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PI7C8148A

2-Port PCI-to-PCI Bridge

REVISION 1.04

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REVISION HISTORY

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11-13-2003	0.01	First Draft of Datasheet
03-25-2004	0.02	First release of preliminary datasheet
04-26-2004	0.03	Revisions/changes to GPIO and EEPROM references
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TABLE OF CONTENTS

1 SIGNAL DEFINITIONS 13

1.1 SIGNAL TYPES 13
1.2 SIGNALS 13
1.2.1 PRIMARY BUS INTERFACE SIGNALS 13
1.2.2 SECONDARY BUS INTERFACE SIGNALS 14
1.2.3 CLOCK SIGNALS 16
1.2.4 MISCELLANEOUS SIGNALS 16
1.2.5 GENERAL PURPOSE I/O INTERFACE SIGNALS 17
1.2.6 POWER AND GROUND 17
1.3 PIN LIST – 160-PIN LFBGA 18

2 PCI BUS OPERATION 19

2.1 TYPES OF TRANSACTIONS 19
2.2 SINGLE ADDRESS PHASE 20
2.3 DEVICE SELECT (DEVSEL#) GENERATION 20
2.4 DATA PHASE 20
2.5 WRITE TRANSACTIONS 20
2.5.1 MEMORY WRITE TRANSACTIONS 21
2.5.2 MEMORY WRITE AND INVALIDATE 22
2.5.3 DELAYED WRITE TRANSACTIONS 22
2.5.4 WRITE TRANSACTION BOUNDARIES 23
2.5.5 BUFFERING MULTIPLE WRITE TRANSACTIONS 23
2.5.6 FAST BACK-TO-BACK TRANSACTIONS 23
2.6 READ TRANSACTIONS 24
2.6.1 PREFETCHABLE READ TRANSACTIONS 24
2.6.2 DYNAMIC PREFETCHING CONTROL 24
2.6.3 NON-PREFETCHABLE READ TRANSACTIONS 24
2.6.4 READ PREFETCH ADDRESS BOUNDARIES 25
2.6.5 DELAYED READ REQUESTS 25
2.6.6 DELAYED READ COMPLETION WITH TARGET 26
2.6.7 DELAYED READ COMPLETION ON INITIATOR BUS 26
2.6.8 FAST BACK-TO-BACK READ TRANSACTIONS 27
2.7 CONFIGURATION TRANSACTIONS 27
2.7.1 TYPE 0 ACCESS TO PI7C8148A 28
2.7.2 TYPE 1 TO TYPE 0 CONVERSION 28
2.7.3 TYPE 1 TO TYPE 1 FORWARDING 29
2.7.4 SPECIAL CYCLES 30
2.8 TRANSACTION TERMINATION 30
2.8.1 MASTER TERMINATION INITIATED BY PI7C8148A 31
2.8.2 MASTER ABORT RECEIVED BY PI7C8148A 32
2.8.3 TARGET TERMINATION RECEIVED BY PI7C8148A 32
2.8.4 TARGET TERMINATION INITIATED BY PI7C8148A 34

3 ADDRESS DECODING 36

3.1 ADDRESS RANGES 36
3.2 I/O ADDRESS DECODING 36
3.2.1 I/O BASE AND LIMIT ADDRESS REGISTER 37
3.2.2 ISA MODE 37
3.3 MEMORY ADDRESS DECODING 38
3.3.1 MEMORY-MAPPED I/O BASE AND LIMIT ADDRESS REGISTERS 38
3.3.2 PREFETCHABLE MEMORY BASE AND LIMIT ADDRESS REGISTERS 39

3.4 VGA SUPPORT 40
3.4.1 VGA MODE *40*
3.4.2 VGA SNOOP MODE *40*

4 TRANSACTION ORDERING 41

4.1 TRANSACTIONS GOVERNED BY ORDERING RULES 41
4.2 GENERAL ORDERING GUIDELINES 42
4.3 ORDERING RULES 43
4.4 DATA SYNCHRONIZATION 44

5 ERROR HANDLING 44

5.1 ADDRESS PARITY ERRORS 44
5.2 DATA PARITY ERRORS 45
5.2.1 CONFIGURATION WRITE TRANSACTIONS TO CONFIGURATION SPACE 45
5.2.2 READ TRANSACTIONS 45
5.2.3 DELAYED WRITE TRANSACTIONS 46
5.2.4 POSTED WRITE TRANSACTIONS 48
5.3 DATA PARITY ERROR REPORTING SUMMARY 49
5.4 SYSTEM ERROR (SERR#) REPORTING 52

6 PCI BUS ARBITRATION 53

6.1 PRIMARY PCI BUS ARBITRATION 53
6.2 SECONDARY PCI BUS ARBITRATION 53
6.2.1 PREEMPTION 53
6.2.2 BUS PARKING 54

7 CLOCKS 54

7.1 PRIMARY CLOCK INPUTS 54
7.2 SECONDARY CLOCK OUTPUTS 54
7.3 PCI CLOCKRUN 54

8 GENERAL PURPOSE I/O INTERFACE 55

8.1 GPIO CONTROL REGISTERS 55

9 EEPROM INTERFACE 55

9.1 AUTO MODE EEPROM ACCESS 55
9.2 EEPROM MODE AT RESET 56
9.3 EEPROM DATA STRUCTURE 56
9.4 EEPROM SPACE ADDRESS MAP 56
9.4.1 EEPROM CONTENT 56

10 COMPACT PCI HOT SWAP 58

11 PCI POWER MANAGEMENT 58

12 RESET 59

12.1 PRIMARY INTERFACE RESET 59
12.2 SECONDARY INTERFACE RESET 59
12.3 CHIP RESET 60

13 SUPPORTED COMMANDS 60

13.1 PRIMARY INTERFACE 60
13.2 SECONDARY INTERFACE 61

14 BRIDGE BEHAVIOR 62

14.1 BRIDGE ACTIONS FOR VARIOUS CYCLE TYPES 62
14.2 ABNORMAL TERMINATION (INITIATED BY BRIDGE MASTER) 63
14.2.1 MASTER ABORT 63
14.2.2 PARITY AND ERROR REPORTING 63
14.2.3 REPORTING PARITY ERRORS 63
14.2.4 SECONDARY IDSEL MAPPING 63

