sat --- (MMX reg 1 [byte] + MMX reg 2 [byte])	2	
Memory to Register	0FDC [mod mm r/m]	MMX reg [byte] <--- sat --- (memory [byte] + MMX reg [byte])	2	
PADDUSW *Add Unsigned Word with Saturation*				
MMX Register 2 to MMX Register 1	0FDD [11 mm1 mm2]	MMX reg 1 [word] <--- sat --- (MMX reg 1 [word] + MMX reg 2 [word])	2	
Memory to Register	0FDD [mod mm r/m]	MMX reg [word] <--- sat --- (memory [word] + MMX reg [word])	2	
PADDW *Packed Add Word with Wrap-Around*				
MMX Register 2 to MMX Register 1	0FFD [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] + MMX reg 2 [word]	2	
Memory to MMX Register	0FFD [mod mm r/m]	MMX reg [word] <--- memory [word] + MMX reg [word]	2	
PAND *Bitwise Logical AND*				
MMX Register 2 to MMX Register 1	0FDB [11 mm1 mm2]	MMX reg 1 [qword] --- MMX reg 1 [qword], <--- logic AND --- MMX reg 2 [qword]	2	
Memory to MMX Register	0FDB [mod mm r/m]	MMX reg [qword] memory [qword], <--- logic AND --- MMX reg [qword]	2	
PANDN *Bitwise Logical AND NOT*				
MMX Register 2 to MMX Register 1	0FDF [11 mm1 mm2]	MMX reg 1 [qword] NOT (MMX reg 1 [qword], <--- logic AND --- MMX reg 2) [qword]	2	
Memory to MMX Register	0FDF [mod mm r/m]	MMX reg [qword] --- NOT (MMX reg [qword], <--- logic AND --- Memory [qword])	2	
PAVGB *Packed Average of Unsigned Byte*				
MMX Register 1 with MMX Register 2	0FE0 [11 mm1 mm2]	MMX reg 1 [byte] <--- round up --- (MMX reg 1 [byte] + MMX reg 2 [byte] + 01h)/2	2	
MMX Register with Memory64	0FE0 [mod mm r/m]	MMX reg 1 [byte] <--- round up --- (MMX reg 1 [byte] + Memory64 [byte] + 01h)/2	2	

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PAVGW *Packed Average of Unsigned Word*				
MMX Register 1 with MMX Register 2	0FE3 [11 mm1 mm2]	MMX reg 1 [word] <--- round up --- (MMX reg 1[word] + MMX reg 2 [word] + 01h)/2	2	
MMX Register with Memory	0FE3 [mod mm r/m]	MMX reg 1[word] <--- round up --- (MMX reg, [word] + Memory64 [word] + 01h)/2	2	
PCMPEQB *Packed Byte Compare for Equality*				
MMX Register 2 with MMX Register 1	0F74 [11 mm1 mm2]	MMX reg 1 [byte] <--- FFh --- if MMX reg 1 [byte] = MMX reg 2 [byte] MMX reg 1 [byte]<--- 00h --- if MMX reg 1 [byte] NOT = MMX reg 2 [byte]	2	
Memory with MMX Register	0F74 [mod mm r/m]	MMX reg [byte] <--- FFh --- if memory[byte] = MMX reg [byte] MMX reg [byte] <--- 00h --- if memory[byte] NOT = MMX reg [byte]	2	
PCMPEQD *Packed Dword Compare for Equality*				
MMX Register 2 with MMX Register 1	0F76 [11 mm1 mm2]	MMX reg 1 [dword] <--- FFFF FFFFh --- if MMX reg 1 [dword] = MMX reg 2 [dword] MMX reg 1 [dword]<--- 0000 0000h ---if MMX reg 1[dword] NOT = MMX reg 2 [dword]	2	
Memory with MMX Register	0F76 [mod mm r/m]	MMX reg [dword] <--- FFFF FFFFh --- if memory[dword] = MMX reg [dword] MMX reg [dword] <--- 0000 0000h --- if memory[dword] NOT = MMX reg [dword]	2	
PCMPEQW *Packed Word Compare for Equality*				
MMX Register 2 with MMX Register 1	0F75 [11 mm1 mm2]	MMX reg 1 [word] <--- FFFFh --- if MMX reg 1 [word] = MMX reg 2 [word] MMX reg 1 [word]<--- 0000h --- if MMX reg 1 [word] NOT = MMX reg 2 [word]	2	
Memory with MMX Register	0F75 [mod mm r/m]	MMX reg [word] <--- FFFFh --- if memory[word] = MMX reg [word] MMX reg [word] <--- 0000h --- if memory[word] NOT = MMX reg [word]	2	
PCMPGTB *Pack Compare Greater Than Byte*				
MMX Register 2 to MMX Register 1	0F64 [11 mm1 mm2]	MMX reg 1 [byte] <--- FFh --- if MMX reg 1 [byte] > MMX reg 2 [byte] MMX reg 1 [byte]<--- 00h --- if MMX reg 1 [byte] NOT > MMX reg 2 [byte]	2	
Memory with MMX Register	0F64 [mod mm r/m]	MMX reg [byte] <--- FFh --- if memory[byte] > MMX reg [byte] MMX reg [byte] <--- 00h --- if memory[byte] NOT > MMX reg [byte]	2	
PCMPGTD *Pack Compare Greater Than Dword*				
MMX Register 2 to MMX Register 1	0F66 [11 mm1 mm2]	MMX reg 1 [dword] <--- FFFF FFFFh --- if MMX reg 1 [dword] > MMX reg 2 [dword] MMX reg 1 [dword]<--- 0000 0000h ---if MMX reg 1 [dword]NOT > MMX reg 2 [dword]	2	
Memory with MMX Register	0F66 [mod mm r/m]	MMX reg [dword] <--- FFFF FFFFh --- if memory[dword] > MMX reg [dword] MMX reg [dword] <--- 0000 0000h --- if memory[dword] NOT > MMX reg [dword]	2	
PCMPGTW *Pack Compare Greater Than Word*				
MMX Register 2 to MMX Register 1	0F65 [11 mm1 mm2]	MMX reg 1 [word] <--- FFFFh --- if MMX reg 1 [word] > MMX reg 2 [word] MMX reg 1 [word]<--- 0000h --- if MMX reg 1 [word] NOT > MMX reg 2 [word]	2	
Memory with MMX Register	0F65 [mod mm r/m]	MMX reg [word] <--- FFFFh --- if memory[word] > MMX reg [word] MMX reg [word] <--- 0000h --- if memory[word] NOT > MMX reg [word]	2	
PEXTRW *Extract Word into Integer Register*			1	
Register 32, MMX Register 2 imm8	0FC5 [11 reg mm] #	Reg 32 [high word] <--- 0000 reg32 [low word] <--- MMX reg [windex0 (imm8)]		

