Intel® 80321 I/O Processor

Datasheet

Product Features

- Core Features
  - Integrated Intel® XScale™ Core
  - ARM* V5T Instruction Set
  - ARM V5E DSP Extensions
  - 400 MHz and 600 MHz
  - Write Buffer, Write-back Cache
- PCI Bus Interface
  - *PCI Local Bus Specification*, Rev. 2.2 compliant
  - *PCI-X Addendum to the PCI Local Bus Specification*, Rev. 1.0a
  - 64-bit/66MHz Operation in PCI Mode
  - 64-bit/133MHz Operation in PCI-X Mode
  - Support 32-bit PCI Initiators and Targets
  - Four Split Read Requests as Initiator
  - Eight Split Read Requests as Target
  - 64-bit Addressing Support
- Memory Controller
  - PC200 Double Data Rate (DDR) SDRAM
  - Up to 1 GB of 64-bit DDR SDRAM
  - Up to 512 MB of 32-bit DDR SDRAM
  - Single-bit Error Correction, Multi-bit Support (ECC)
  - 1024-byte Posted Memory Write Queue
  - 40- and 72-bit wide Memory Interface
- Address Translation Unit
  - 2 KB or 4 KB Outbound Read Queue
  - 4 KB Outbound Write Queue
  - 4 KB Inbound Read and Write Queue
  - Connects Internal Bus to PCI/PCI-X Bus
- DMA Controller
  - Two Independent Channels Connected to Internal Bus
  - Up to 1064 MB/s Burst Support in PCI-X Mode
  - Up to 1600 MB/s Burst Support for Internal Bus
  - Two 1-KB Queues in Ch-0 and Ch-1
  - 2^{32} Addressing Range on Internal Bus Interface
  - 2^{64} Addressing Range on PCI Interface
- Application Accelerator Unit
  - Performs XOR on Read Data
  - Compute Parity Across Local Memory Blocks
  - 1 KB/512-byte Store Queue
- I^2C Bus Interface Units
  - Two Separate I^2C Units
  - Serial Bus
  - Master/Slave Capabilities
  - System Management Functions
- SSP Serial Port
  - Full-duplex Synchronous Serial Interface
  - Supports 7.2 KHz to 1.84 MHz Bit Rates
- Peripheral Performance Monitoring Unit
  - One Dedicated Global Time Stamp Counter
  - Fourteen Programmable Event Counters
  - Three Control/Status Registers
- Timers
  - Two Dual-programmable 32-bit Timers
  - Watchdog Timer
- 544-Ball, Plastic Ball Grid Array (PBGA)
- Eight General Purpose I/O Pins

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Contents

Figures

Tables

Revision History

Date	Revision #	Description
June 2002	002	Removed Advance Information designation.
February 2002	001	Initial release.

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1.0 Introduction

1.1 About This Document

This is the *Intel® 80321 I/O Processor Datasheet*. This datasheet contains a functional overview, package signal locations, targeted electrical specifications, and bus functional waveforms. Detailed functional descriptions other than parametric performance is published in the *Intel® 80321 I/O Processor Developer's Manual*.

Intel Corporation assumes no responsibility for any errors which may appear in this document nor does it make a commitment to update the information contained herein.

Intel retains the right to make changes to these specifications at any time, without notice. In particular, descriptions of features, timings, packaging, and pin-outs does not imply a commitment to implement them. In fact, this document does not imply a commitment by Intel to design, manufacture, or sell the product described herein.

1.1.1 Terminology

To aid the discussion of the Intel® 80321 I/O processor (80321) architecture, the following terminology is used:

Downstream	At or toward a PCI bus with a higher number (after configuration)
Host processor	Processor located upstream from the 80321
Local processor	Intel® XScale™ core (ARM* architecture compliant) within the 80321
Local bus	80321 Internal Bus
Local memory	Memory subsystem on the Intel® XScale™ core PC200 DDR SDRAM or Peripheral Bus Interface busses
Upstream	At or toward a PCI bus with a lower number (after configuration)

1.1.2 Other Relevant Documents

Table 1. Related Documentation

Document Title	Document# / Contact
Intel® 80312 I/O Companion Chip Developer's Manual	273410
Intel® 80312 I/O Companion Chip Specification Update	273416
Intel® 80200 Processor based on Intel® XScale™ Microarchitecture Developer's Manual	273411
Intel® 80310 I/O Processor Chipset with Intel® XScale™ Microarchitecture Design Guide	273354
Intel® 80200 Processor based on Intel® XScale™ Microarchitecture Datasheet	273414
Intel® 80200 Processor based on Intel® XScale™ Microarchitecture Specification Update	273415
PCI Local Bus Specification, Revision 2.2	PCI Special Interest Group 1-800-433-5177 http://www.pcisig.com/home
PCI-X Addendum to the PCI Local Bus Specification, Revision 1.0a	
PCI-to-PCI Bridge Architecture Specification, Revision 1.1	
PCI System Design Guide, Revision 1.0	
PCI Hot-Plug Specification, Revision 1.0	
PCI Bus Power Management Interface Specification, Revision 1.1	
I^2C Peripherals for Microcontrollers	Philips Semiconductor
Advanced Configuration and Power Interface Specification, Revision 1.0 (ACPI)	http://www.teleport.com/~acpi/

NOTE: Also see our product website at: http://developer.intel.com/design/iio/.

1.2 About the Intel® 80321 I/O Processor

The 80321 is a single-function device that integrates the Intel® XScale™ core with intelligent peripherals, including a PCI bus application bridge. The 80321 consolidates into a single system:

- Intel® XScale™ core
- PCI - Local Memory Bus Address Translation Unit
- I_2O* Messaging Unit
- Direct Memory Access (DMA) Controller
- Peripheral Bus Interface Unit
- Integrated Memory Controller
- Performance Monitor
- Application Accelerator
- Two I^2C Bus Interface Units
- Synchronous Serial Port Unit
- Eight General Purpose Input Output (GPIO) ports

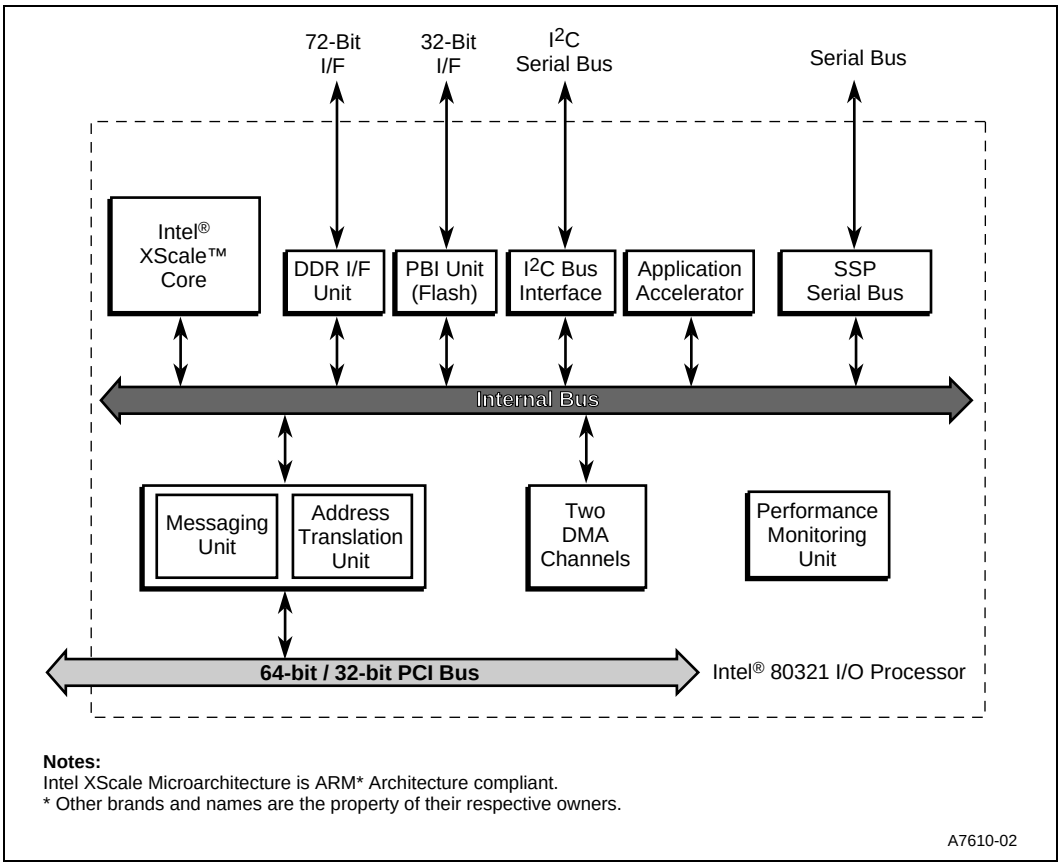
It is an integrated processor that addresses the needs of intelligent I/O applications and helps reduce intelligent I/O system costs.