15 CONFIGURATION REGISTERS 64

15.1 REGISTER TYPES 64
15.2 CONFIGURATION REGISTER 64
15.2.1 VENDOR ID REGISTER – OFFSET 00h 65
15.2.2 DEVICE ID REGISTER – OFFSET 00h 65
15.2.3 COMMAND REGISTER – OFFSET 04h 65
15.2.4 PRIMARY STATUS REGISTER – OFFSET 04h 66
15.2.5 REVISION ID REGISTER – OFFSET 08h 67
15.2.6 CLASS CODE REGISTER – OFFSET 08h 67
15.2.7 CACHE LINE REGISTER – OFFSET 0Ch 67
15.2.8 PRIMARY LATENCY TIMER REGISTER – OFFSET 0Ch 67
15.2.9 HEADER TYPE REGISTER – OFFSET 0Ch 67
15.2.10 PRIMARY BUS NUMBER REGISTER – OFFSET 18h 67
15.2.11 SECONDARY BUS NUMBER REGISTER – OFFSET 18h 68
15.2.12 SUBORDINATE BUS NUMBER REGISTER – OFFSET 18h 68
15.2.13 SECONDARY LATENCY TIMER REGISTER – OFFSET 18h 68
15.2.14 I/O BASE ADDRESS REGISTER – OFFSET 1Ch 68
15.2.15 I/O LIMIT ADDRESS REGISTER – OFFSET 1Ch 68
15.2.16 SECONDARY STATUS REGISTER – OFFSET 1Ch 69
15.2.17 MEMORY BASE ADDRESS REGISTER – OFFSET 20h 69
15.2.18 MEMORY LIMIT ADDRESS REGISTER – OFFSET 20h 70
15.2.19 PREFETCHABLE MEMORY BASE ADDRESS REGISTER – OFFSET 24h 70
15.2.20 PREFETCHABLE MEMORY LIMIT ADDRESS REGISTER – OFFSET 24h 70
15.2.21 PREFETCHABLE MEMORY BASE ADDRESS UPPER 32-BITS REGISTER – OFFSET 28h 70
15.2.22 PREFETCHABLE MEMORY LIMIT ADDRESS UPPER 32-BITS REGISTER – OFFSET 2Ch 71
15.2.23 I/O BASE ADDRESS UPPER 16-BITS REGISTER – OFFSET 30h 71
15.2.24 I/O LIMIT ADDRESS UPPER 16-BITS REGISTER – OFFSET 30h 71
15.2.25 CAPABILITY POINTER REGISTER – OFFSET 34h 71
15.2.26 INTERRUPT LINE REGISTER – OFFSET 3Ch 71
15.2.27 INTERRUPT PIN REGISTER – OFFSET 3Ch 71
15.2.28 BRIDGE CONTROL REGISTER – OFFSET 3Ch 72
15.2.29 DIAGNOSTIC/CHIP CONTROL REGISTER – OFFSET 40h 73
15.2.30 ARBITER CONTROL REGISTER – OFFSET 40h 74
15.2.31 EXTENDED CHIP CONTROL REGISTER – OFFSET 48h 74
15.2.32 SECONDARY BUS ARBITER PREEMPTION CONTROL REGISTER – OFFSET 4Ch 75
15.2.33 P_SERR# EVENT DISABLE REGISTER – OFFSET 64h 76
15.2.34 SECONDARY CLOCK CONTROL REGISTER – OFFSET 68h 77
15.2.35 P_SERR# STATUS REGISTER – OFFSET 68h 77
15.2.36 CLKRUN REGISTER – OFFSET 6Ch 78
15.2.37 PORT OPTION REGISTER – OFFSET 74h 78
15.2.38 CAPABILITY ID REGISTER – OFFSET 80h 80
15.2.39 NEXT ITEM POINTER REGISTER – OFFSET 80h 80
15.2.40 POWER MANAGEMENT CAPABILITIES REGISTER – OFFSET 80h 81

15.2.41 POWER MANAGEMENT DATA REGISTER – OFFSET 84h *81*
15.2.42 PPB SUPPORT EXTENSIONS – OFFSET 84h *81*
15.2.43 DATA REGISTER – OFFSET 84h *81*
15.2.44 PRIMARY MASTER TIMEOUT COUNTER REGISTER – OFFSET 88h *82*
15.2.45 SECONDARY MASTER TIMEOUT COUNTER REGISTER – OFFSET 88h *82*
15.2.46 CAPABILITY ID REGISTER – OFFSET 90h *82*
15.2.47 NEXT ITEM POINTER REGISTER – OFFSET 90h *82*
15.2.48 HOT SWAP CAPABILITY STRUCTURE REGISTER – OFFSET 90h *82*
15.2.49 HOT SWAP SWITCH REGISTER – OFFSET 94h *83*
15.2.50 VPD CAPABILITY ID REGISTER – OFFSET A0h *83*
15.2.51 NEXT ITEM POINTER REGISTER – OFFSET A0h *83*
15.2.52 VPD REGISTER – OFFSET A0h *83*
15.2.53 VPD DATA REGISTER – OFFSET A4h *84*
15.2.54 MISCELLANEOUS CONTROL REGISTER – OFFSET C0h *84*
15.2.55 GPIO CONTROL REGISTER – OFFSET C4h *84*
15.2.56 EEPROM CONTROL REGISTER – OFFSET C8h *85*
15.2.57 EEPROM ADDRESS REGISTER – OFFSET C8h *85*
15.2.58 EEPROM DATA REGISTER – OFFSET C8h *86*
15.2.59 EEPROM TEST REGISTER – OFFSET CCh *86*
15.2.60 SUBSYSTEM VENDOR ID REGISTER – OFFSET F0h *86*
15.2.61 SUBSYSTEM ID – OFFSET F0h *87*

16 ELECTRICAL AND TIMING SPECIFICATIONS 87

16.1 MAXIMUM RATINGS 87
16.2 DC SPECIFICATIONS 87
16.3 AC SPECIFICATIONS 88
16.4 66MHZ TIMING 89
16.5 33MHZ TIMING 89
16.6 POWER CONSUMPTION 89