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PINSRW *Insert Word from Integer Register*				
MMX Register, Register 32 imm8	0FC4 [11 mm1 reg] #	tmp1 <--- 0 tmp1 [windex0 (imm8)] <--- reg 32 [low word] tmp2 <--- MMX reg tmp2 [windex0 (imm8)] <--- 0 MMX reg <--- tmp 1 Logic OR tmp2	2	
MMX Register, Memory 16, imm8	0FC4 [mod mm r/m] #	temp1 <--- 0 tmp1 [windex0 (imm8)] <--- Memory 16 tmp2 <--- MMX reg tmp2 [windex0 (imm8)] <--- 0 MMX reg <--- tmp1 Logic OR tmp2 [windex 0 (imm8)]	2	
PMADDWD *Packed Multiply and Add*				
MMX Register 2 to MMX Register 1	0FF5 [11 mm1 mm2]	MMX reg 1 [dword] <--- (MMX reg 1 [low sign word] * MMX reg 2 [low sign word] + (MMX reg 1 [high sign word] * MMX reg2 [high sign word]	2	
Memory to MMX Register	0FF5 [mod mm r/m]	MMX reg 1 [dword] <--- (memory [low sign word] * MMX reg [high sign word] + (memory1 [high sign word] * MMX reg [high sign word])	2	
PMAXSW *Packed Maximum Signed Word*				
MMX Register 1 with MMX Register 2	0FEE [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] --- if (MMX reg 1 [sign word] > MMX reg 2 [sign word]) MMX reg 1 [word] <--- MMX reg 2 [word] --- if (MMX reg 1 [sign word] NOT > MMX reg 2 [sign word]	2	
MMX Register with Memory64	0FEE [mod mm r/m]	MMX reg [word] <--- MMX reg [word] --- if (MMX reg [sign word] > Memory64 [word]) MMX reg [word] <--- Memory64 [word] --- if (MMX reg [sign word] NOT > Memory64 [sign word]	2	
PMAXUB *Packed Maximum Unsigned Byte*				
MMX Register 1 with MMX Register 2	0FDE [11 mm1 mm2]	MMX reg 1 [byte] <--- MMX reg 1 [byte] --- if (MMX reg 1 [byte] > MMX reg 2 [byte]0 MMX reg 1 [byte] <--- MMX reg 2 [byte] --- if (MMX reg 1 [byte] NOT > MMX reg 2 [byte])	2	
MMX Register with Memory64	0FDE [mod mm r/m]	MMX reg [byte] <--- MMX reg [byte] --- if (MMX reg [byte] > Memory64 [byte]) MMX reg [byte] <--- Memory64 [byte] --- if (MMX reg [byte] NOT > Memory64 [byte])	2	
PMINSW *Packed Minimum Signed Word*				
MMX Register 1with MMX Register 2	0FEA [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] --- if (MMX reg 1 [sign word] ≤ MMX reg 2 [sign word]) MMX reg 1 [word] <--- MMX reg 2 [word] --- if (MMX reg 1 [sign word] NOT ≤ MMX reg 2 [sign word])	2	
MMX Register 1with Memory64	0FEA [mod mm r/m]	MMX reg [word] <--- MMX reg 1 [word] --- if (MMX reg [sign word] ≤ Memory64 [sign word]) MMX reg [word] <--- Memory64 [word] --- if (MMX reg [sign word] NOT ≤ Memory64 [sign word])	2	
PMINUB *Packed Minimum Unsigned Byte*				
MMX Register 1with MMX Register 2	0FDA [11 mm1 mm2]	MMX reg 1 [byte] <--- MMX reg 1 [byte] --- if (MMX reg 1 [byte] ≤ MMX reg 2 [byte])	2	
		MMX reg 1 [byte] <--- MMX reg 2 [byte] --- if (MMX reg 1 [byte] NOT ≤ MMX reg 2 [byte])	2	
MMX Register 1with Memory64	0FDA [mod mm r/m]	MMX reg [byte] <--- MMX reg [byte] --- if (MMX reg [byte] ≤ Memory64 [byte])	2	
		MMX reg [byte] <--- Memory64 [byte] --- if (MMX reg [byte] NOT ≤ Memory64 [byte])	2	
PMOVMSKB *Move Byte Mask to Integer Register*			1	
Register 32 with MMX Register	0FD7 [11 reg mm]	reg32 <--- zero extend, MSB [bytes]		
PMULHRW *Packed Multiply High with Rounding*				
MMX Register 2 to MMX Register 1	0FB7 [11 mm1 mm2]	Multiply the signed packed word in the MMX register/memory with the signed packed word in the MMX register. Round with 1/2 bit 15, and store bits 30 - 15 of result in the MMX register.	2	
Memory to MMX Register	0FB7 [mod mm r/m]		2	
PMULHUW *Packed Multiply High Unsigned Word*				
MMX Register1 with MMX Register2	0FE4 [11 mm1 mm2]	MMX reg 1 [word] <--- high word --- (MMXreg 1[word] * MMX reg 2 [word])	2	
MMX Register with Memory64	0FE4 [mod mm r/m]	MMX reg [word] <--- high word --- (MMX reg [word] * Memory64 [word])	2	

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PMULHW *Packed Multiply High*				
MMX Register 2 to MMX Register 1	0FE5 [11 mm1 mm2]	MMX reg 1 [word] <--- high word --- (MMX reg 1 [sign word] * MMX reg 2 [sign word])	2	
Memory to MMX Register	0FE5 [mod mm r/m]	MMX reg [word] <--- high word --- MMX reg [sign word] * Memory64 [sign word]	2	
PMULLW *Packed Multiply Low*				
MMX Register 2 to MMX Register 1	0FD5 [11 mm1 mm2]	MMX reg 1 [word] <--- low word --- (MMX reg 1 [sign word] * MMX reg 2 [sign word])	2	
Memory to MMX Register	0FD5 [mod mm r/m]	MMX reg 1 [word] <--- low word --- (MMX reg [sign word] * Memory64 [sign word])	2	
POR *Bitwise OR*				
MMX Register 2 to MMX Register 1	0FEB [11 mm1 mm2]	MMX reg 1 [qword] <--- MMX reg 1 [qword] logic OR MMX reg 2 [qword]	2	
Memory to MMX Register	0FEB [mod mm r/m]	MMX reg [qword] <--- MMX reg [qword] logic OR memory64 [qword]	2	
PREFETCH NTA *Move Data Closer to the Processor using the NTA Register*				
Memory8	0F18 [mod 000 r/m]			
PREFETCH0 *Move Data Closer to the Processor using the T0 Register*				
Memory8	0F18 [mod 001 r/m]			
PREFETCH1 *Move Data Closer to the Processor using the T1 Register*				
Memory8	0F18 [mod 010 r/m]			
PREFETCH2 *Move Data Closer to the Processor using the T2 Register*				
Memory8	0F18 [mod 011 r/m]			
PSADBW *Packed Sum of Absolute Byte Differences*				
MMX Register1 with MMX Register2	0FF6 [11 mm1 mm2]	MMX reg 1 [low word] <--- Sum --- (abs --- (MMXreg 1[byte] - MMX reg 2 [byte])) MMX reg 1 [upper three words] <--- 0	3	
MMX Register with Memory64	0FF6 [mod mm r/m]	MMX reg [low word] <--- Sum --- (abs --- (MMX reg [byte] - Memory64 [byte])) MMX reg [up three word] <--- 0	3	
PSHUFW *Packed Shuffle Word*				
MMX Register1, MMX Register2, imm8	0F70 [11 mm1 mm2] #	MMX reg 1 [word] <--- MMX reg 2 [windexall (imm8)]	2	
MMX Register, Memory64, imm8	0F70 [mod mm r/m] #	MMX reg [word] <--- Memory64 [windexall (imm8)]	2	
PSLLD *Packed Shift Left Logical Dword*				
MMX Register 1 by MMX Register 2	0FF2 [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [dword] shift left by MMX reg 2 [dword], shifting in zeroes	2	
MMX Register by Memory	0FF2 [mod mm r/m]	MMX reg [dword] <--- MMX reg [dword] shift left by memory [dword], shifting in zeroes	2	
MMX Register by immediate	0F72 [11 110 mm] #	MMX reg [dword] <--- MMX reg [dword] shift left by [im byte], shifting in zeroes	2	
PSLLQ *Packed Shift Left Logical Qword*				
MMX Register 1 by MMX Register 2	0FF3 [11 mm1 mm2]	MMX reg 1 [qword] <--- MMX reg 1 [qword] shift left by MMX reg 2 [qword], shifting in zeroes	2	
MMX Register by Memory	0FF3 [mod mm r/m]	MMX reg [qword] <--- MMX reg [qword] shift left by memory [qword], shifting in zeroes	2	
MMX Register by immediate	0F73 [11 110 mm] #	MMX reg [qword] <--- MMX reg [qword]shift left by [im byte], shifting in zeroes	2	
PSLLW *Packed Shift Left Logical Word*				
MMX Register 1 by MMX Register 2	0FF1 [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] shift left by MMX reg 2 [word], shifting in zeroes	2	
MMX Register by Memory	0FF1 [mod mm r/m]	MMX reg [word] <--- MMX reg [word] shift left by memory [word], shifting in zeroes	2	
MMX Register by immediate	0F71 [11 110mm] #	MMX reg [word] <--- MMX reg [word] shift left by [im byte], shifting in zeroes	2	