The PCI Bus is an industry standard, high performance, low latency system bus. The 80321 PCI Bus is capable of 133 MHz operation in PCI-X mode as defined by the *PCI-X Addendum to the PCI Local Bus Specification*, Revision 1.0a. Also, the processor supports a 66 MHz conventional PCI mode as defined by the *PCI Local Bus Specification*, Revision 2.2. The addition of the Intel® XScale™ core brings intelligence to the PCI bus application bridge.

The 80321 is a single-function PCI device. This function represents the address translation unit. The address translation unit is an ‘application bridge’ as defined by the *PCI-X Addendum to the PCI Local Bus Specification*, Revision 1.0a. The 80321 contains PCI configuration space accessible through the PCI bus.

Figure 1 is a block diagram of the 80321.

Figure 1. Intel® 80321 I/O Processor Functional Block Diagram



2.0 Features

The 80321 combines the Intel® XScale™ core with powerful new features to create an intelligent I/O processor. This single-function PCI device is fully compliant with the *PCI Local Bus Specification*, Revision 2.2. 80321-specific features include:

- Address Translation Unit
- Memory Controller
- Peripheral Bus Interface
- Application Accelerator Unit
- I2C Bus Interface Units
- DMA Controller
- Performance Monitoring Unit
- Synchronous Serial Port Unit
- Messaging Unit
- I_2O* Compatibility

The subsections that follow briefly overview each feature. Refer to the appropriate chapter in the *Intel® 80321 I/O Processor Developer's Manual* for full technical descriptions.

The 80321 core is based upon the Intel® XScale™ core. The core processor operates at a maximum frequency of 600 MHz. The instruction cache is 32 Kbytes in size and is 32-way set associative. Also, the core processor includes a data cache that is 32 Kbytes and is 32-way set associative and a mini data cache that is 2 Kbytes and is 2-way set associative.

The 80321 includes 8 General Purpose I/O (GPIO) pins.

2.1 Internal Bus

The Internal Bus is a high-speed interconnect between all internal units and controllers. The Internal Bus operates at 200 MHz and is 64 bits wide.

2.2 DMA Controller

The DMA Controller allows low-latency, high-throughput data transfers between PCI bus agents and the local memory. Two separate DMA channels accommodate data transfers on the PCI bus. The DMA Controller supports chaining and unaligned data transfers. It is programmable through the Intel® XScale™ core only.

2.3 Address Translation Unit

The Address Translation Unit (ATU) allows PCI transactions direct access to the 80321 local memory. The ATU supports transactions between PCI address space and the 80321 address space. Address translation is controlled through programmable registers accessible from both the PCI interface and the Intel® XScale™ core. Dual access to registers allows flexibility in mapping the two address spaces. The ATU also supports the following extended capability configuration headers:

1. Power Management header as defined by *PCI Bus Power Management Interface Specification*, Revision 1.1.
2. Message Signaled Interrupt capability structure specified in *PCI Local Bus Specification*, Revision 2.2.
3. PCI-X Capabilities List Item specified in the *PCI-X Addendum to the PCI Local Bus Specification*, Revision 1.0a.

2.4 Messaging Unit

The Messaging Unit (MU) provides data transfer between the PCI system and the 80321. It uses interrupts to notify each system when new data arrives. The MU has four messaging mechanisms:

- Message Registers
- Doorbell Registers
- Circular Queues
- Index Registers

Each allows a host processor or external PCI device and the 80321 to communicate through message passing and interrupt generation.

2.5 Memory Controller

The Memory Controller allows direct control of a PC200 DDR SDRAM memory subsystem. It features programmable chip selects and support for error correction codes (ECC). External memory can be configured as PCI addressable memory or private 80321 memory.

2.6 Peripheral Bus Interface

The Peripheral Bus Interface Unit (PBI) is a data communication path to certain components of a 80321 hardware system that do not have PCI bus interfaces and/or do not optimally reside on the PCI Bus. Examples of such components include Flash Memory and DSP host interface ports. The PBI allows the processor to manipulate data and interact with these components in the I/O environment. To perform these tasks at high bandwidth, the bus features a burst transfer capability which allows successive 32-bit data transfers. The bus has a 33 MHz, 66 MHz and a 100 MHz operating mode.

2.7 Application Accelerator Unit

The Application Accelerator Unit transfers blocks of data to and from the local memory and performs boolean operations, such as XOR, on the data.

2.8 Performance Monitoring Unit

The Performance Monitoring Unit (PMON) allows various events on the 80321 to be monitored. The 14 Event Counters can be programmed to observe events selected from a pre-defined set of events.

2.9 I²C Bus Interface Units

There are two I²C (Inter-Integrated Circuit) Bus Interface Units that allow the Intel® XScale™ core to serve as a master and slave device residing on the I²C bus. The I²C unit uses a serial bus developed by Philips Semiconductor* consisting of a two-pin interface. The bus allows the 80321 to interface to other I²C peripherals and microcontrollers for system management functions. It requires a minimum of hardware for an economical system to relay status and reliability information on the I/O subsystem to an external device. Also refer to *I²C Peripherals for Microcontrollers* (Philips Semiconductor*).

2.10 Synchronous Serial Port Unit

The Synchronous Serial Port (SSP) Unit is a full-duplex synchronous serial interface. It can connect to a variety of external analog-to-digital (A/D) converters, audio and telecom codecs, and many other devices which use serial protocols for transferring data. It supports the National Microwire*, Texas Instrument* synchronous serial protocol, and the Motorola* serial peripheral interface (SPI) protocol. The SPI interface can be configured to operate as the Philips Semiconductor I²C interface.

3.0 Package Information

3.1 Package Introduction

The 80321 is offered in a Plastic Ball Grid Array (PBGA) package. This is a perimeter array package with 508 ball connections in the outer area of the package and a square 6x6 grid of rows of ball connections in the middle area of the package. See Figure 3 “544-Lead PBGA Package (Bottom View)” on page 26.

3.1.1 Functional Signal Definitions

This section defines the pins and signals.