17 PACKAGE INFORMATION 90

17.1 160-PIN LFBGA PACKAGE OUTLINE 90
17.2 PART NUMBER ORDERING INFORMATION 90

LIST OF TABLES

TABLE 2-1. PCI TRANSACTIONS 19
TABLE 2-2. WRITE TRANSACTION FORWARDING 21
TABLE 2-3. WRITE TRANSACTION DISCONNECT ADDRESS BOUNDARIES 23
TABLE 2-4. READ PREFETCH ADDRESS BOUNDARIES 25
TABLE 2-5. READ TRANSACTION PREFETCHING 25
TABLE 2-6. DEVICE NUMBER TO IDSEL S_AD PIN MAPPING 29
TABLE 2-7. DELAYED WRITE TARGET TERMINATION RESPONSE 33
TABLE 2-8. RESPONSE TO POSTED WRITE TARGET TERMINATION 33
TABLE 2-9. RESPONSE TO DELAYED READ TARGET TERMINATION 34
TABLE 4-1. SUMMARY OF TRANSACTION ORDERING 43
TABLE 5-1. SETTING THE PRIMARY INTERFACE DETECTED PARITY ERROR BIT 49
TABLE 5-2. SETTING SECONDARY INTERFACE DETECTED PARITY ERROR BIT 49
TABLE 5-3. SETTING PRIMARY INTERFACE MASTER DATA PARITY ERROR DETECTED BIT 50
TABLE 5-4. SETTING SECONDARY INTERFACE MASTER DATA PARITY ERROR DETECTED BIT 50
TABLE 5-5. ASSERTION OF P_PERR# 51
TABLE 5-6. ASSERTION OF S_PERR# 51
TABLE 5-7. ASSERTION OF P_SERR# FOR DATA PARITY ERRORS 52
TABLE 11-1. POWER MANAGEMENT TRANSITIONS 59

LIST OF FIGURES

FIGURE 16-1 PCI SIGNAL TIMING MEASUREMENT CONDITIONS 88
FIGURE 17-1 160-PIN LFBGA PACKAGE OUTLINE 90

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INTRODUCTION

Product Description

The PI7C8148A is Pericom Semiconductor's PCI-to-PCI Bridge, designed to be fully compliant with the 32-bit, 66MHz implementation of the *PCI Local Bus Specification, Revision 2.2*. The PI7C8148A supports synchronous bus transactions between devices on the Primary Bus and the Secondary Buses operating up to 66MHz. Both primary and secondary buses must operate at the same frequency. The primary and secondary buses can also operate in concurrent mode, resulting in added increase in system performance.

Product Features

- 32-bit Primary and Secondary Ports run up to 66MHz
- Compliant with the *PCI Local Bus Specification,* Revision 2.2
- Compliant with *PCI-to-PCI Bridge Architecture Specification*, Revision 1.1.
  - All I/O and memory commands
  - Type 1 to Type 0 configuration conversion
  - Type 1 to Type 1 configuration forwarding
  - Type 1 configuration write to special cycle conversion
- Compliant with the *Advanced Configuration Power Interface* (ACPI)
- Compliant with the *PCI Power Management Specification,* Revision 1.1
- Compliant with the *PCI Mobile Design Guide,* Revision 1.1
- Provides internal arbitration for four secondary bus masters
  - Programmable 2-level priority arbiter
- Supports serial EEPROM interface for register auto-load and VPD access
- Supports posted write buffers in all directions
- *Dynamic Prefetching Control*
- Four 128 byte FIFO's for delay transactions
- Two 128 byte FIFO's for posted memory transactions
- Enhanced address decoding
- 32-bit I/O address range
- 32-bit memory-mapped I/O address range
- 64-bit prefetchable address range
- Extended commercial temperature range 0°C to 85°C
- 3.3V and 5V signaling
- 160-pin LFBGA package

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1 SIGNAL DEFINITIONS

1.1 SIGNAL TYPES

SIGNAL TYPE	DESCRIPTION
I	Input only
O	Output only
P	Power
TS	Tri-state bi-directional
STS	Sustained tri-state. Active LOW signal must be pulled HIGH for 1 cycle when deasserting.
OD	Open Drain

1.2 SIGNALS

Signals that end with "#" are active LOW.

1.2.1 PRIMARY BUS INTERFACE SIGNALS

Name	Pin Number	Type	Description
P_AD[31:0]	P10, N10, M10, P11, N11, M11, P12, N12, M14, L12, L13, L14, K12, K13, K14, J12, E14, E13, E12, D14, D13, D12, C13, B14, B12, A12, C11, B11, A11, C10, A10, C9	TS	**Primary Address / Data:** Multiplexed address and data bus. Address is indicated by P_FRAME# assertion. Write data is stable and valid when P_IRDY# is asserted and read data is stable and valid when P_TRDY# is asserted. Data is transferred on rising clock edges when both P_IRDY# and P_TRDY# are asserted. During bus idle, PI7C8148A drives P_AD to a valid logic level when P_GNT# is asserted.
P_CBE#[3:0]	P14, J13, F12, A13	TS	**Primary Command/Byte Enables:** Multiplexed command field and byte enable field. During address phase, the initiator drives the transaction type on these pins. After that, the initiator drives the byte enables during data phases. During bus idle, PI7C8148A drives P_CBE#[3:0] to a valid logic level when P_GNT# is asserted.
P_PAR	F13	TS	**Primary Parity.** Parity is even across P_AD[31:0], P_CBE#[3:0], and P_PAR (i.e. an even number of 1's). P_PAR is an input and is valid and stable one cycle after the address phase (indicated by assertion of P_FRAME#) for address parity. For write data phases, P_PAR is an input and is valid one clock after P_IRDY# is asserted. For read data phase, P_PAR is an output and is valid one clock after P_TRDY# is asserted. Signal P_PAR is tri-stated one cycle after the P_AD lines are tri-stated. During bus idle, PI7C8148A drives P_PAR to a valid logic level when P_GNT# is asserted.
P_FRAME#	J14	STS	**Primary FRAME (Active LOW).** Driven by the initiator of a transaction to indicate the beginning and duration of an access. The de-assertion of P_FRAME# indicates the final data phase requested by the initiator. Before being tri-stated, it is driven to a de-asserted state for one cycle.
P_IRDY#	H12	STS	**Primary IRDY (Active LOW).** Driven by the initiator of a transaction to indicate its ability to complete current data phase on the primary side. Once asserted in a data phase, it is not de-asserted until the end of the data phase. Before tri-stated, it is driven to a de-asserted state for one cycle.