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PSRAD *Packed Shift Right Arithmetic Dword*				
MMX Register 1 by MMX Register 2	0FE2 [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [dword] shift right by MMX reg 2 [dword], shifting in sign bits	2	
MMX Register by Memory	0FE2 [mod mm r/m]	MMX reg [dword] <--- MMX reg [dword] shift right by memory [dword], shifting in sign bits	2	
MMX Register by immediate	0F72 [11 100 mm] #	MMX reg [dword] <--- MMX reg [dword] shift right by [im byte], shifting in sign bits	2	
PSRAW *Packed Shift Right Arithmetic Word*				
MMX Register 1 by MMX Register 2	0FE1 [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] shift right by MMX reg 2 [word], shifting in sign bits	2	
MMX Register by Memory	0FE1 [mod mm r/m]	MMX reg [word] <--- MMX reg [word] shift right by memory [word], shifting in sign bits	2	
MMX Register by immediate	0F71 [11 100 mm] #	MMX reg [word] <--- MMX reg [word] shift right by [im byte], shifting in sign bits	2	
PSRLD *Packed Shift Right Logical Dword*				
MMX Register 1 by MMX Register 2	0FD2 [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [dword] shift right by MMX reg 2 [dword], shifting in zeroes	2	
MMX Register by Memory	0FD2 [mod mm r/m]	MMX reg [dword] <--- MMX reg [dword] shift right by memory[dword], shifting in zeroes	2	
MMX Register by immediate	0F72 [11 010 mm] #	MMX reg [dword] <--- MMX reg [dword]shift right by [im byte], shifting in zeroes	2	
PSRLQ *Packed Shift Right Logical Qword*				
MMX Register 1 by MMX Register 2	0FD3 [11 mm1 mm2]	MMX reg 1 [qword] <--- MMX reg 1 [qword] shift right by MMX reg 2 [qword], shifting in zeroes	3	
MMX Register by Memory	0FD3 [mod mm r/m]	MMX reg [qword] <--- MMX reg [qword] shift right by memory [qword], shifting in zeroes	3	
MMX Register by immediate	0F73 [11 010 mm] #	MMX reg [qword] <--- MMX reg [qword] shift right by [im byte], shifting in zeroes	3	
PSRLW *Packed Shift Right Logical Word*				
MMX Register 1 by MMX Register 2	0FD1 [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [word] shift right by MMX reg 2 [word], shifting in zeroes	2	
MMX Register by Memory	0FD1 [mod mm r/m]	MMX reg [word] <--- MMX reg [word] shift right by memory [word], shifting in zeroes	2	
MMX Register by immediate	0F71 [11 010 mm] #	MMX reg [word] <--- MMX reg [word] shift right by imm [word], shifting in zeroes	2	
PSUBB *Subtract Byte With Wrap-Around*				
MMX Register 2 to MMX Register 1	0FF8 [11 mm1 mm2]	MMX reg 1 [byte] <--- MMX reg 1 [byte] - MMX reg 2 [byte]	2	
Memory to MMX Register	0FF8 [mod mm r/m]	MMX reg [byte] <--- MMX reg [byte] - memory [byte]	2	
PSUBD *Subtract Dword With Wrap-Around*				
MMX Register 2 to MMX Register 1	0FFA [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [dword] - MMX reg 2 [dword]	2	
Memory to MMX Register	0FFA [mod mm r/m]	MMX reg [dword] <--- MMX reg [dword] - memory64 [dword]	2	
PSUBSB *Subtract Byte Signed With Saturation*				
MMX Register 2 to MMX Register 1	0FE8 [11 mm1 mm2]	MMX reg 1 [sign byte] <--- sat -- (MMX reg 1 [sign byte] subtract MMX reg 2 [sign byte])	2	
Memory to MMX Register	0FE8 [mod mm r/m]	MMX reg [sign byte] <--- sat --- (MMX reg [sign byte] subtract memory64 [sign byte])	2	
PSUBSW *Subtract Word Signed With Saturation*				
MMX Register 2 to MMX Register 1	0FE9 [11 mm1 mm2]	MMX reg 1 [sign word] <--- sat --- (MMX reg 1 [sign word] - MMX reg 2 [sign word])	2	
Memory to MMX Register	0FE9 [mod mm r/m]	MMX reg [sign word] <--- sat --- (MMX reg [sign word] - memory64 [sign word])	2	
PSUBUSB *Subtract Byte Unsigned With Saturation*				
MMX Register 2 to MMX Register 1	0FD8 [11 mm1 mm2]	MMX reg 1 [byte] <--- sat --- (MMX reg 1 [byte] - MMX reg 2 [byte])	2	
Memory to MMX Register	0FD8 [11 mm reg]	MMX reg [byte] <--- sat --- (MMX reg [byte] - memory64 [byte])	2	
PSUBUSW *Subtract Word Unsigned With Saturation*				
MMX Register 2 to MMX Register 1	0FD9 [11 mm1 mm2]	MMX reg 1 [word] <--- sat --- (MMX reg 1 [word] - MMX reg 2 [word])	2	
Memory to MMX Register	0FD9 [11 mm reg]	MMX reg [word] <--- sat --- (MMX reg [word] - memory64 [word])	2	

Instruction Set (Continued)

Table 7-29. MMX Instruction Set (Continued)

MMX Instructions	Opcode	Operation	Clock Ct	Notes
PSUBW *Subtract Word With Wrap-Around*				
MMX Register 2 to MMX Register 1	0FF9 [11 mm1 mm2]	MMX reg 1 [word] <--- (MMX reg 1 [word] - MMX reg 2 [word])	2	
Memory to MMX Register	0FF9 [mod mm r/m]	MMX reg [word] <--- (MMX reg [word] - memory64 [word])	2	
PUNPCKHBW *Unpack High Packed Byte, Data to Packed Words*				
MMX Register 2 to MMX Register 1	0F68 [11 mm1 mm2]	MMX reg 1 [word] <--- {MMX reg 1 [high byte], MMX reg 2 [high byte]}	2	
Memory to MMX Register	0F68 [11 mm reg]	MMX reg [word] <--- {memory64 [high byte], MMX reg [high byte]}	2	
PUNPCKHDQ *Unpack High Packed Dword, Data to Qword*				
MMX Register 2 to MMX Register 1	0F6A [11 mm1 mm2]	MMX reg 1 <--- MMX reg 1 [high dword], MMX reg 2 [high dword]	2	
Memory to MMX Register	0F6A [11 mm reg]	MMX reg <--- {memory64 [high dword], MMX reg [high dword]}	2	
PUNPCKHWD *Unpack High Packed Word, Data to Packed Dwords*				
MMX Register 2 to MMX Register 1	0F69 [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [high word], MMX reg 2 [high word]	2	
Memory to MMX Register	0F69 [11 mm reg]	MMX reg [dword] <--- memory64 [high word], MMX reg [high word]	2	
PUNPCKLBW *Unpack Low Packed Byte, Data to Packed Words*				
MMX Register 2 to MMX Register 1	0F60 [11 mm1 mm2]	MMX reg 1 [word] <--- MMX reg 1 [low byte], MMX reg 2 [low byte]	2	
Memory to MMX Register	0F60 [11 mm reg]	MMX reg [word] <--- memory64 [low byte], MMX reg [low byte]	2	
PUNPCKLDQ *Unpack Low Packed Dword, Data to Qword*				
MMX Register 2 to MMX Register 1	0F62 [11 mm1 mm2]	MMX reg 1 <--- MMX reg 1 [low dword], MMX reg 2 [low dword]	2	
Memory to MMX Register	0F62 [11 mm reg]	MMX reg <--- memory64 [low dword], MMX reg [low dword]	2	
PUNPCKLWD *Unpack Low Packed Word, Data to Packed Dwords*				
MMX Register 2 to MMX Register 1	0F61 [11 mm1 mm2]	MMX reg 1 [dword] <--- MMX reg 1 [low word], MMX reg 2 [low word]	2	
Memory to MMX Register	0F61 [11 mm reg]	MMX reg [dword] <--- memory64 [low word], MMX reg [low word]	2	
PXOR *Bitwise XOR*				
MMX Register 2 to MMX Register 1	0FEF [11 mm1 mm2]	MMX reg 1 [qword] --- MMX reg 1 [qword], <--- logic exclusive OR MMX reg 2 [qword]	2	
Memory to MMX Register	0FEF [11 mm reg]	MMX reg [qword] --- memory64 [qword], <--- logic exclusive OR MMX reg [qword]	2	
SFENCE *Store Fence*				
	0FAE [mod 111 r/m]			

1) This instruction must wait for the FPU pipeline to flush. Cycle count depends on what instructions are in the pipeline.