Table 2. Pin Description Nomenclature

Symbol	Description
I	Input pin only
O	Output pin only
I/O	Pin can be either an input or output
OD	Open Drain pin
-	Pin must be connected as described
Sync(...)	Synchronous. Signal meets timings relative to an input clock. Sync(P) Synchronous to **P_CLK** Sync(M) Synchronous to **M_CK[2:0]** Sync(PB) Synchronous to **PB_CLK** Sync(SS) Synchronous to **SSCKO** Sync(T) Synchronous to **TCK**
Async	Asynchronous. Inputs may be asynchronous relative to all clocks. All asynchronous signals are level-sensitive.
Rst(P)	The pin is reset with **P_RST#**.
Rst(M)	The pin is reset with **M_RST#**. Note that **M_RST#** is asserted when **P_RST#** is asserted or PCSR[5] is set with software.
Rst(T)	The pin is reset with **TRST#**
(Configuration Pin)	These pins are used during reset to configure the processor. These pins have internal pullup resisters which are turned on when P_RST# is low. To configure the pin low connect a 4.7KΩ resister from the pin to ground. By default the pin is configured high.

Table 3. DDR SDRAM Signals

Name	Count	Type	Description
RCVENI#	1	I	**RECEIVE ENABLE IN** provides delay information for enabling the input receivers and must be connected to **RCVENO#** of the 80321.
RCVENO#	1	O	**RECEIVE ENABLE OUT** must be connected to **RCVENI#** of the 80321 and be trace length matched to Clock Trace plus average DQ Traces.
M_CK[2:0]	3	O	**MEMORY CLOCKS** are used to provide the positive differential clocks to the external SDRAM memory subsystem.
M_CK[2:0]#	3	O	**MEMORY CLOCKS** are used to provide the negative differential clocks to the external SDRAM memory subsystem.
M_RST#	1	**O** Async	**MEMORY RESET** indicates when the memory subsystem has been reset with **P_RST#** or a software reset.
SA[12:0]	13	O Sync(M) Rst(M)	**MEMORY ADDRESS BUS** carries the multiplexed row and column addresses to the SDRAM memory banks. For **SA[10]**, See Note 1.
SBA[1:0]	2	O Sync(M) Rst(M)	**SDRAM BANK ADDRESS** indicates which of the SDRAM internal banks are read or written during the current transaction. See Note 1.
SRAS#	1	O Sync(M) Rst(M)	**SDRAM ROW ADDRESS STROBE** indicates the presence of a valid row address on the Multiplexed Address Bus **SA[12:0]**. See Note 1.
SCAS#	1	O Sync(M) Rst(M)	**SDRAM COLUMN ADDRESS STROBE** indicates the presence of a valid column address on the Multiplexed Address Bus **SA[12:0]**. See Note 1.
SWE#	1	O Sync(M) Rst(M)	**SDRAM WRITE ENABLE** indicates that the current memory transaction is a write operation. See Note 1.
SCE[1:0]#	2	O Sync(M) Rst(M)	**SDRAM CHIP SELECT** enables the SDRAM devices for a memory access (Physical banks 0 and 1). See Note 1.
SCKE[1:0]	2	O Sync(M) Rst(M)	**SDRAM CLOCK ENABLE** enables the clocks for the SDRAM memory. Deasserting places the SDRAM in self-refresh mode. See Note 1.
DQ[63:0]	64	I/O Sync(M) Rst(M)	**SDRAM DATA BUS** carries 64-bit data to and from memory. During a data cycle, read or write data is present on one or more contiguous bytes. During write operations, unused pins are driven to determinate values. See Note 1.
SCB[7:0]	8	I/O Sync(M) Rst(M)	**SDRAM ECC CHECK BITS** carry the 8-bit ECC code to and from memory during data cycles. See Note 1.
DQS[8:0]	9	I/O Sync(M) Rst(M)	**SDRAM DATA STROBES** carry the strobe signals which are used to capture data on the data bus. See Note 1.
SDQM[8:0]	9	O Sync(M) Rst(M)	**SDRAM DATA MASK** controls which bytes on the data bus should be written. When **SDQM[8:0]** is asserted, the SDRAM devices do not accept valid data from the byte lanes. See Note 1.
V_{REF}	1	I	**SDRAM VOLTAGE REFERENCE** is used to supply the reference voltage to the differential inputs of the memory controller pins.

NOTE:
1. These pins remain functional for 20 **M_CK[2:0]** periods after **M_RST#** is asserted for a warm boot. The designated Rst(M) state applies after 20 **M_CK[2:0]** periods after **M_RST#** is asserted. For more details, refer to the MCU Chapter of the *Intel® 80321 I/O Processor Developer's Manual*.

Table 4. Peripheral Bus Interface Signals (Sheet 1 of 3)

Name	Count	Type	Description
AD[31:0]	32	I/O Sync(PB) Rst(M)	**ADDRESS / DATA BUS** During an address cycle bits 31-2 contain the physical word address and bits 1-0 specify the number of data transfers during the bus transaction. 00= 1 Transfer 01= 2 Transfers 10= 3 Transfers 11= 4 Transfers. During a data cycle bits 31-0, 15-0 or 7-0 contain valid data, depending on the corresponding 32-, 16- or 8-bit bus width. During 16- and 8-bit bus write operations the unused bus pins are driven to determinate values.
A[3:2]	2	O Sync(PB) Rst(M)	**ADDRESS [3:2]** carries a demultiplexed version of bits 3 and 2 of the address bus. During an address cycle **A[3:2]** matches **AD[3:2]**. During a bursted read or write data cycle **A[3:2]** represents the current DWORD address in the bursted transaction.
BE[3:0]#	4	O Sync(PB) Rst(M)	**BYTE ENABLES** select which of up to four data bytes on the bus participate in the current bus access. The byte enables are asserted during the address cycle. These signals do not toggle during a burst and they remain active through the last data cycle. Byte enable encoding is dependent on the bus width: 32-bit bus: • **BE[3]#** enables data on **AD[31:24]** • **BE[2]#** enables data on **AD[23:16]** • **BE[1]#** enables data on **AD[15:8]** • **BE[0]#** enables data on **AD[7:0]** 16-bit bus: • **BE[3]#** enables data on **AD[15:8]** • **BE[2]#** is not used (state is high) • **BE[1]#** becomes Address Bit 1 (**A[1]**) • **BE[0]#** enables data on **AD[7:0]** 8-bit bus: • **BE[3]#** is not used (state is high) • **BE[2]#** is not used (state is high) • **BE[1]#** becomes Address Bit 1 (**A[1]**) • **BE[0]#** becomes Address Bit 0 (**A[0]**) For 16- and 8-bit bus accesses these address bits are asserted in conjunction with **A[3:2]**.
ALE	1	O Sync(PB) Rst(M)	**ADDRESS LATCH ENABLE** indicates the transfer of a physical address. The pin is asserted during the first address cycle and deasserted during the second address cycle. The pin floats whenever the bus is relinquished to an external device
ADS#	1	O Sync(PB) Rst(M)	**ADDRESS STROBE** indicates a valid address and the start of a new bus access. The pin is asserted during the second address cycle and deasserted during the first data cycle. The pin floats whenever the bus is relinquished to an external device
PB_CLK	1	O	**PERIPHERAL BUS CLOCK** is the reference clock for all signals on the peripheral bus.
W/R#	1	O Sync(PB) Rst(M)	**WRITE / READ** indicates whether the bus access is a write or a read with respect to the 80321 and is valid during the entire bus access. This pin can be used to control the OE# input on the flash ROM. The pin floats whenever the bus is relinquished to an external device 0 = read 1 = write