Name	Pin Number	Type	Description
P_TRDY#	H13	STS	**Primary TRDY (Active LOW).** Driven by the target of a transaction to indicate its ability to complete current data phase on the primary side. Once asserted in a data phase, it is not de-asserted until the end of the data phase. Before tri-stated, it is driven to a de-asserted state for one cycle.
P_DEVSEL#	H14	STS	**Primary Device Select (Active LOW).** Asserted by the target indicating that the device is accepting the transaction. As a master, PI7C8148A waits for the assertion of this signal within 5 cycles of P_FRAME# assertion; otherwise, terminate with master abort. Before tri-stated, it is driven to a de-asserted state for one cycle.
P_STOP#	G14	STS	**Primary STOP (Active LOW).** Asserted by the target indicating that the target is requesting the initiator to stop the current transaction. Before tri-stated, it is driven to a de-asserted state for one cycle.
P_IDSEL	N14	I	**Primary ID Select.** Used as a chip select line for Type 0 configuration access to PI7C8148A configuration space.
P_PERR#	G12	STS	**Primary Parity Error (Active LOW).** Asserted when a data parity error is detected for data received on the primary interface. Before being tri-stated, it is driven to a de-asserted state for one cycle.
P_SERR#	F14	OD	**Primary System Error (Active LOW).** Can be driven LOW by any device to indicate a system error condition. PI7C8148A drives this pin on: ▪ Address parity error ▪ Posted write data parity error on target bus ▪ Secondary S_SERR# asserted ▪ Master abort during posted write transaction ▪ Target abort during posted write transaction ▪ Posted write transaction discarded ▪ Delayed write request discarded ▪ Delayed read request discarded ▪ Delayed transaction master timeout This signal requires an external pull-up resistor for proper operation.
P_REQ#	M9	TS	**Primary Request (Active LOW):** This is asserted by PI7C8148A to indicate that it wants to start a transaction on the primary bus. PI7C8148A de-asserts this pin for at least 2 PCI clock cycles before asserting it again.
P_GNT#	N9	I	**Primary Grant (Active LOW):** When asserted, PI7C8148A can access the primary bus. During idle and P_GNT# asserted, PI7C8148A will drive P_AD, P_CBE, and P_PAR to valid logic levels.
P_RST#	P8	I	**Primary RESET (Active LOW):** When P_RST# is active, all PCI signals should be asynchronously tri-stated.

1.2.2 SECONDARY BUS INTERFACE SIGNALS

Name	Pin Number	Type	Description
S_AD[31:0]	M1, L3, L2, L1, K3, K1, J3, J2, H3, H2, H1, G1, G2, G3, F1, F2, A3, C4, A4, C5, B5, A5, C6, B6, C7, B7, A7, A8, B8, C8, A9, B9	TS	**Secondary Address/Data:** Multiplexed address and data bus. Address is indicated by S_FRAME# assertion. Write data is stable and valid when S_IRDY# is asserted and read data is stable and valid when S_TRDY# is asserted. Data is transferred on rising clock edges when both S_IRDY# and S_TRDY# are asserted. During bus idle, PI7C8148A drives S_AD to a valid logic level when S_GNT# is asserted respectively.
S_CBE#[3:0]	J1, F3, A2, A6	TS	**Secondary Command/Byte Enables:** Multiplexed command field and byte enable field. During address phase, the initiator drives the transaction type on these pins. The initiator then drives the byte enables during data phases. During bus idle, PI7C8148A drives S_CBE#[3:0] to a valid logic level when the internal grant is asserted.

Name	Pin Number	Type	Description
S_PAR	B1	TS	**Secondary Parity:** Parity is even across S_AD[31:0], S_CBE#[3:0], and S_PAR (i.e. an even number of 1's). S_PAR is an input and is valid and stable one cycle after the address phase (indicated by assertion of S_FRAME#) for address parity. For write data phases, S_PAR is an input and is valid one clock after S_IRDY# is asserted. For read data phase, S_PAR is an output and is valid one clock after S_TRDY# is asserted. Signal S_PAR is tri-stated one cycle after the S_AD lines are tri-stated. During bus idle, PI7C8148A drives S_PAR to a valid logic level when the internal grant is asserted.
S_FRAME#	E2	STS	**Secondary FRAME (Active LOW):** Driven by the initiator of a transaction to indicate the beginning and duration of an access. The de-assertion of S_FRAME# indicates the final data phase requested by the initiator. Before being tri-stated, it is driven to a de-asserted state for one cycle.
S_IRDY#	E3	STS	**Secondary IRDY (Active LOW):** Driven by the initiator of a transaction to indicate its ability to complete current data phase on the secondary side. Once asserted in a data phase, it is not de-asserted until the end of the data phase. Before tri-stated, it is driven to a de-asserted state for one cycle.
S_TRDY#	D1	STS	**Secondary TRDY (Active LOW):** Driven by the target of a transaction to indicate its ability to complete current data phase on the secondary side. Once asserted in a data phase, it is not de-asserted until the end of the data phase. Before tri-stated, it is driven to a de-asserted state for one cycle.
S_DEVSEL#	D2	STS	**Secondary Device Select (Active LOW):** Asserted by the target indicating that the device is accepting the transaction. As a master, PI7C8148A waits for the assertion of this signal within 5 cycles of S_FRAME# assertion; otherwise, terminate with master abort. Before tri-stated, it is driven to a de-asserted state for one cycle.
S_STOP#	D3	STS	**Secondary STOP (Active LOW):** Asserted by the target indicating that the target is requesting the initiator to stop the current transaction. Before tri-stated, it is driven to a de-asserted state for one cycle.
S_PERR#	C1	STS	**Secondary Parity Error (Active LOW):** Asserted when a data parity error is detected for data received on the secondary interface. Before being tri-stated, it is driven to a de-asserted state for one cycle.
S_SERR#	C2	I	**Secondary System Error (Active LOW):** Can be driven LOW by any device to indicate a system error condition.
S_REQ#[3:0]	P2, P1, N1, M2	I	**Secondary Request (Active LOW):** This is asserted by an external device to indicate that it wants to start a transaction on the secondary bus. The input is externally pulled up through a resistor to VDD.
S_GNT#[3:0]	N4, M4, P3, N3	TS	**Secondary Grant (Active LOW):** PI7C8148A asserts these pins to allow external masters to access the secondary bus. PI7C8148A de-asserts these pins for at least 2 PCI clock cycles before asserting it again. During idle and S_GNT# deasserted, PI7C8148A will drive S_AD, S_CBE, and S_PAR.
S_RST#	P4	O	**Secondary RESET (Active LOW):** Asserted when any of the following conditions are met: 1. Signal P_RST# is asserted. 2. Secondary reset bit in bridge control register in configuration space is set. When asserted, all control signals are tri-stated and zeroes are driven on S_AD, S_CBE, and S_PAR.