Instruction Set (Continued)

Table 7-30. FPU Instruction Set

FPU Instruction	Opcode	Operation	Clock Ct Sngle/Dbl (or extended)	Notes
F2XM1 *Function Evaluation 2x-1*	D9 F0	TOS <--- 2^{TOS}-1	145 - 166	2
FABS *Floating Absolute Value*	D9 E1	TOS <--- | TOS |	1	3
FADD *Floating Point Add*				
Top of Stack	DC [1100 0 n]	ST(n) <--- ST(n) + TOS	1/6	
80-bit Register	D8 [1100 0 n]	TOS <--- TOS + ST(n)	1/6	
64-bit Real	DC [mod 000 r/m]	TOS <--- TOS + M.DR	1/6	
32-bit Real	D8 [mod 000 r/m]	TOS <--- TOS + M.SR	1/6	
FADDP *Floating Point Add, Pop*	DE [1100 0 n]	ST(n) <--- ST(n) + TOS; then pop TOS	1/6	
FIADD *Floating Point Integer Add*				
32-bit integer	DA [mod 000 r/m]	TOS <--- TOS + M.SI	2/7	
16-bit integer	DE [mod 000 r/m]	TOS <--- TOS + M.WI	2/7	
FCHS *Floating Change Sign*	D9 E0	TOS <--- - TOS	1	
FCLEX *Clear Exceptions*	(9B) DB E2	Wait then Clear Exceptions	1+	2
FNCLEX *Clear Exceptions*	DB E2	Clear Exceptions	1+	2
FCMOVB *Floating Point Conditional Move if Below*	DA [1100 0 n]	If (CF=1) ST(0) <--- ST(n)	1	3
FCMOVE *Floating Point Conditional Move if Equal*	DA [1100 1 n]	If (ZF=1) ST(0) <--- ST(n)	1	3
FCMOVBE *Floating Point Conditional Move if Below or Equal*	DA [1101 0 n]	If (CF=1 or ZF=1) ST(0) <--- ST(n)	1	3
FCMOVU *Floating Point Conditional Move if Unordered*	DA [1101 1 n]	If (PF=1) ST(0) <--- ST(n)	1	3
FCMOVNB *Floating Point Conditional Move if Not Below*	DB [1100 0 n]	If (CF=0) ST(0) <--- ST(n)	1	3
FCMOVNE *Floating Point Conditional Move if Not Equal*	DB [1100 1 n]	If (ZF=0) ST(0) <--- ST(n)	1	3
FCMOVNBE *Floating Point Conditional Move if Not Below or Equal*	DB [1101 0 n]	If (CF=0 and ZF=0) ST(0) <--- ST(n)	1	3
FCMOVNU *Floating Point Conditional Move if Not Unordered*	DB [1101 1 n]	If (PF=0) ST(0) <--- ST(n)	1	3
FCOM *Floating Point Compare*				
80-bit Register	D8 [1101 0 n]	CC set by TOS - ST(n)	1/6	
64-bit Real	DC [mod 010 r/m]	CC set by TOS - M.DR	1/6	
32-bit Real	D8 [mod 010 r/m]	CC set by TOS - M.SR	1/6	
FCOMP *Floating Point Compare, Pop*				
80-bit Register	D8 [1101 1 n]	CC set by TOS - ST(n); then pop TOS	1/6	
64-bit Real	DC [mod 011 r/m]	CC set by TOS - M.DR; then pop TOS	1/6	
32-bit Real	D8 [mod 011 r/m]	CC set by TOS - M.SR; then pop TOS	1/6	
FCOMPP *Floating Point Compare, Pop Two Stack Elements*	DE D9	CC set by TOS - ST(1); then pop TOS and ST(1)	1/6	
FCOMI *Floating Point Compare Real and Set EFLAGS*				
80-bit Register	DB [1111 0 n]	EFLAG set by TOS - ST(n)	1/6	
FCOMIP *Floating Point Compare Real and Set EFLAGS, Pop*				
80-bit Register	DF [1111 0 n]	EFLAG set by TOS - ST(n); then pop TOS	1/6	
FUCOMI *Floating Point Unordered Compare Real and Set EFLAGS*				
80-bit Integer	DB [1110 1 n]	EFLAG set by TOS - ST(n)	1/6	
FUCOMIP *Floating Point Unordered Compare Real and Set EFLAGS, Pop*				
80-bit Integer	DF [1110 1 n]	EFLAG set by TOS - ST(n); then pop TOS	1/6	
FICOM *Floating Point Integer Compare*				
32-bit integer	DA [mod 010 r/m]	CC set by TOS - M.WI	2/7	
16-bit integer	DE [mod 010 r/m]	CC set by TOS - M.SI	2/7	
FICOMP *Floating Point Integer Compare, Pop*				
32-bit integer	DA [mod 011 r/m]	CC set by TOS - M.WI; then pop TOS	2/7	
16-bit integer	DE [mod 011 r/m	CC set by TOS - M.SI; then pop TOS	2/7	
FCOS *Function Evaluation: Cos(x)*	D9 FF	TOS <--- COS(TOS)	146 - 215	1
FDECSTP *Decrement Stack pointer*	D9 F6	Decrement top of stack pointer	1	3

Instruction Set (Continued)

Table 7-30. FPU Instruction Set (Continued)

FPU Instruction	Opcode	Operation	Clock Ct Sngle/Dbl (or extended)	Notes
FDIV *Floating Point Divide*				
Top of Stack	DC [1111 1 n]	ST(n) <--- ST(n) / TOS	12/47	
80-bit Register	D8 [1111 0 n]	TOS <--- TOS / ST(n)	12/47	
64-bit Real	DC [mod 110 r/m]	TOS <--- TOS / M.DR	12/47	
32-bit Real	D8 [mod 110 r/m]	TOS <--- TOS / M.SR	12/47	
FDIVP *Floating Point Divide, Pop*	DE [1111 1 n]	ST(n) <--- ST(n) / TOS; then pop TOS	12/47	
FDIVR *Floating Point Divide Reversed*				
Top of Stack	DC [1111 0 n]	TOS <--- ST(n) / TOS	12/47	
80-bit Register	D8 [1111 1 n]	ST(n) <--- TOS / ST(n)	12/47	
64-bit Real	DC [mod 111 r/m]	TOS <--- M.DR / TOS	12/47	
32-bit Real	D8 [mod 111 r/m]	TOS <--- M.SR / TOS	12/47	
FDIVRP *Floating Point Divide Reversed, Pop*	DE [1111 0 n]	ST(n) <--- TOS / ST(n); then pop TOS	12/47	
FIDIV *Floating Point Integer Divide*				
32-bit Integer	DA [mod 110 r/m]	TOS <--- TOS / M.SI	13/48	
16-bit Integer	DE [mod 110 r/m]	TOS <--- TOS / M.WI	13/48	
FIDIVR *Floating Point Integer Divide Reversed*				
32-bit Integer	DA [mod 111 r/m]	TOS <--- M.SI / TOS	13/48	
16-bit Integer	DE [mod 111 r/m]	TOS <--- M.WI / TOS	13/48	
FFREE *Free Floating Point Register*	DD [1100 0 n]	TAG(n) <--- Empty	1	3
FINCSTP *Increment Stack Pointer*	D9 F7	Increment top-of-stack pointer	1	3
FINIT *Initialize FPU*	(9B)DB E3	Wait, then initialize	1	2
FNINIT *Initialize FPU*	DB E3	Initialize	1	2
FLD *Load Data to FPU Register*				
Top of Stack	D9 [1100 0 n]	Push ST(n) onto stack	1	3
80-bit Real	DB [mod 101 /m]	Push M.XR onto stack	1	3
64-bit Real	DD [mod 000 r/m]	Push M.DR onto stack	1	3
32-bit Real	D9 [mod 000 r/m]	Push M.SR onto stack	1	3
FBLD *Load Packed BCD Data to FPU Register*	DF [mod 100 r/m]	Push M.BCD onto stack	28	
FILD *Load Integer Data to FPU Register*				
64-bit Integer	DF [mod 101 r/m]	Push M.LI onto stack	4	
32-bit Integer	DB [mod 000 r/m]	Push M.SI onto stack	1	
16-bit Integer	DF [mod 000 r/m]	Push M.WI onto stack	1	
FLD1 *Load Floating Const.= 1.0*	D9 E8	Push 1.0 onto stack	1	3
FLDCW *Load FPU Mode Control Register*	D9 [mod 101 r/m]	Ctl Word <--- Memory	1	3
FLDENV *Load FPU Environment*	D9 [mod 100 r/m]	Env Regs <--- Memory	1	3
FLDL2E *Load Floating Const.= Log2(e)*	D9 EA	Push $Log_2(e)$ onto stack	1	3
FLDL2T *Load Floating Const.= Log2(10)*	D9 E9	Push $Log_2(10)$ onto stack	1	3
FLDLG2 *Load Floating Const.= Log10(2)*	D9 EC	Push $Log_{10}(2)$ onto stack	1	3
FLDLN2 *Load Floating Const.= Ln(2)*	D9 ED	Push $Log_e(2)$ onto stack	1	3
FLDPI *Load Floating Const.= π*	D9 EB	Push π onto stack	1	3
FLDZ *Load Floating Const.= 0.0*	D9 EE	Push 0.0 onto stack	1	3
FMUL *Floating Point Multiply*				
Top of Stack	DC [1100 1 n]	ST(n) <--- ST(n) × TOS	1/10	
80-bit Register	D8 [1100 1 n]	TOS <--- TOS × ST(n)	1/10	
64-bit Real	DC [mod 001 r/m]	TOS <--- TOS × M.DR	1/10	
32-bit Real	D8 [mod 001 r/m]	TOS <--- TOS × M.SR	1/10	
FMULP *Floating Point Multiply & Pop*	DE [1100 1 n]	ST(n) <--- ST(n) × TOS; then pop TOS	1/10	
FIMUL *Floating Point Integer Multiply*				
32-bit Integer	DA [mod 001 r/m]	TOS <--- TOS × M.SI	2/11	
16-bit Integer	DE [mod 001 r/m]	TOS <--- TOS × M.WI	2/11	
FNOP *No Operation*	D9 D0	No Operation	1	3
FPATAN *Function Eval: Tan-1(y/x)*	D9 F3	ST(1) <--- ATAN[ST(1) / TOS]; then pop TOS	269 - 354	3