Table 4. Peripheral Bus Interface Signals (Sheet 2 of 3)

Name	Count	Type	Description
FWE#	1	O Sync(PB) Rst(M)	**FLASH WRITE ENABLE** indicates whether the bus access is a write or a read with respect to the 80321 and is valid during the entire bus access. This pin is used for flash memory accesses and controls the **SWE#** input on the ROM. The pin floats whenever the bus is relinquished to an external device. 0 = write 1 = read
DEN#	1	O Sync(PB) Rst(M)	**DATA ENABLE** indicates data transfer cycles during a bus access. **DEN#** is asserted at the start of the first data cycle and deasserted at the end of the last data cycle. The pin is used to provide control for data transceivers connected to the bus. The pin floats whenever the bus is relinquished to an external device
BLAST#	1	O Sync(PB) Rst(M)	**BURST LAST** indicates the last data transfer of a bus access. **BLAST#** remains active when wait states are inserted and becomes inactive after the final data transfer is complete. The pin floats whenever the bus is relinquished to an external device
RDYRCV#	1	I/O Sync(PB) Rst(M)	**READY / RECOVER** During a data cycle the pin indicates that data can be sampled or removed. 0 = sample data 1 = insert wait state During a recover state the pin indicates that the recover state is repeated. This function allows slow external devices longer to float their pins before the next address is driven. 0 = insert recovery state 1 = recovery complete
HOLD	1	I Sync(PB)	**HOLD** is used by an external device to request access to the bus.
HOLDA	1	O Sync(PB) Rst(M)	**HOLD ACKNOWLEDGE** indicates to an external device that it has been granted access to the bus.
PB_RST#	1	O Async	**PERIPHERAL BUS RESET** indicates when the peripheral bus has been reset with **P_RST#** or a software reset.
PCE[5]# / PBI100MHZ# (Configuration Pin)	1	I/O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **PERIPHERAL BUS 100 MHz ENABLE** is latched at the deasserting edge of P_RST# and it indicates the speed at which the PBI bus operates. [**PBI100MHZ#**, **PBI66MHZ#**] 11= 33MHz (Default Mode) 10 = 66MHz 01 = 100MHz 00 = Undefined (Reserved - Do Not Use)
PCE[4]# / PBI66MHZ# (Configuration Pin)	1	I/O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **PERIPHERAL BUS 66MHz ENABLE** is latched at the deasserting edge of P_RST# and it indicates the speed at which the PBI bus operates. [**PBI100MHZ#**, **PBI66MHZ#**] 11= 33MHz (Default Mode) 10 = 66MHz 01 = 100MHz 00 = Undefined (Reserved - Do Not Use)

Table 4. Peripheral Bus Interface Signals (Sheet 3 of 3)

Name	Count	Type	Description
PCE[3]# / P_BOOT16# (Configuration Pin)	1	O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **PERIPHERAL BUS BOOT WIDTH 16 ENABLE** specifies the width of the peripheral bus for flash accesses during boot up. 0 = 16-bit bus width (Requires Pull-Down Resistor) 1 = 8-bit bus width (Default Mode)
PCE[2]# / 32BITPCI# (Configuration Pin)	1	I/O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **32 BIT PCI** is latched at the deasserting edge of P_RST# and it indicates the width of the PCI-X bus to the PCI-X Status Register (bit 16 of the PCI-X Status Register). 0 = 32-Bit PCI-X Bus (Requires pull-down resistor) 1 = 64-Bit PCI-X Bus (Default mode)
PCE[1]# / RETRY (Configuration Pin)	1	I/O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **RETRY** is latched at the deasserting edge of P_RST# and it determines when the Primary PCI interface disables PCI configuration cycles by signaling a Retry until the Configuration Cycle Retry bit is cleared in the PCI Configuration and Status Register. 0 = Configuration Cycles enabled (Requires pull-down resistor) 1 = Retry enabled (Default mode)
PCE[0]# / RST_MODE# (Configuration Pin)	1	I/O Sync(PB) Rst(M)	**PERIPHERAL CHIP ENABLES** specify which of the six memory address ranges are associated with the current bus access. The pin remains valid during the entire bus access. **RESET MODE** is latched at the deasserting edge of P_RST# and it determines when the 80321 is held in reset until the Intel® XScale™ microprocessor Reset bit is cleared in the PCI Configuration and Status Register. 0 = Hold in reset (Requires pull-down resistor) 1 = Don't hold in reset (Default mode)
WIDTH[1:0]	2	O Sync(PB) Rst(M)	**WIDTH** denotes the physical memory attributes for a bus transaction. The pins float whenever the bus is relinquished to an external device. 00 = 8 Bits Wide 01 = 16 Bits Wide 10 = 32 Bits Wide 11 = Reserved

Table 5. PCI Bus Signals (Sheet 1 of 2)

Name	Count	Type	Description
P_AD[31:0]	32	I/O Sync(P) Rst(P)	**PCI ADDRESS/DATA** is the multiplexed PCI address and bottom 32 bits of the data bus.
P_AD[63:32]	32	I/O Sync(P) Rst(P)	**PCI DATA** is the upper 32 bits of the PCI data bus driven during the data phase.
P_PAR	1	I/O Sync(P) Rst(P)	**PCI BUS PARITY** is even parity across **P_AD[31:0]** and **P_C/BE[3:0]#**.
P_PAR64	1	I/O Sync(P) Rst(P)	**PCI BUS UPPER DWORD PARITY** is even parity across **P_AD[63:32]** and **P_C/BE[7:4]#**.
P_C/BE[3:0]#	4	I/O Sync(P) Rst(P)	**PCI BUS COMMAND and BYTE ENABLES** are multiplexed on the same PCI pins. During the address phase, they define the bus command. During the data phase, they are used as byte enables for **P_AD[31:0]**.
P_C/BE[7:4]#	4	I/O Sync(P) Rst(P)	**PCI BUS BYTE ENABLES** are as byte enables for **P_AD[63:32]** during the data phase.
P_REQ#	1	O Rst(P)	**PCI BUS REQUEST** indicates to the PCI bus arbiter that the 80321 desires use of the PCI bus.
P_REQ64#	1	I/O Sync(P) Rst(P)	**PCI BUS REQUEST 64-BIT TRANSFER** indicates the attempt of a 64-bit transaction on the PCI bus. When the target is 64-bit capable, the target acknowledges the attempt with the assertion of **P_ACK64#**.
P_GNT#	1	I Sync(P)	**PCI BUS GRANT** indicates that access to the PCI bus has been granted.
P_ACK64#	1	I/O Sync(P) Rst(P)	**PCI BUS ACKNOWLEDGE 64-BIT TRANSFER** indicates that the device has positively decoded its address as the target of the current access and the target transfers data using the full 64-bit data bus.
P_FRAME#	1	I/O Sync(P) Rst(P)	**PCI BUS CYCLE FRAME** is asserted to indicate the beginning and duration of an access.
P_IRDY#	1	I/O Sync(P) Rst(P)	**PCI BUS INITIATOR READY** indicates the initiating agent's ability to complete the current data phase of the transaction. During a write, it indicates that valid data is present on the Address/Data bus. During a read, it indicates the processor is ready to accept the data.
P_TRDY#	1	I/O Sync(P) Rst(P)	**PCI BUS TARGET READY** indicates the target agent's ability to complete the current data phase of the transaction. During a read, it indicates that valid data is present on the Address/Data bus. During a write, it indicates the target is ready to accept the data.
P_STOP#	1	I/O Sync(P) Rst(P)	**PCI BUS STOP** indicates a request to stop the current transaction on the PCI bus.
P_DEVSEL#	1	I/O Sync(P) Rst(P)	**PCI BUS DEVICE SELECT** is driven by a target agent that has successfully decoded the address. As an input, it indicates whether or not an agent has been selected.
P_SERR#	1	I/O OD Sync(P) Rst(P)	***PCI BUS SYSTEM ERROR*** is driven for address parity errors on the PCI bus.
P_CLK	1	I	**PCI BUS INPUT CLOCK** provides the timing for all PCI transactions and is the clock source for most internal 80321 units.