1.2.3 CLOCK SIGNALS

Name	Pin Number	Type	Description
P_CLK	M8	I	**Primary Clock Input:** Provides timing for all transactions on the primary interface.
S_CLKIN	M5	I	**Secondary Clock Input:** Provides timing for all transactions on the secondary interface.
S_CLKOUT[4:0]	M7, P6, N6, M6, P5	O	**Secondary Clock Output:** Provides secondary clocks phase synchronous with the P_CLK. One of the clock outputs must be fed back to S_CLKIN. Unused outputs may be disabled by: 1. Writing the secondary clock disable bits in the configuration space 2. Terminating them electrically.
P_CLKRUN#	A14	TS	**Primary Clock Run:** Allows main system to stop the primary clock based on the specifications in the *PCI Mobile Design Guide*, Revision 1.0. If unused, this pin should be tied to ground to signify that P_CLK is always running.
S_CLKRUN#	B3	TS	**Secondary Clock Run:** Allows main system to slow down or stop the secondary clock and is controlled by the primary or bit[4] offset 6Fh. If the secondary devices do not support CLKRUN, this pin should be pulled LOW by a 300 ohm resistor.

1.2.4 MISCELLANEOUS SIGNALS

Name	Pin Number	Type	Description
ENUM#	B4	O	**Hot Swap Status Indicator:** The output of ENUM# indicates to the system that an insertion has occurred or that an extraction is about to occur.
LOO	B10	I/O	**Hot Swap LED:** The output of this pin lights an LED to indicate insertion or removal ready status. This pin may also be used as a input or detect pin. Every 500us, the pin tri-states for 8 primary PCI clock cycles to sample the status.
EJECT	C14	I	**Hot Swap Switch.** When driven LOW, this signal indicates that the board ejector handle indicates an insertion or impending extraction of a board.
EECLK	G13	O	**EEPROM Clock:** Clock signal to the EEPROM interface
EEPD	E1	TS	**EEPROM Data:** Serial data interface to the EEPROM
P_VIO	P9	I	**Primary I/O Voltage:** This pin is used to determine either 3.3V or 5V signaling on the primary bus. P_VIO must be tied to 3.3V only when all devices on the primary bus use 3.3V signaling. Otherwise, P_VIO is tied to 5V.
S_VIO	N5	I	**Secondary I/O Voltage:** This pin is used to determine either 3.3V or 5V signaling on the secondary bus. S_VIO must be tied to 3.3V only when all devices on the secondary bus use 3.3V signaling. Otherwise, S_VIO is tied to 5V.
SCAN_TM#	P7	I	**Full-Scan Test Mode Enable:** For normal operation, pull SCAN_TM# to HIGH. Manufacturing test pin.
SCAN_EN	N7	I/O	**Full-Scan Enable Control:** For normal operation, SCAN_TM# should be pulled HIGH and SCAN_EN becomes an output with logic 0. Manufacturing test pin.
BPCEE	A1	I	**Bus/Power Clock Control Management Pin:** When this pin is tied HIGH and the PI7C8148A is placed in the $D3_{HOT}$ power state, it enables the PI7C8148A to place the secondary bus in the B2 power state. The secondary clocks are disabled and driven to 0. When this pin is tied LOW, there is no effect on the secondary bus clocks when the PI7C8148A enters the $D3_{HOT}$ power state.

1.2.5 GENERAL PURPOSE I/O INTERFACE SIGNALS

Name	Pin Number	Type	Description
GPIO[3:0]	M13, P13, N8, K2	TS	**General Purpose I/O Data Pins:** The 4 general-purpose signals are programmable as either input-only or bi-directional signals by writing the GPIO output enable control register in the configuration space.

1.2.6 POWER AND GROUND

Name	Pin Number	Type	Description
VDD	D6, D7, D8, D9, F4, F11, G4, G11, H4, H11, J4, J11, L6, L7, L8 ,L9	P	**Power:** 3.3V power
VSS	B2, B13, C3, C12, D4, D5, D10, D11, E4, E11, K4, K11, L4, L5, L10, L11, M3, M12, N2, N13	P	**Ground**

1.3 PIN LIST – 160-PIN LFBGA

Pin Number	Name	Type	Pin Number	Name	Type
A1	BPCEE	I	A2	S_CBE#[1]	TS
A3	S_AD[15]	TS	A4	S_AD[13]	TS
A5	S_AD[10]	TS	A6	S_CBE#[0]	TS
A7	S_AD[5]	TS	A8	S_AD[4]	TS
A9	S_AD[1]	TS	A10	P_AD[1]	TS
A11	P_AD[3]	TS	A12	P_AD[6]	TS
A13	P_CBE#[0]	TS	A14	P_CLKRUN#	TS
B1	S_PAR	TS	B2	VSS	P
B3	S_CLKRUN#	TS	B4	ENUM#	O
B5	S_AD[11]	TS	B6	S_AD[8]	TS
B7	S_AD[6]	TS	B8	S_AD[3]	TS
B9	S_AD[0]	TS	B10	LOO	I/O
B11	P_AD[4]	TS	B12	P_AD[7]	TS
B13	VSS	P	B14	P_AD[8]	TS
C1	S_PERR#	STS	C2	S_SERR#	I
C3	VSS	P	C4	S_AD[14]	TS
C5	S_AD[12]	TS	C6	S_AD[9]	TS
C7	S_AD[7]	TS	C8	S_AD[2]	TS
C9	P_AD[0]	TS	C10	P_AD[2]	TS
C11	P_AD[5]	TS	C12	VSS	P
C13	P_AD[9]	TS	C14	EJECT	I
D1	S_TRDY#	STS	D2	S_DEVSEL#	STS
D3	S_STOP#	STS	D4	VSS	P
D5	VSS	P	D6	VDD	P
D7	VDD	P	D8	VDD	P
D9	VDD	P	D10	VSS	P
D11	VSS	P	D12	P_AD[10]	TS
D13	P_AD[11]	TS	D14	P_AD[12]	TS
E1	EEPD	TS	E2	S_FRAME#	STS
E3	S_IRDY#	STS	E4	VSS	P
E11	VSS	P	E12	P_AD[13]	TS
E13	P_AD[14]	TS	E14	P_AD[15]	TS
F1	S_AD[17]	TS	F2	S_AD[16]	TS
F3	S_CBE#[2]	TS	F4	VDD	P
F11	VDD	P	F12	P_CBE#[1]	TS
F13	P_PAR	TS	F14	P_SERR#	OD
G1	S_AD[20]	TS	G2	S_AD[19]	TS
G3	S_AD[18]	TS	G4	VDD	P
G11	VDD	P	G12	P_PERR#	G12
G13	EECLK	O	G14	P_STOP#	I
H1	S_AD[21]	TS	H2	S_AD[22]	TS
H3	S_AD[23]	TS	H4	VDD	P
H11	VDD	P	H12	P_IRDY#	STS
H13	P_TRDY#	STS	H14	P_DEVSEL#	STS
J1	S_CBE#[3]	TS	J2	S_AD[24]	TS
J3	S_AD[25]	TS	J4	VDD	P
J11	VDD	P	J12	P_AD[16]	TS
J13	P_CBE#[2]	TS	J14	P_FRAME#	STS
K1	S_AD[26]	TS	K2	GPIO[0]	TS
K3	S_AD[27]	TS	K4	VSS	P
K11	VSS	P	K12	P_AD[19]	TS
K13	P_AD[18]	TS	K14	P_AD[17]	TS
L1	S_AD[28]	TS	L2	S_AD[29]	TS
L3	S_AD[30]	TS	L4	VSS	P
L5	VSS	P	L6	VDD	P
L7	VDD	P	L8	VDD	P
L9	VDD	P	L10	VSS	P
L11	VSS	P	L12	P_AD[22]	TS
L13	P_AD[21]	TS	L14	P_AD[20]	TS