Instruction Set (Continued)

Table 7-30. FPU Instruction Set (Continued)

FPU Instruction	Opcode	Operation	Clock Ct Sngle/Dbl (or extended)	Notes
FPREM *Floating Point Remainder*	D9 F8	TOS <--- Rem[TOS / ST(1)]	53 - 208	
FPREM1 *Floating Point Remainder IEEE*	D9 F5	TOS <--- Rem[TOS / ST(1)]	53 - 208	
FPTAN *Function Eval: Tan(x)*	D9 F2	TOS <--- TAN(TOS); then push 1.0 onto stack	217 - 232	1, 2
FRNDINT *Round to Integer*	D9 FC	TOS <--- Round(TOS)	12	
FRSTOR *Load FPU Environment and Register*	DD [mod 100 r/m]	Restore state	19	2
FSAVE *Save FPU Environment and Register*	(9B)DD [mod 110 r/m]	Wait, then save state	19	2
FNSAVE *Save FPU Environment and Register*	DD [mod 110 r/m]	Save state	19	2
FSCALE *Floating Multiply by 2n*	D9 FD	TOS <--- TOS $\times$ $2^{(ST(1))}$	3	
FSIN *Function Evaluation: Sin(x)*	D9 FE	TOS <--- SIN(TOS)	130 - 215	1
FSINCOS *Function Eval.: Sin(x)& Cos(x)*	D9 FB	temp <--- TOS; TOS <--- SIN(temp); then push COS(temp) onto stack	345 - 374	1, 2
FSQRT *Floating Point Square Root*	D9 FA	TOS <--- Square Root of TOS	13/54	
FST *Store FPU Register*				
FPU Stack	DD [1101 0 n]	ST(n) <--- TOS	1	3
64-bit Real	DD [mod 010 r/m]	M.DR <--- TOS	6	
32-bit Real	D9 [mod 010 r/m]	M.SR <--- TOS	1/4	
FSTP *Store FPU Register, Pop*				
FPU Stack	DB [1101 1 n]	ST(n) <--- TOS; then pop TOS	1	3
80-bit Real	DB [mod 111 r/m]	M.XR <--- TOS; then pop TOS	1	3
64-bit Real	DD [mod 011 r/m]	M.DR <--- TOS; then pop TOS	6	
32-bit Real	D9 [mod 011 r/m]	M.SR <--- TOS; then pop TOS	1/4	
FBSTP *Store BCD Data, Pop*	DF [mod 110 r/m]	M.BCD <--- TOS; then pop TOS	82	
FIST *Store Integer FPU Register*				
32-bit Integer	DB [mod 010 r/m]	M.SI <--- TOS	4	
16-bit Integer	DF [mod 010 r/m]	M.WI <--- TOS	3	
FISTP *Store Integer FPU Register, Pop*				
64-bit Integer	DF [mod 111 r/m]	M.LI <--- TOS; then pop TOS	6	
32-bit Integer	DB [mod 011 r/m]	M.SI <--- TOS; then pop TOS	4	
16-bit Integer	DF [mod 011 r/m]	M.WI <--- TOS; then pop TOS	3	
FSTCW *Store FPU Mode Control Register*	(9B)D9 [mod 111 r/m]	Wait Memory <--- Control Mode Register	1	2
FNSTCW *Store FPU Mode Control Register*	D9 [mod 111 r/m]	Memory <--- Control Mode Register	1	2
FSTENV *Store FPU Environment*	(9B)D9 [mod 110 r/m]	Wait Memory <--- Env. Registers	1	2
FNSTENV *Store FPU Environment*	D9 [mod 110 r/m]	Memory <--- Env. Registers	1	2
FSTSW *Store FPU Status Register*	(9B)DD [mod 111 r/m]	Wait Memory <--- Status Register	1	2
FNSTSW *Store FPU Status Register*	DD [mod 111 r/m]	Memory <--- Status Register	1	2
FSTSW AX *Store FPU Status Register to AX*	(9B)DF E0	Wait AX <--- Status Register	1	2
FNSTSW AX *Store FPU Status Register to AX*	DF E0	AX <--- Status Register	1	2
FSUB *Floating Point Subtract*				
Top of Stack	DC [1110 1 n]	ST(n) <--- ST(n) - TOS	1/6	
80-bit Register	D8 [1110 0 n]	TOS <--- TOS - ST(n	1/6	
64-bit Real	DC [mod 100 r/m]	TOS <--- TOS - M.DR	1/6	
32-bit Real	D8 [mod 100 r/m]	TOS <--- TOS - M.SR	1/6	
FSUBP *Floating Point Subtract, Pop*	DE [1110 1 n]	ST(n) <--- ST(n) - TOS; then pop TOS	1/6	
FSUBR *Floating Point Subtract Reverse*				
Top of Stack	DC [1110 0 n]	TOS <--- ST(n) - TOS	1/6	
80-bit Register	D8 [1110 1 n]	ST(n) <--- TOS - ST(n)	1/6	
64-bit Real	DC [mod 101 r/m]	TOS <--- M.DR - TOS	1/6	
32-bit Real	D8 [mod 101 r/m]	TOS <--- M.SR - TOS	1/6	
FSUBRP *Floating Point Subtract Reverse, Pop*	DE [1110 0 n]	ST(n) <--- TOS - ST(n); then pop TOS	1/6	
FISUB *Floating Point Integer Subtract*				
32-bit Integer	DA [mod 100 r/m]	TOS <--- TOS - M.SI	2/7	
16-bit Integer	DE [mod 100 r/m]	TOS <--- TOS - M.WI	2/7	

Instruction Set (Continued)

Table 7-30. FPU Instruction Set (Continued)

FPU Instruction	Opcode	Operation	Clock Ct Sngle/Dbl (or extended)	Notes
FISUBR *Floating Point Integer Subtract Reverse*				
32-bit Integer Reversed	DA [mod 101 r/m]	TOS <--- M.SI - TOS	2/7	
16-bit Integer Reversed	DE [mod 101 r/m]	TOS <--- M.WI - TOS	2/7	
FTST *Test Top of Stack*	D9 E4	CC set by TOS - 0.0	1	
FUCOM *Unordered Compare*	DD [1110 0 n]	CC set by TOS - ST(n)	1/6	
FUCOMP *Unordered Compare, Pop*	DD [1110 1 n]	CC set by TOS - ST(n); then pop TOS	1/6	
FUCOMPP *Unordered Compare, Pop two elements*	DA E9	CC set by TOS - ST(I); then pop TOS and ST(1)	1/6	
FWAIT *Wait*	9B	Wait for FPU not busy	1+	2
FXAM *Report Class of Operand*	D9 E5	CC <--- Class of TOS	1	3
FXCH *Exchange Register with TOS*	D9 [1100 1 n]	TOS <--> ST(n) Exchange	1	3
FXTRACT *Extract Exponent*	D9 F4	temp <--- TOS; TOS <--- exponent (temp); then push significant (temp) onto stack	3/6	
FLY2X *Function Eval. y × Log2(x)*	D9 F1	ST(1) <--- ST(1) × Log_2(TOS); then pop TOS	204 - 222	
FLY2XP1 *Function Eval. y × Log2(x+1)*	D9 F9	ST(1) <--- ST(1) × Log_2(1+TOS); then pop TOS	220	4