Table 5. PCI Bus Signals (Sheet 2 of 2)

Name	Count	Type	Description
P_RST#	1	I Async	**RESET** brings PCI-specific registers, sequencers, and signals to a consistent state. When **P_RST#** is asserted: PCI output signals are driven to a known consistent state. PCI bus interface output signals are three-stated. Open drain signals such as **P_SERR#** are floated. **P_RST#** may be asynchronous to **P_CLK** when asserted or deasserted. Although asynchronous, deassertion must be guaranteed to be a clean, bounce-free edge.
P_PERR#	1	I/O Sync(P) Rst(P)	**PCI BUS PARITY ERROR** is asserted when a data parity error occurs during a PCI bus transaction.
P_IDSEL	1	I Sync(P)	**PCI BUS INITIALIZATION DEVICE SELECT** is used to select the 80321 during a Configuration Read or Write command on the PCI bus.
P_INT[A:D]#	4	O OD Async Rst(P)	**PCI BUS INTERRUPT** requests an interrupt. The assertion and deassertion of **P_INT[A:D]#** is asynchronous to **P_CLK**. A device asserts its **P_INT[A:D]#** line when requesting attention from its device driver. Once the **P_INT[A:D]#** signal is asserted, it remains asserted until the device driver clears the pending request. **P_INT[A:D]#** Interrupts are level sensitive.
P_M66EN	1	I	**PCI BUS 66 MHz ENABLE** indicates the speed of the PCI bus. When this signal is sampled high the PCI bus speed is 66 MHz, when low the bus speed is 33 MHz.

Table 6. Serial Port Interface Signals

Name	Count	Type	Description
SSCKO	1	O	**SERIAL PORT CLOCK OUT** is the output bit-rate clock.
SFRM	1	O Sync(SS) Rst(M)	**SERIAL FRAME** indicates the beginning and end of a serial data word.
TXD	1	O Sync(SS) Rst(M)	**TRANSMIT DATA** is the outbound serial data pin.
RXD	1	I Sync(SS)	**RECEIVE DATA** is the inbound serial data pin.
SSCKI	1	I	**SERIAL PORT CLOCK** IN is the input bit-rate clock which can be used when a frequency other than the default of 3.7 MHz is needed.

Table 7. Miscellaneous Signals (Sheet 1 of 2)

Name	Count	Type	Description
XINT[3:0]#	4	I Async	**EXTERNAL INTERRUPT REQUESTS** are used by external devices to request interrupt service. These pins are level-detect only and are internally synchronized. These interrupts can be directed to either the PCI pins **P_INT[A:D]#** or to the 80321 interrupt controller pins **XINT[3:0]#** as shown below. **XINT[0]#** ⇒ **P_INT[A]#** or **XINT[0]#** **XINT[1]#** ⇒ **P_INT[B]#** or **XINT[1]#** **XINT[2]#** ⇒ **P_INT[C]#** or **XINT[2]#** **XINT[3]#** ⇒ **P_INT[D]#** or **XINT[3]#**
HPI#	1	I Async	**HIGH PRIORITY INTERRUPT** causes a high priority non-maskable interrupt to the 80321. This pin is level-detect only and is internally synchronized.
GPIO[3:0]	4	I/O Async Rst(M)	**GENERAL PURPOSE INPUT/OUTPUT**. These pins can be selected on a per pin basis as general purpose inputs or outputs. The default mode is a general purpose input.
GPIO[4] / SDA1	1	I/O Async Rst(P) I/O OD Rst(M)	**GENERAL PURPOSE INPUT/OUTPUT**. These pins can be selected on a per pin basis as general purpose inputs or outputs. The default mode is a general purpose input. **I^2C DATA** is used for data transfer and arbitration on the I^2C bus. This is one of two I^2C buses that the user can enable.
GPIO[5] / SCL1	1	I/O Async Rst(P) I/O OD Rst(M)	**GENERAL PURPOSE INPUT/OUTPUT**. These pins can be selected on a per pin basis as general purpose inputs or outputs. The default mode is a general purpose input. **I^2C CLOCK** provides synchronous operation of the I^2C bus. This is one of two I^2C buses that the user can enable.
GPIO[6] / SDA0	1	I/O Async Rst(P) I/O OD Rst(M)	**GENERAL PURPOSE INPUT/OUTPUT**. These pins can be selected on a per pin basis as general purpose inputs or outputs. The default mode is a general purpose input. **I^2C DATA** is used for data transfer and arbitration on the I^2C bus. This is one of two I^2C buses that the user can enable.
GPIO[7] / SCL0	1	I/O Async Rst(P) I/O OD Rst(M)	**GENERAL PURPOSE INPUT/OUTPUT**. These pins can be selected on a per pin basis as general purpose inputs or outputs. The default mode is a general purpose input. **I^2C CLOCK** provides synchronous operation of the I^2C bus. This is one of two I^2C buses that the user can enable.
TCK	1	I Rst(T)	**TEST CLOCK** is an input which provides the clocking function for the IEEE 1149.1 Boundary Scan Testing (JTAG). State information and data are clocked into the component on the rising edge and data is clocked out of the component on the falling edge.
TDI	1	I Sync(T) Rst(T)	**TEST DATA INPUT** is the serial input pin for the JTAG feature. TDI is sampled on the rising edge of **TCK**, during the SHIFT-IR and SHIFT-DR states of the Test Access Port. This signal has a weak internal pull-up to ensure proper operation when this signal is unconnected.
TDO	1	O Sync(T)Rst(T)	**TEST DATA OUTPUT** is the serial output pin for the JTAG feature. **TDO** is driven on the falling edge of **TCK** during the SHIFT-IR and SHIFT-DR states of the Test Access Port. At other times, **TDO** floats. The behavior of **TDO** is independent of **P_RST#**.
TRST#	1	I Asyn Rst(T)	**TEST RESET** asynchronously resets the Test Access Port (TAP) controller function of IEEE 1149.1 Boundary Scan Testing (JTAG). This signal has a weak internal pull-up.