Pin Number	Name	Type	Pin Number	Name	Type
M1	S_AD[31]	TS	M2	S_REQ#[0]	I
M3	VSS	P	M4	S_GNT#[2]	TS
M5	S_CLKIN	I	M6	S_CLKOUT[1]	O
M7	S_CLKOUT[4]	O	M8	P_CLK	I
M9	P_REQ#	TS	M10	P_AD[29]	TS
M11	P_AD[26]	TS	M12	VSS	P
M13	GPIO[3]	TS	M14	P_AD[23]	TS
N1	S_REQ#[1]	I	N2	VSS	P
N3	S_GNT#[0]	TS	N4	S_GNT#[3]	TS
N5	S_VIO	I	N6	S_CLKOUT[2]	O
N7	SCAN_EN	I/O	N8	GPIO[1]	TS
N9	P_GNT#	I	N10	P_AD[30]	TS
N11	P_AD[27]	TS	N12	P_AD[24]	TS
N13	VSS	P	N14	P_IDSEL	I
P1	S_REQ#[2]	I	P2	S_REQ#[3]	I
P3	S_GNT#[1]	TS	P4	S_RST#	O
P5	S_CLKOUT[0]	O	P6	S_CLKOUT[3]	O
P7	SCAN_TM#	I	P8	P_RST#	I
P9	P_VIO	I	P10	P_AD[31]	TS
P11	P_AD[28]	TS	P12	P_AD[25]	TS
P13	GPIO[2]	TS	P14	P_CBE#[3]	TS

2 PCI BUS OPERATION

This Chapter offers information about PCI transactions, transaction forwarding across the bridge, and transaction termination. The bridge has two 128-byte FIFO's for buffering of upstream and downstream transactions. These hold addresses, data, commands, and byte enables that are used for write transactions. The bridge also has an additional four 128-byte FIFO's that hold addresses, data, commands, and byte enables for read transactions.

2.1 TYPES OF TRANSACTIONS

This section provides a summary of PCI transactions performed by the bridge. Table 2-1 lists the command code and name of each PCI transaction. The Master and Target columns indicate support for each transaction when the bridge initiates transactions as a master, on the primary (P) and secondary (S) buses, and when the bridge responds to transactions as a target, on the primary (P) and secondary (S) buses.

Table 2-1. PCI Transactions

Types of Transactions		Initiates as Master		Responds as Target	
		Primary	Secondary	Primary	Secondary
0000	Interrupt Acknowledge	N	N	N	N
0001	Special Cycle	Y	Y	N	N
0010	I/O Read	Y	Y	Y	Y
0011	I/O Write	Y	Y	Y	Y
0100	Reserved	N	N	N	N
0101	Reserved	N	N	N	N
0110	Memory Read	Y	Y	Y	Y
0111	Memory Write	Y	Y	Y	Y
1000	Reserved	N	N	N	N
1001	Reserved	N	N	N	N
1010	Configuration Read	N	Y	Y	N
1011	Configuration Write	Y (Type 1 only)	Y	Y	Y (Type 1 only)
1100	Memory Read Multiple	Y	Y	Y	Y

Types of Transactions		Initiates as Master		Responds as Target	
		Primary	Secondary	Primary	Secondary
1101	Dual Address Cycle	Y	Y	Y	Y
1110	Memory Read Line	Y	Y	Y	Y
1111	Memory Write and Invalidate	Y	Y	Y	Y

As indicated in Table 2-1, the following PCI commands are not supported by the bridge:

- The bridge never initiates a PCI transaction with a reserved command code and, as a target, the bridge ignores reserved command codes.
- The bridge does not generate interrupt acknowledge transactions. The bridge ignores interrupt acknowledge transactions as a target.
- The bridge does not respond to special cycle transactions. The bridge cannot guarantee delivery of a special cycle transaction to downstream buses because of the broadcast nature of the special cycle command and the inability to control the transaction as a target. To generate special cycle transactions on other PCI buses, either upstream or downstream, Type 1 configuration write must be used.
- The bridge neither generates Type 0 configuration transactions on the primary PCI bus nor responds to Type 0 configuration transactions on the secondary PCI buses.

2.2 SINGLE ADDRESS PHASE

A 32-bit address uses a single address phase. This address is driven on P_AD[31:0], and the bus command is driven on P_CBE[3:0]. The bridge supports the linear increment address mode only, which is indicated when the lowest two address bits are equal to zero. If either of the lowest two address bits is nonzero, the bridge automatically disconnects the transaction after the first data transfer.

2.3 DEVICE SELECT (DEVSEL#) GENERATION

The bridge always performs positive address decoding (medium decode) when accepting transactions on either the primary or secondary buses. The bridge never does subtractive decode.

2.4 DATA PHASE

The address phase of a PCI transaction is followed by one or more data phases. A data phase is completed when IRDY# and either TRDY# or STOP# are asserted. A transfer of data occurs only when both IRDY# and TRDY# are asserted during the same PCI clock cycle. The last data phase of a transaction is indicated when FRAME# is de-asserted and both TRDY# and IRDY# are asserted, or when IRDY# and STOP# are asserted. See Section 2.8 for further discussion of transaction termination.

Depending on the command type, the bridge can support multiple data phase PCI transactions. For detailed descriptions of how the bridge imposes disconnect boundaries, see Section 2.5.4 for write address boundaries and Section 2.6.4 read address boundaries.