All references to TOS and ST(n) refer to stack layout prior to execution. Values popped off the stack are discarded. A POP from the stack increments the top of stack pointer. A PUSH to the stack decrements the top of stack pointer. Issues:

1) For FCOS, FSIN, FSINCOS, and FPTAN, time shown is for the absolute value of TOS < π/4:
   - — If FSINCOS is outside this range, add two times the FPREM clock counts for argument reduction
   - — If FCOS, FSIN, or FPTAN is outside this range, add FPREM clock counts for argument reduction
2) These instructions must wait for the FPU pipeline to flush. Cycle count depends on what instructions are in the pipeline.
3) These instructions are executed in a separate unit and execute in parallel with other multicycle instructions.
4) GX2 performs PFRCP and PFRSQRT to 24-bit accuracy in one cycle, so these instructions are unnecessary. They are treated as a move.
5) 5. The following opcodes are reserved:
   D9D7, D9E2, D9E7, DDFC, DED8, DEDA, DEDC, DEDD, DEDE, and DFFC. If a reserved opcode is executed, unpredictable results may occur (exceptions are not generated).

Instruction Set (Continued)

Table 7-31. 3DNow! Instruction Set

3DNow! Instructions	Opcode/imm8	Operation	Clk Cnt	Notes
FEMMS *Faster Exit of the MMX or 3DNow! State*	0F0E	Tag Word <--- FFFFh (empties the floating point tag word) MMX registers <--- undefined value	1	1
PAVGUSB *Average of Unsigned Packed 8-Bit Values*			2	
MMX Register 1 with MMX Register2	0F0F [11 mm1 mm2] BF	MMX reg1 [byte] <--- rounded up --- (MMX reg 1 [byte] + MMX reg 2 [byte] + 01h)/2		
MMX Register with Memory64	0F0F [mod mm r/m] BF	MMX reg [byte] <--- rounded up --- (MMX reg 1 [byte] + Memory [byte] + 01h)/2		
PF2ID *Converts Packed Floating-Point Operand to Packed 32-Bit Integer*			2	
MMX Register 1 by MMX Register2	0F0F [11 mm1 mm2] 1D	MMX reg 1 [dword] <--- Sat integer --- MMX reg 2 [dword]		
MMX Register 1 by Memory64	0F0F [mod mm r/m] 1D	MMX reg 1 [dword] <--- Sat integer --- Memory64 [dword]		
PF2IW *Packed Floating-Point to Integer Word Conversion with Sign Extend*			2	
MMX Register1 by MMX Register2	0F0F [11 mm1 mm2] 1C	MMX reg 1 [dword] <--- integer sign extended --- sat --- MMX reg 2 [dword]		
MMX Register by Memory64	0F0F [mod mm r/m] 1C	MMX reg [dword] <--- integer sign extended --- sat --- Memory64 [dword]		
PFACC *Floating-Point Accumulate*			2	
MMX Register 1 with MMX Register2	0F0F [11 mm1 mm2] AE	MMX reg 1 [low dword] <--- MMX reg 1 [low dword] + MMX reg 1 [high dword] MMX reg 1 [high dword] <--- MMX reg 2 [low dword] + MMX reg 2 [high dword]		
MMX Register 1 with Memory64	0F0F [mod mm r/m] AE	MMX reg 1 [low dword] <--- MMX reg 1[low dword] + MMX reg 1 [high dword] MMX reg 1 [high dword] <--- Memory64 [low dword] + Memory64 [high dword]		
PFADD *Packed Floating-Point Addition*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 9E	MMX reg 1[dword] <--- MMX reg 1 [dword] + MMX reg 2 [dword]		
MMX Register1 with Memory64	0F0F [mod mm r/m] 9E	MMX reg 1 [dword] <--- MMX reg 1 [dword] + Memory64 [dword]		
PFCMPEQ *Packed Floating-Point Comparison, Equal to*			2	
MMX Register 1with MMX Register 2	0F0F [11 mm1 mm2] B0	MMX reg 1 [dword] <--- FFFF FFFFh --- if (MMX reg 1 [dword] = MMX reg 2 [dword]) MMX [dword] <--- 0000 0000 h --- if (MMX reg 1 [dword] NOT + MMX reg 2 [dword])		
MMX Register with Memory64	0F0F [mod mm r/m] B0	MMX reg [dword] <--- FFFF FFFFh --- if (MMX reg [dword] = Memory64 [dword]) MMX reg [dword] <---0000 0000h --- if (MMX reg [dword] NOT = Memory64 [dword])		
PFCMPGE *Packed Floating-Point Comparison, Greater Than or Equal to*			2	
MMX Register 1 with MMX Register2	0F0F [11 mm1 mm2] 90	MMX reg 1 [dword] <--- FFFF FFFFh --- if (MMX reg 1 [dword] $\geq$ MMX reg 2 [dword]) MMX reg 1 [dword] <---0000 0000h --- if (MMX reg 1 [dword] NOT $\geq$ MMX reg 2 [dword])		
MMX Register with Memory64	0F0F [mod mm r/m] 90	MMX reg 1 [dword] <--- FFFF FFFFh --- if (MMX reg 1[dword] $\geq$ Memory64 [dword]) MMX reg [dword] <--- 0000 0000h --- if (MMX reg [dword] NOT $\geq$ Memory64 [dword])		
PFCMPGT *Packed Floating- Point Comparison, Greater Than*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] A0	MMX reg 1 [dword] <--- FFFF FFFFh --- if (MMX reg 1 [dword] > MMX reg 2 [dword]) MMX reg 1 [dword] <---0000 0000h --- if (MMX reg 1 [dword] NOT > MMX reg 2 [dword])		
MMX Register with Memory64	0F0F [mod mm r/m] A0	MMX reg [dword] <---FFFF FFFFh --- if (MMX reg [dword] > Memory64 [dword]) MMX reg [dword] <--- 0000 0000h --- if (MMX reg [dword] NOT > Memory64 [dword])		

Instruction Set (Continued)

Table 7-31. 3DNow! Instruction Set (Continued)