Table 7. Miscellaneous Signals (Sheet 2 of 2)

Name	Count	Type	Description
TMS	1	I Sync(T) Rst(T)	**TEST MODE SELECT** is sampled at the rising edge of **TCK** to select the operation of the test logic for IEEE 1149.1 Boundary Scan testing. This signal has a weak internal pull-up to ensure proper operation when this signal is unconnected.
RCOMP	1	I	**RESISTER COMPENSATION** is connected through a 30.1 Ω 1% 1/4 W resister to ground. This is used to minimize the PCI pin variations due to voltage and temperature variations.
PWRDELAY	1	I Async	**POWER FAIL DELAY** is used with external delay circuits to delay the reset of the memory controller in a power-fail condition. This allows the self-refresh command to be sent to the DDR SDRAM array.
POR#	1	I	**POWER ON RESET** should be tied to the 1.3 V supply. It is used to provide cloclks to the core from an internal ring oscillator during power up, which prevents internal contention. It also tristates the other pins to prevent external power sequencing contention.
NC[2:0]	3	I/O	**NO CONNECT** pins have no usable function. However they are in the boundary scan chain and must not be connected to any signal, power or ground.
V_{CCPLL1}	1	PWR	**PLL POWER** is a separate **V_{CC13}** supply ball for the phase lock loop clock generator. It is to be connected to the board **V_{CC13}** plane. In noisy environments, add a simple bypass filter circuit to reduce noise-induced clock jitter and its effects on timing relationships.
V_{CCPLL2}	1	PWR	**PLL POWER** is a separate **V_{CC13}** supply ball for the phase lock loop clock generator. It is to be connected to the board **V_{CC13}** plane. In noisy environments, add a simple bypass filter circuit to reduce noise-induced clock jitter and its effects on timing relationships.
V_{CC33}	51	PWR	**3.3 V POWER** balls to be connected to a 3.3 V power board plane.
V_{CC25}	38	PWR	**2.5 V POWER** balls to be connected to a 2.5 V power board plane.
V_{CC13}	34	PWR	**1.3 V POWER** balls to be connected to a 1.3 V power board plane.
V_{SS}	118	GND	**GROUND** balls to be connected to a ground board plane.

Table 8. Pin Mode Behavior (Sheet 1 of 2)

Pin	Reset	Norm	Hold	32-Bit PCI	32-Bit Mem	ECC Off
RCVENI#	VI	VI	-	-	-	-
RCVENO#	1*	VO	-	-	-	-
M_CK[2:0]	VO	VO	-	-	-	-
M_CK[2:0]#	VO	VO	-	-	-	-
M_RST#	0	VO	-	-	-	-
SA[12:0]	0*	VO	-	-	-	-
SBA[1:0]	0*	VO	-	-	-	-
SRAS#	1*	VO	-	-	-	-
SCAS#	1*	VO	-	-	-	-
SWE#	1*	VO	-	-	-	-
SCE[1:0]#	1*	VO	-	-	-	-
SCKE[1:0]	0*	VO	-	-	-	-
DQ[63:32]	Z*	VB	-	-	ID	-
Q[31:0]	Z*	VB	-	-	-	-
SCB[7:0]	Z*	VB	-	-	-	ID
DQS[7:4]	Z*	VB	-	-	ID	-
DQS[3:0]	Z*	VB	-	-	-	-
DQS[8]	Z*	VB	-	-	-	ID
SDQM[7:4]	Z*	VO	-	-	Z	-
SDQM[3:0]	Z*	VO	-	-	-	-
SDQM[8]	Z*	VO	-	-	-	Z
AD[31:16]	0	VB	Z	-	-	-
AD[15:8]	0	VB	Z	-	-	-
AD[7:0]	0	VB	Z	-	-	-
A[3:2]	0	VO	Z	-	-	-
BE[3:0]#	1	VO	Z	-	-	-
ALE	0	VO	Z	-	-	-
ADS#	1	VO	Z	-	-	-
PB_CLK	VO	VO	-	-	-	-
W/R#	0	VO	Z	-	-	-
FWE#	1	VO	Z	-	-	-
DEN#	1	VO	Z	-	-	-
BLAST#	1	VO	Z	-	-	-
RDYRCV#	VI	VI	-	-	-	-
HOLD	VI	VI	-	-	-	-
HOLDA	VO	VO	1	-	-	-
PB_RST#	0	VO	-	-	-	-
PCE[5]# / PBI100MHZ#	H	VO	1	-	-	-
PCE[4]# / PBI66MHZ#	H	VO	1	-	-	-
PCE[3]# / P_BOOT16#	H	VO	1	-	-	-
PCE[2]# / 32BITPCI#	H	VO	1	-	-	-
PCE[1]# / RETRY	H	VO	1	-	-	-
PCE[0]# / RST_MODE#	H	VO	1	-	-	-
WIDTH[1:0]	0	VO	Z	-	-	-

Table 8. Pin Mode Behavior (Sheet 2 of 2)

Pin	Reset	Norm	Hold	32-Bit PCI	32-Bit Mem	ECC Off
P_AD[63:32]	Z	VB	-	H	-	-
P_AD[31:16]	Z	VB	-	-	-	-
P_AD[15:0]	Z	VB	-	-	-	-
P_PAR	Z	VB	-	-	-	-
P_PAR64	Z	VB	-	H	-	-
P_C/BE[3:0]#	Z	VB	-	-	-	-
P_C/BE[7:4]#	Z	VB	-	H	-	-
P_REQ#	Z	VO	-	-	-	-
P_REQ64#	Z	VB	-	-	-	-
P_GNT#	VI	VI	-	-	-	-
P_ACK64#	Z	VB	-	-	-	-
P_FRAME#	VI	VB	-	-	-	-
P_IRDY#	VI	VB	-	-	-	-
P_TRDY#	VI	VB	-	-	-	-
P_STOP#	VI	VB	-	-	-	-
P_DEVSEL#	VI	VB	-	-	-	-
P_SERR#	Z	VB	-	-	-	-
P_CLK	VI	VI	-	-	-	-
P_RST#	VI	VI	-	-	-	-
P_PERR#	Z	VB	-	-	-	-
P_IDSEL	VI	VI	-	-	-	-
P_INT[A:D]#	Z	VO	-	-	-	-
P_M66EN	VI	VI	-	-	-	-
SSCKO	VO	VO	-	-	-	-
SFRM	VO	VO	-	-	-	-
TXD	VO	VO	-	-	-	-
RXD	VI	VI	-	-	-	-
SSCKI	VI	VI	-	-	-	-
XINT[3:0]#	VI	VI	-	-	-	-
HPI#	VI	VI	-	-	-	-
GPIO[7]	VI	VB	-	-	-	-
GPIO[6]	VI	VB	-	-	-	-
GPIO[5]	VI	VB	-	-	-	-
GPIO[4:0]	VI	VB	-	-	-	-
TCK	VI	VI	-	-	-	-
TDI	H	H	-	-	-	-
TDO	Z	VO	-	-	-	-
TRST#	H	H	-	-	-	-
TMS	H	H	-	-	-	-
PWRDELAY	VI	VI	-	-	-	-
NC[2:0]	H	H	-	-	-	-

NOTES:
1 = driven to V_{CC}
0 = driven to V_{SS}
X = driven to unknown state
ID = The input is disabled
H = pulled up to V_{CC}
PD = pull-up disabled

NOTES:(continued)
L = pulled down to V_{SS}
Z = output disabled (Floats)
VB = acts like a Valid Bidirectional pin.
VO = a Valid Output level is driven.
VI = Need to drive a Valid Input level.
* = After power fail sequence completes.
** = Caused by Hi-Z from mode pins only.