2.5 WRITE TRANSACTIONS

Write transactions are treated as either posted write or delayed write transactions. Table 2-2 shows the method of forwarding used for each type of write operation.

Table 2-2. Write Transaction Forwarding

Type of Transaction	Type of Forwarding
Memory Write	Posted (except VGA memory)
Memory Write and Invalidate	Posted
Memory Write to VGA memory	Delayed
I/O Write	Delayed
Type 1 Configuration Write	Delayed

2.5.1 MEMORY WRITE TRANSACTIONS

Posted write forwarding is used for "Memory Write" and "Memory Write and Invalidate" transactions.

When the bridge determines that a memory write transaction is to be forwarded across the bridge, the bridge asserts DEVSEL# with medium timing and TRDY# in the next cycle, provided that enough buffer space is available in the posted memory write queue for the address and at least one DWORD of data. Under this condition, the bridge accepts write data without obtaining access to the target bus. The bridge can accept one DWORD of write data every PCI clock cycle. That is, no target wait state is inserted. The write data is stored in an internal posted write buffers and is subsequently delivered to the target. The bridge continues to accept write data until one of the following events occurs:

- The initiator terminates the transaction by de-asserting FRAME# and IRDY#.
- An internal write address boundary is reached, such as a cache line boundary or an aligned 4KB boundary, depending on the transaction type.
- The posted write data buffer fills up.

When one of the last two events occurs, the bridge returns a target disconnect to the requesting initiator on this data phase to terminate the transaction.

Once the posted write data moves to the head of the posted data queue, the bridge asserts its request on the target bus. This can occur while the bridge is still receiving data on the initiator bus. When the grant for the target bus is received and the target bus is detected in the idle condition, the bridge asserts FRAME# and drives the stored write address out on the target bus. On the following cycle, the bridge drives the first DWORD of write data and continues to transfer write data until all write data corresponding to that transaction is delivered, or until a target termination is received. As long as write data exists in the queue, the bridge can drive one DWORD of write data each PCI clock cycle; that is, no master wait states are inserted. If write data is flowing through the bridge and the initiator stalls, the bridge will signal the last data phase for the current transaction at the target bus if the queue empties. The bridge will restart the follow-on transactions if the queue has new data.

The bridge ends the transaction on the target bus when one of the following conditions is met:

- All posted write data has been delivered to the target.
- The target returns a target disconnect or target retry (the bridge starts another transaction to deliver the rest of the write data).
- The target returns a target abort (the bridge discards remaining write data).
- The master latency timer expires, and the bridge no longer has the target bus grant (the bridge starts another transaction to deliver remaining write data).

Section 2.8.3.2 provides detailed information about how the bridge responds to target termination during posted write transactions.

2.5.2 MEMORY WRITE AND INVALIDATE

Posted write forwarding is used for Memory Write and Invalidate transactions.

If offset 74h bits [8:7] = 11, the bridge disconnects Memory Write and Invalidate commands at aligned cache line boundaries. The cache line size value in the cache line size register gives the number of DWORD in a cache line.

If offset 74h bits [8:7] = 00, the bridge converts Memory Write and Invalidate transactions to Memory Write transactions at the destination.

If the value in the cache line size register does meet the memory write and invalidate conditions, the bridge returns a target disconnect to the initiator on a cache line boundary.

2.5.3 DELAYED WRITE TRANSACTIONS

Delayed write forwarding is used for I/O write transactions and Type 1 configuration write transactions.

A delayed write transaction guarantees that the actual target response is returned back to the initiator without holding the initiating bus in wait states. A delayed write transaction is limited to a single DWORD data transfer.

When a write transaction is first detected on the initiator bus, and the bridge forwards it as a delayed transaction, the bridge claims the access by asserting DEVSEL# and returns a target retry to the initiator. During the address phase, the bridge samples the bus command, address, and address parity one cycle later. After IRDY# is asserted, the bridge also samples the first data DWORD, byte enable bits, and data parity. This information is placed into the delayed transaction queue. The transaction is queued only if no other existing delayed transactions have the same address and command, and if the delayed transaction queue is not full. When the delayed write transaction moves to the head of the delayed transaction queue and all ordering constraints with posted data are satisfied. The bridge initiates the transaction on the target bus. The bridge transfers the write data to the target. If the bridge receives a target retry in response to the write transaction on the target bus, it continues to repeat the write transaction until the data transfer is completed, or until an error condition is encountered.

If the bridge is unable to deliver write data after 2^{24} (default) or 2^{32} (maximum) attempts, the bridge will report a system error. The bridge also asserts P_SERR# if the primary SERR# enable bit is set in the command register. See Section 5.4 for information on the assertion of P_SERR#. When the initiator repeats the same write transaction (same command, address, byte enable bits, and data), and the completed delayed transaction is at the head of the queue, the bridge claims the access by asserting DEVSEL# and returns TRDY# to the initiator, to indicate that the write data was transferred. If the initiator requests multiple DWORD, the bridge also asserts STOP# in conjunction with TRDY# to signal a target disconnect. Note that only those bytes of write data with valid byte enable bits are compared. If any of the byte enable bits are turned off (driven HIGH), the corresponding byte of write data is not compared.

If the initiator repeats the write transaction before the data has been transferred to the target, the bridge returns a target retry to the initiator. The bridge continues to return a target retry to the initiator until write data is delivered to the target, or until an error condition is encountered. When the write transaction is repeated, the bridge does not make a new entry into the delayed transaction queue. Section 2.8.3.1 provides detailed information about how the bridge responds to target termination during delayed write transactions.

The bridge implements a discard timer that starts counting when the delayed write completion is at the head of the delayed transaction completion queue. The initial value of this timer can be set to the retry counter register offset 88h.

If the initiator does not repeat the delayed write transaction before the discard timer expires, the bridge discards the delayed write completion from the delayed transaction completion queue. The bridge also conditionally asserts P_SERR# (see Section 5.4).

2.5.4 WRITE TRANSACTION BOUNDARIES

The bridge imposes internal address boundaries when accepting write data. The aligned address boundaries are used to prevent the bridge from continuing a transaction over a device address boundary and to provide an upper limit on maximum latency. The bridge returns a target disconnect to the initiator when it reaches the aligned address boundaries under conditions shown in Table 2-3.