3DNow! Instructions	Opcode/imm8	Operation	Clk Cnt	Notes
PFMAX *Packed Floating-Point MAXimum*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] A4	MMX reg 1[dword] <--- MMX reg 1 [dword] --- if (MMX reg 1 [dword] > MMX reg 2 [dword]) MMX reg 1 [dword] <--- MMX reg 2 [dword] --- if (MMX reg 1 [dword] NOT > MMX reg 2 [dword])		
MMX Register with Memory64	0F0F [mod mm r/m] A4	MMX reg [dword] <--- MMX reg [dword] --- if (MMX reg [dword] > Memory64 [dword]) MMX reg [dword] <--- Memory [dword --- if (MMX reg [dword] NOT > Memory64 [dword])		
PFMIN *Packed Floating - Point MINimum*			2	
MMX Register 1 with MMX Register2	0F0F [11 mm1 mm2] 94	MMX reg 1 [dword] <--- MMX reg 1 [dword] --- if (MMX reg 1 [dword] < MMX reg 2 [dword]) MMX reg 1 [dword] <--- MMX reg 1 [dword] --- if (MMX reg 1 [dword] NOT < MMX reg 2 [dword])		
MMX register1 with Mwnory64	0F0F [mod mm r/m] 94	MMX reg [dword] <--- MMX reg [dword] --- if (MMX reg [dword] < Memory64 [dword]) MMX reg [dword] <--- Memory64 [dword] --- if (MMX reg [dword] NOT < Memory64 [dword])		
PFMUL *Packed Floating-Point Multiplication*			2	
MMX Register 1 with MMX Register 2	0F0F [11 mm1 mm2] B4	MMX reg 1 [dword] <--- sat --- MMX reg 1 [dword] * MMX reg 2 [dword]		
MMX Register with Memory64	0F0F [mod mm 2] B4	MMX reg [dword] <--- sat --- MMX reg [dword] * Memory64 [dword]		
PFNACC *Packed Floating-Point Negative Accumulate*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 8A	MMX reg 1 [low dword] <--- (MMX reg 1 [low dword] - MMX reg 1 [high dword]) MMX reg 1 [high dword] <--- (MMX reg 2 [low dword] - MMX reg 2 [high dword])		
MMX Register with Memory64	0F0F [mod mm r/m] 8A	MMX reg [low dword] <--- (MMX reg [low dword] - MMX reg [high dword]) MMX reg [high dword] <--- (Memory64 [low dword] - Memory64 [high dword])		
PFPNACC *Packed Floating-Point Mixed Positive-Negative Accumulate*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 8E	MMX reg 1 [low dword] <--- (MMX reg 1 [low dword] - MMX reg 1 [high dword]) MMX reg 1 [high dword] <--- (MMX reg 2 [low dword] + MMX reg 2 [high dword])		
MMX Register with Memory64	0F0F [mod mm r/m] 8E	MMX reg [low dword] <--- (MMX reg [low dword] - MMX reg [low dword]) MMX reg [high dword] <--- (Memory64 [low dword] - Memory64 [high dword])		
PFRCP *Floating-Point Reciprocal Approximation*			2	1
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 96	MMX reg 1 [low dword] <--- sat --- reciprocal --- MMX reg 2 [low dword] MMX reg 1 [high dword] <--- sat --- reciprocal --- MMX reg 2 [low dword]		
MMX Register with Memory64	0F0F [mod mm r/m] 96	MMX reg [Low dword] <--- sat --- reciprocal --- Memory64 [low dword] MMX reg [high dword] <--- sat --- reciprocal --- Memory64 [low dword]		
PFRCPV *Floating-Point Reciprocal Vector*			2	
MMX Register1 with MMX Register	0F0F [11 mm1 mm2] 86	MMX reg 1 [low dword] <---sat --- reciprocal --- MMX reg 2 [low dword] MMX reg 1 [high dword] <--- sat --- reciprocal MMX reg 2 [high dword]		
MMX Register with Memory64	0F0F [mod mm r/m] 86	MMX reg [low dword] <---sat --- reciprocal Value - Memory64 [low dword] MMX reg [high dword] <--- sat --- reciprocal value - Memory64 [high dword]		
PFRCPIT1 *Packed Floating-Point Reciprocal, First Iteration Step*			1	1, 2
MMX Register1 with MMX Register 2	0F0F [11 mm1 mm2] A6	MMX reg 1 [dword] <--- move --- MMX reg 2 [dword]		
MMX Register with Memory64	0F0F [mod mm r/m] A6	MMX reg [dword] <-- move --- Memory64 [dword]		
PFRCPIT2 *Packed Floating-Point Reciprocal/Reciprocal Square Root, Second Iteration Step*			1	1, 2
MMX Register 1 with MMX Register 2	0FDF [11 mm1 mm2] B6	MMX reg 1 [dword] <--- move --- MMX reg 2 [dword]		
MMX Register with Memory64	0FDF [mod mm r/m] B6	MMX reg [dword] <--- move --- Memory64 [dword]		

Instruction Set (Continued)

Table 7-31. 3DNow! Instruction Set (Continued)

3DNow! Instructions	Opcode/imm8	Operation	Clk Cnt	Notes
PFSRQIT1 *Packed Floating-Point Reciprocal Square Root, First Iteration Step*			1	1, 2
MMX Register1 with MMX Register 2	0F0F [11 mm1 mm2] A7	MMX reg 1 [dword] <--- move --- MMX reg 2 [dword]		
MMX Register with Memory64	0F0F [mod mm r/m] A7	MMX reg [dword] <--- move --- Memory64 [dword]		
PFRSQRT *Floating-Point Reciprocal Square Root*			2	
MMX Register 1 by MMX Register 2	0F0F [11 mm1 mm2] 97	MMX reg.1 [low dword] <--- reciprocal --- square root --- MMX reg 2 [low dword] MMX reg 2 [high dword] <--- reciprocal --- square root --- MMX reg 2 [low dword]		
MMX Register by Memory64	0F0F [mod mm r/m] 97	MMX reg [low dword] <--- reciprocal --- square root --- Memory64 [low dword] MMX reg [high word] <--- reciprocal --- square root --- Memory64 [low dword]		
PFRSQRTV *Floating-Point Reciprocal Square Root Vector*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 87	MMX reg 1 [low dword] <--- sat --- reciprocal --- square root --- MMX reg 2 [low dword] MMX reg 1 [high word] <--- sat --- reciprocal --- square root --- MMX reg 2 [high dword]		
MMX Register with Memory64	0F0F [mod mm r/m] 87	MMX reg [low dword] <---sat --- reciprocal --- square root --- Memory64 [low dword] MMX reg [high dword] <--- sat --- reciprocal --- square root --- Memory64 [high dword]		
PFSUB *Packed Floating- Point Subtraction*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2] 9A	MMX reg 1 [dword] <--- (MMX reg1 [dword] - MMX reg 2 [dword])		
MMX Register with MMX Memory64	0F0F [mod mm r/m 9A	MMX reg [dword] <--- (MMX reg [dword] - Memory64 [dword])		
PFSUBR *Packed Floating-Point Reverse Subtraction*			2	
MMX Register1 with MMX Register2	0F0F [11mm1 mm2] AA	MMX reg 1 [dword] <---(MMX reg 2 [dword] - MMX reg [dword])		
MMX Register with Memory64	0F0F [mod mm r/m] AA	MMX REG [dword] <--- (Memory64 [dword] - MMX reg [dword])		
PI2FD *Packed 32-Bit Integer to Floating-Point Conversion*			2	
MMX Register1 by MMX Regester2	0F0F [11 mm1 mm2] 0D	MMX reg 1 [dword] <--- trun --- float --- MMX reg 2 [dword]		
MMX Register by Memory64	0F0F [mod mm r/m] 0D	MMX reg [dword] <--- trun --- float --- Memory64 [dword]		
PIF2W *Packed Integer Word to Floating-Point Conversion*			2	
MMX Register1 by MMX Register2	0F0F [11 mm1 mm2] 0C	MMX reg 1 [low dword] <--- float --- MMX reg 2 [low word (low dword)] MMX reg 1 [high dword] <--- float --- MMX reg 2 [low word (high dword)]		
MMX Register by Memory64	0F0F [mod mm r/m] 0C	MMX reg [low dword] <--- float --- Memory64 [low word (low dword)] MMX reg [high dword] <--- float --- Memory64 [low dword (high dword)]		
PMULHRW *Multiply Signed Packed 16-bit Value with Rounding and Store the High 16 bits*			2	
MMX Register1 with MMX Register2	0F0F [11 mm1 mm2 B7	MMX reg 1 [word] <--- (MMX reg 1 [word] * MMX reg 2 [word]) + 8000h		
MMX Register with Memory64	0F0F [mod mm r/m B7	MMX reg [word] <--- (MMX reg [word] * Memory64 [word]) + 8000h		
PREFETCH/PREFETCHW *Prefetch Cache Line into L1 Data Cache (Dcache)*				
Memory 8	0F0D			
PSWAPD *Packed Swap Doubleword*			1	
MMX Register1 by MMX Register2	0F0F [11 mm1 mm2] BB	MMX reg 1 [low dword] <--- MMX reg 2 [high dword] MMX reg 1 [high dword] <--- MMX reg 2 [low dword]		
MMX Register by Memory64	0F0F [mod mm r/m] BB	MMX reg [low dword] <--- Memory64 [high dword] MMX reg [high dword] <--- Memory64 [low dword]		

1) These instructions must wait for the FPU pipeline to flush. Cycle count depends on what instructions are in the pipeline.

2) GX2 performs PFRCP and PFRSQRT to 24-bit accuracy in one cycle, so these instructions are unnecessary. They are treated as a move.

8.0 Package Specifications

The thermal characteristics and physical dimensions for the Geode GX2 processor are provided in this section.

8.1 THERMAL CHARACTERISTICS

Table 8-1 shows the junction-to-case thermal resistance of the EBGA (Enhanced Ball Grid Array) package and can be used to calculate the junction (die) temperature under any given circumstance.