3.1.2 544-Lead PBGA Package

Figure 2. 544-Lead PBGA Package (Top View)

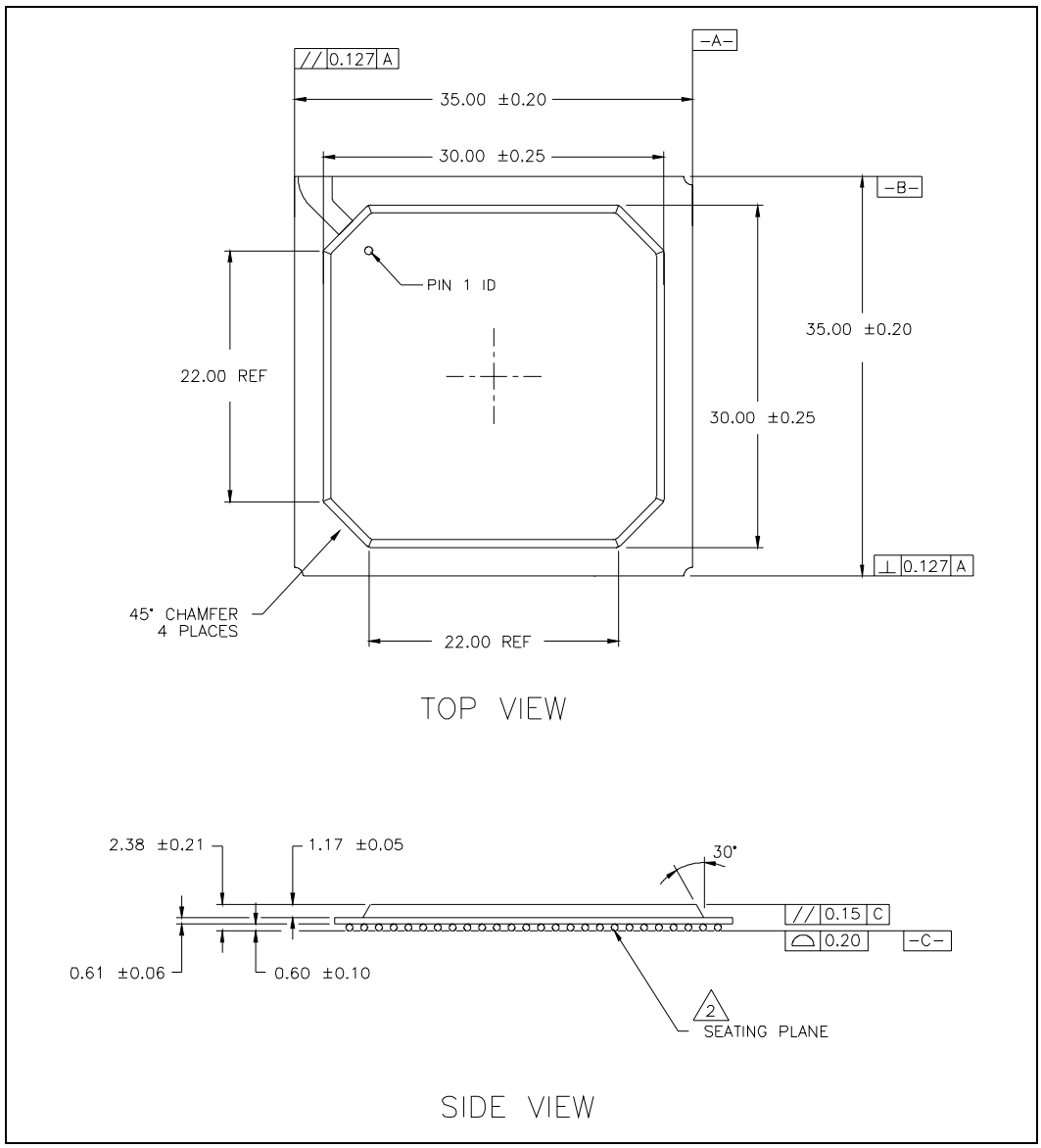


Figure 3. 544-Lead PBGA Package (Bottom View)

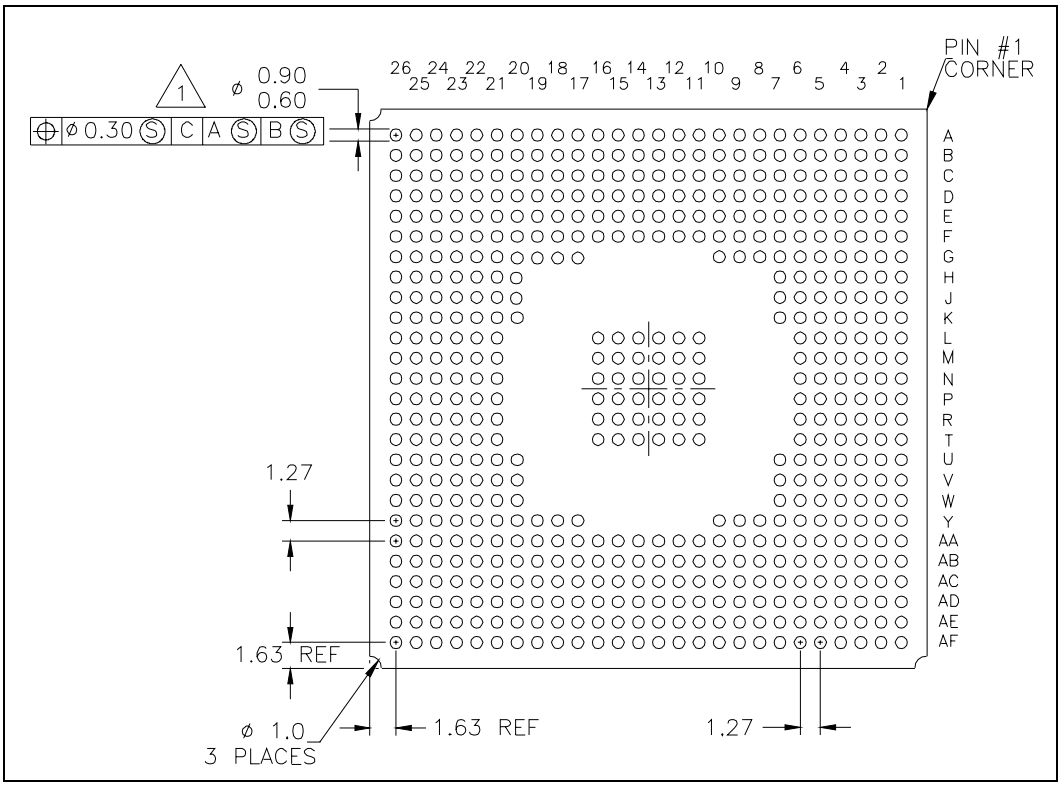


Figure 4. Ball Map - Left Side - Top View

Figure 5. Ball Map - Right Side - Top View

Table 9. 544-Lead PBGA Package - Alphabetical Ball Listing (Sheet 1 of 5)