Table 2-3. Write Transaction Disconnect Address Boundaries

Type of Transaction	Condition	Aligned Address Boundary
Delayed Write	All	Disconnects after one data transfer
Posted Memory Write	Memory write disconnect control bit = 0[1]	4KB aligned address boundary
Posted Memory Write	Memory write disconnect control bit = 1[1]	Disconnects at cache line boundary
Posted Memory Write and Invalidate	Cache line size ≠ 1, 2, 4, 8, 16	4KB aligned address boundary
Posted Memory Write and Invalidate	Cache line size = 1, 2, 4, 8, 16	Cache line boundary if posted memory write data FIFO does not have enough space for the cache line

Note 1. Memory write disconnect control bit is bit 1 of the chip control register at offset 44h in the configuration space.

2.5.5 BUFFERING MULTIPLE WRITE TRANSACTIONS

The bridge continues to accept posted memory write transactions as long as space for at least one DWORD of data in the posted write data buffer remains. If the posted write data buffer fills before the initiator terminates the write transaction, the bridge returns a target disconnect to the initiator.

Delayed write transactions are posted as long as at least one open entry in the delayed transaction queue exists. Therefore, several posted and delayed write transactions can exist in data buffers at the same time. See Chapter 5 for information about how multiple posted and delayed write transactions are ordered.

2.5.6 FAST BACK-TO-BACK TRANSACTIONS

The bridge can recognize and post fast back-to-back write transactions. When the bridge cannot accept the second transaction because of buffer space limitations, it returns a target retry to the initiator. The fast back-to-back enable bit must be set in the command register for upstream write transactions, and in the bridge control register for downstream write transactions.

2.6 READ TRANSACTIONS

Delayed read forwarding is used for all read transactions crossing the bridge. Delayed read transactions are treated as either prefetchable or non-prefetchable. Table 2-5 shows the read behavior, prefetchable or non-prefetchable, for each type of read operation.

2.6.1 PREFETCHABLE READ TRANSACTIONS

A prefetchable read transaction is a read transaction where the bridge performs speculative DWORD reads, transferring data from the target before it is requested from the initiator. This behavior allows a prefetchable read transaction to consist of multiple data transfers. However, byte enable bits cannot be forwarded for all data phases as is done for the single data phase of the non-prefetchable read transaction. For prefetchable read transactions, the bridge forces all byte enable bits to be turned on for all data phases.

Prefetchable behavior is used for memory read line and memory read multiple transactions, as well as for memory read transactions that fall into prefetchable memory space.

The amount of data that is pre-fetched depends on the type of transaction. The amount of pre-fetching may also be affected by the amount of free buffer space available in the bridge, and by any read address boundaries encountered.

Pre-fetching should not be used for those read transactions that have side effects in the target device, that is, control and status registers, FIFO's, and so on. The target device's base address register or registers indicate if a memory address region is prefetchable.

2.6.2 DYNAMIC PREFETCHING CONTROL

For prefetchable reads described in the previous section, the prefetching length is normally predefined and cannot be changed once it is set. This may cause some inefficiency as the prefetching length determined could be larger or smaller than the actual data being prefetched. To make prefetching more efficient, PI7C8148A incorporates dynamic prefetching control logic. This logic regulates the different PCI memory read commands (MR – memory read, MRL – memory read line, and MRM – memory read multiple) to improve memory read burst performance. The bridge tracks every memory read burst transaction and tallies the status. By using the status information, the bridge can determine to increase, reduce, or keep the same cache line length to be prefetched. Over time, the bridge can better match the correct cache line setting to the length of data being requested. The dynamic prefetching control logic is set with bits[3:2] offset 48h.

2.6.3 NON-PREFETCHABLE READ TRANSACTIONS

A non-prefetchable read transaction is a read transaction where the bridge requests one and only one DWORD from the target and disconnects the initiator after delivery of the first DWORD of read data. Unlike prefetchable read transactions, the bridge forwards the read byte enable information for the data phase.

Non-prefetchable behavior is used for I/O and configuration read transactions, as well as for memory read transactions that fall into non-prefetchable memory space.

If extra read transactions could have side effects, for example, when accessing a FIFO, use non-prefetchable read transactions to those locations. Accordingly, if it is important to retain the value of the byte enable bits during the data phase, use non-prefetchable read transactions. If these locations are mapped in memory space, use the memory read command and map the target into non-prefetchable (memory-mapped I/O) memory space to use non-prefetching behavior.

2.6.4 READ PREFETCH ADDRESS BOUNDARIES

The bridge imposes internal read address boundaries on read pre-fetched data. When a read transaction reaches one of these aligned address boundaries, the bridge stops pre-fetched data, unless the target signals a target disconnect before the read pre-fetched boundary is reached. When the bridge finishes transferring this read data to the initiator, it returns a target disconnect with the last data transfer, unless the initiator completes the transaction before all pre-fetched read data is delivered. Any leftover pre-fetched data is discarded.

Prefetchable read transactions in flow-through mode pre-fetch to the nearest aligned 4KB address boundary, or until the initiator de-asserts FRAME_L. Section 2.6.7 describes flow-through mode during read operations.

Table 2-4 shows the read prefetch address boundaries for read transactions during non-flow-through mode.

Table 2-4. Read Prefetch Address Boundaries

Type of Transaction	Address Space	Cache Line Size (CLS)	Prefetch Aligned Address Boundary
Configuration Read	-	*	One DWORD (no prefetch)
I/O Read	-	*	One DWORD (no prefetch)
Memory Read	Non-Prefetchable	*	One DWORD (no prefetch)
Memory Read	Prefetchable	CLS = 0 or 16	16-DWORD aligned address boundary
Memory Read	Prefetchable	CLS = 1, 2, 4, 8, 16	Cache line address boundary
Memory Read Line	-	CLS = 0 or 16	16-DWORD aligned address boundary
Memory Read Line	-	CLS = 1, 2, 4, 8, 16	Cache line boundary
Memory Read Multiple	-	CLS = 0 or 16	32-DWORD aligned address boundary
Memory Read Multiple	-	CLS = 1, 2, 4, 8, 16	2X of cache line boundary

- does not matter if it is prefetchable or non-prefetchable
* don't care

Table 2-5. Read Transaction Prefetching

Type of Transaction	Read Behavior
I/O Read	Prefetching never allowed
Configuration Read	Prefetching never allowed
Memory Read	Downstream: Prefetching used if address is prefetchable space
	Upstream: Prefetching used or programmable
Memory Read Line	Prefetching always used
Memory Read Multiple	Prefetching always used

See Section 3.3 for detailed information about prefetchable and non-prefetchable address spaces.

2.6.5 DELAYED READ REQUESTS

The bridge treats all read transactions as delayed read transactions, which means that the read request from the initiator is posted into a delayed transaction queue. Read data from the target is placed in the