Table 8-1. Junction-to-Case Thermal Resistance

Package	θ_{JC}
EBGA	2 °C/W

Note that there is no specification for maximum junction temperature given since the operation of EBGA devices is guaranteed to a case temperature range of 0°C to 85°C (see Table 6-2 "Operating Conditions" on page 377). As long as the case temperature of the device is maintained within this range, the junction temperature of the die is also maintained within its allowable operating range. However, the die (junction) temperature under a given operating condition can be calculated by using the following equation:

$$T_J = T_C + (P * \theta_{JC})$$

where:

T_J = Junction temperature (°C)

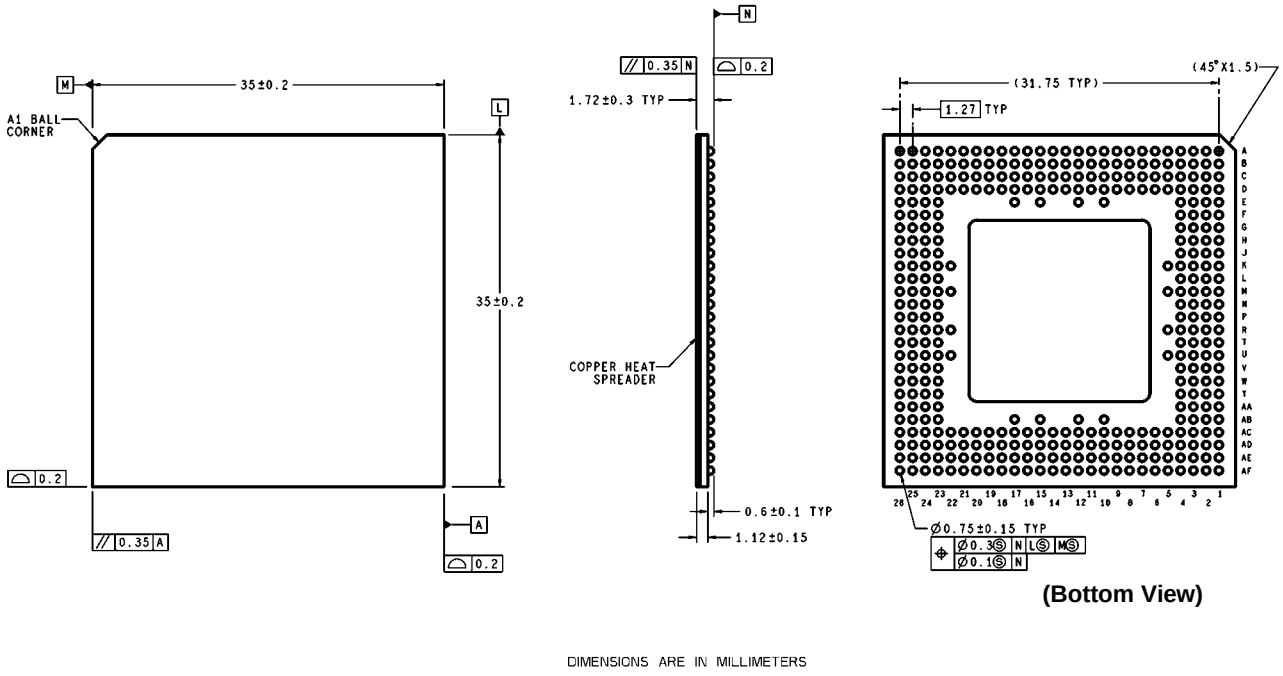
T_C = Case temperature at top center of package (°C)

P = Maximum power dissipation (W)

θ_{JC} = Junction-to-case thermal resistance (°C/W)

8.2 PHYSICAL DIMENSIONS

Figure 8-1 provides the mechanical package outline for the 368-terminal EBGA package.



NOTES: UNLESS OTHERWISE SPECIFIED.

1. SOLDER BALL COMPOSITION: Sn 63%, Pb 37%.
2. DIMENSION IS MEASURED AT THE MAXIMUM SOLDER BALL DIAMETER, PARALLEL TO PRIMARY DATUM N.
3. REFERENCE JEDEC REGISTRATION MO-151, VARIATION -1.27.

Figure 8-1. 368-Terminal EBGA Package (Body Size: 35x35x1.72 mm; Pitch: 1.27 mm)

Appendix A Support Documentation

A.1 ORDER INFORMATION

Order Number (NSID)	Part Marking	Flat Panel or CRT	Core Frequency (MHz)	Memory Controller Data Rate	Data Rate Frequency (MHz)	Core Voltage (V)	Temp Range (°C)	Pkg
SDR								
GX2-S38-CS	GX2-S38-CS	CRT	333	SDR	133	1.5	0 - 85	EBGA
GX2-S38-TS	GX2-S38-TS	FP	333	SDR	133	1.5	0 - 85	EBGA
GX2-S48-CS	GX2-S48-CS	CRT	366	SDR	122	1.5	0 - 85	EBGA
GX2-S48-TS	GX2-S48-TS	FP	366	SDR	122	1.5	0 - 85	EBGA
DDR								
GX2-X18-CD	GX2-X18-CD	CRT	333	DDR	222	1.5	0 - 85	EBGA
GX2-X18-TD	GX2-X18-TD	FP	333	DDR	222	1.5	0 - 85	EBGA
GX2-X28-CD	GX2-X28-CD	CRT	366	DDR	244	1.5	0 - 85	EBGA
GX2-X28-TD	GX2-X28-TD	FP	366	DDR	244	1.5	0 - 85	EBGA
GX2-X38-CD	GX2-X38-CD	CRT	400	DDR	266	1.5	0 - 85	EBGA
GX2-X38-TD	GX2-X38-TD	FP	400	DDR	266	1.5	0 - 85	EBGA

A.2 DATASHEET REVISION HISTORY

This document is a report of the revision/creation process of the datasheet for the GX2 processor. Any revisions (i.e., additions, deletions, parameter corrections, etc.) are recorded in the table(s) below.

Table A-1. Revision History

Revision # (PDF Date)	Revisions / Comments
0.0 (2/16/01)	Tech writer creation phase. Passed to TME for help/editing.
0.1 (5/2/01)	TME/tech writer editing.
0.2 (5/15/01)	First released version for posting on IA Group page.
0.3 (3/26/02)	Updated version for posting on IA Group page. Added sections with Electrical Specifications and Package Specifications. Added Order Information.
0.4 (5/17/02)	Updated version for posting on IA Group page. Added register information.
0.5 (6/24/02)	Added instruction set. Cleaned up/expanded many bit descriptions. Modified Electrical Specifications.
0.6 (8/16/02)	Updated Electrical Specifications. See rev. 0.6 for details.
0.7 (10/10/02)	The majority of changes were made to the GLIU Standard MSRs for consistency throughout the book. Technical changes include updating Electrical Specifications. See rev. 0.7 for details.
0.71 (10/18/02)	The majority of changes were made to the Electrical Specifications. See rev. 0.71 for details.
0.8 (5/19/03)	Changes to several sections; major edits include changing SYS_SETRES (ball AD10) to No Connect (affected several tables and figures), expanding GLIU register descriptions and modifications to the Electrical Specifications. See Table A-2 in rev 0.8 for details.
0.81 (6/17/03)	Added ESD ratings to Electrical Specifications plus other minor corrections and consistency edits. See Table A-2 for details.

Support Documentation (Continued)

Table A-2. Edits to Current Revision

Section	Revision
Global Changes	• Changed GLIU Device (GLD) to GeodeLink Device (GLD).
Section 1.0 "Architecture Overview"	• Table 1-1 "GP Feature Comparison" on page 17: — Corrected VGA support column (GX1 and GX2 columns were reversed).
Section 5.5 "GeodeLink Control Processor Register Descriptions"	• Section 5.5.2.13 "GLCP System Reset and PLL Control (GLCP_SYS_RSTPLL)" on page 339: — Bits [23:16] (HOLD_COUNT): Modified description and decode.
Section 6.0 "Electrical Specifications"	• Table 6-1 "Absolute Maximum Ratings" on page 377: — Added ESD ratings (Human and Machine Models). • Section 6.7 "AC Characteristics" on page 389: — Changed MVREF DDR rating from 1.35V to 1.25V.
Section Appendix A "Support Documentation"	• Section A.1 "Order Information" on page 444: — Typo correction in cell heading.

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