Ball	Signal	Ball	Signal	Ball	Signal
A1	SA1	**B13**	V_{SS}	**C25**	AD29
A2	DQ35	**B14**	SA7	**C26**	AD28
A3	DQ38	**B15**	V_{SS}	**D1**	SRAS#
A4	DQ34	**B16**	DQ21	**D2**	SBA0
A5	DQ33	**B17**	V_{SS}	**D3**	SBA1
A6	V_{REF}	**B18**	SCKE1	**D4**	V_{SS}
A7	SCB3	**B19**	V_{SS}	**D5**	DQ37
A8	SDQM8	**B20**	DQ13	**D6**	DQ32
A9	SCB0	**B21**	V_{SS}	**D7**	RCVENI#
A10	SA2	**B22**	DQ2	**D8**	SCB2
A11	DQ30	**B23**	V_{SS}	**D9**	SCB5
A12	SDQM3	**B24**	DQ4	**D10**	DQ31
A13	DQ28	**B25**	V_{SS}	**D11**	DQ26
A14	SA8	**B26**	AD30	**D12**	DQ25
A15	DQ18	**C1**	SA10	**D13**	SA6
A16	DQS2	**C2**	V_{SS}	**D14**	DQ19
A17	DQ20	**C3**	V_{CC25}	**D15**	SDQM2
A18	SCKE0	**C4**	SDQM4	**D16**	DQ16
A19	DQ14	**C5**	DQ36	**D17**	SA11
A20	DQS1	**C6**	V_{CC25}	**D18**	DQ11
A21	DQ8	**C7**	SCB7	**D19**	DQ15
A22	DQ6	**C8**	SCB1	**D20**	DQ9
A23	DQS0	**C9**	V_{CC25}	**D21**	M_RST#
A24	DQ5	**C10**	SA4	**D22**	DQ7
A25	DQ0	**C11**	DQ27	**D23**	AD25
A26	AD31	**C12**	V_{CC25}	**D24**	AD27
B1	SA0	**C13**	DQ24	**D25**	V_{SS}
B2	DQ39	**C14**	DQ23	**D26**	AD26
B3	V_{SS}	**C15**	V_{CC25}	**E1**	DQ45
B4	DQS4	**C16**	DQ17	**E2**	V_{SS}
B5	V_{SS}	**C17**	SA9	**E3**	DQ44
B6	RCVENO#	**C18**	V_{CC25}	**E4**	DQ40
B7	V_{SS}	**C19**	SDQM1	**E5**	V_{CC25}
B8	DQS8	**C20**	DQ12	**E6**	V_{SS}
B9	V_{SS}	**C21**	V_{CC25}	**E7**	SCB6
B10	SA3	**C22**	SDQM0	**E8**	V_{SS}
B11	V_{SS}	**C23**	DQ1	**E9**	SCB4
B12	DQ29	**C24**	V_{CC25}	**E10**	V_{SS}

Table 9. 544-Lead PBGA Package - Alphabetical Ball Listing (Sheet 2 of 5)

Ball	Signal	Ball	Signal	Ball	Signal
E11	DQS3	**F23**	AD21	**J1**	DQS6
E12	V_{SS}	**F24**	V_{CC33}	**J2**	V_{SS}
E13	SA5	**F25**	V_{SS}	**J3**	V_{CC25}
E14	V_{SS}	**F26**	AD20	**J4**	DQ53
E15	DQ22	**G1**	DQ46	**J5**	DQ52
E16	V_{SS}	**G2**	V_{SS}	**J6**	V_{CC25}
E17	SA12	**G3**	DQ47	**J7**	V_{CC13}
E18	V_{SS}	**G4**	DQ43	**J20**	V_{CC13}
E19	DQ10	**G5**	DQ42	**J21**	V_{CC33}
E20	V_{SS}	**G6**	V_{CC25}	**J22**	V_{SS}
E21	DQ3	**G7**	V_{CC13}	**J23**	AD11
E22	V_{SS}	**G8**	V_{CC13}	**J24**	V_{CC33}
E23	BE3#	**G9**	V_{CC13}	**J25**	AD13
E24	AD22	**G10**	V_{CC13}	**J26**	AD12
E25	AD24	**G17**	V_{CC13}	**K1**	DQ50
E26	AD23	**G18**	V_{CC13}	**K2**	DQ54
F1	SDQM5	**G19**	V_{CC13}	**K3**	SDQM6
F2	DQS5	**G20**	V_{CC13}	**K4**	DQ55
F3	V_{CC25}	**G21**	V_{CC33}	**K5**	V_{SS}
F4	DQ41	**G22**	V_{SS}	**K6**	V_{CC25}
F5	V_{SS}	**G23**	BE1#	**K7**	V_{CC13}
F6	V_{CC25}	**G24**	AD17	**K20**	V_{CC13}
F7	V_{CC25}	**G25**	AD19	**K21**	V_{CC33}
F8	V_{CC25}	**G26**	AD18	**K22**	WIDTH0
F9	V_{CC25}	**H1**	DQ49	**K23**	AD8
F10	V_{CC25}	**H2**	DQ48	**K24**	AD10
F11	V_{CC25}	**H3**	SCAS#	**K25**	V_{SS}
F12	V_{CC25}	**H4**	SWE#	**K26**	AD9
F13	V_{CC25}	**H5**	V_{SS}	**L1**	DQ60
F14	V_{CC25}	**H6**	V_{CC25}	**L2**	V_{SS}
F15	V_{CC25}	**H7**	V_{CC13}	**L3**	DQ51
F16	V_{CC25}	**H20**	V_{CC13}	**L4**	SCE1#
F17	V_{CC25}	**H21**	V_{CC33}	**L5**	SCE0#
F18	V_{CC25}	**H22**	WIDTH1	**L6**	V_{CC25}
F19	V_{CC25}	**H23**	AD14	**L11**	V_{SS}
F20	V_{CC25}	**H24**	AD16	**L12**	V_{SS}
F21	V_{CC25}	**H25**	V_{SS}	**L13**	V_{SS}
F22	BE2#	**H26**	AD15	**L14**	V_{SS}

Table 9. 544-Lead PBGA Package - Alphabetical Ball Listing (Sheet 3 of 5)

Ball	Signal	Ball	Signal	Ball	Signal
L15	V_{SS}	**N21**	V_{CC33}	**R23**	RDYRCV#
L16	V_{SS}	**N22**	V_{SS}	**R24**	V_{CC33}
L21	V_{CC33}	**N23**	A2	**R25**	BLAST#
L22	V_{SS}	**N24**	AD0	**R26**	DEN#
L23	BE0#	**N25**	AD2	**T1**	M_CK1#
L24	AD5	**N26**	AD1	**T2**	P_INTB#
L25	AD7	**P1**	DQ59	**T3**	P_INTA#
L26	AD6	**P2**	M_CK2#	**T4**	RCOMP
M1	DQ57	**P3**	M_CK2	**T5**	V_{SS}
M2	DQ61	**P4**	DQ63	**T6**	V_{CC33}
M3	V_{CC25}	**P5**	V_{SS}	**T11**	V_{SS}
M4	DQ56	**P6**	V_{CC25}	**T12**	V_{SS}
M5	V_{SS}	**P11**	V_{SS}	**T13**	V_{SS}
M6	V_{CC25}	**P12**	V_{SS}	**T14**	V_{SS}
M11	V_{SS}	**P13**	V_{SS}	**T15**	V_{SS}
M12	V_{SS}	**P14**	V_{SS}	**T16**	V_{SS}
M13	V_{SS}	**P15**	V_{SS}	**T21**	V_{CC13}
M14	V_{SS}	**P16**	V_{SS}	**T22**	PB_RST#
M15	V_{SS}	**P21**	V_{CC13}	**T23**	HOLDA
M16	V_{SS}	**P22**	**FWE#**	**T24**	HOLD
M21	V_{CC13}	**P23**	W/R#	**T25**	V_{SS}
M22	A3	**P24**	ADS#	**T26**	PB_CLK
M23	AD4	**P25**	V_{SS}	**U1**	P_INTD#
M24	V_{CC33}	**P26**	ALE	**U2**	V_{SS}
M25	V_{SS}	**R1**	M_CK1	**U3**	P_REQ#
M26	AD3	**R2**	V_{SS}	**U4**	P_INTC#
N1	DQ62	**R3**	V_{CC25}	**U5**	P_RST#
N2	V_{SS}	**R4**	M_CK0#	**U6**	V_{CC33}
N3	DQ58	**R5**	M_CK0	**U7**	V_{CC13}
N4	SDQM7	**R6**	V_{CC25}	**U20**	V_{CC13}
N5	DQS7	**R11**	V_{SS}	**U21**	V_{CC33}
N6	V_{CC25}	**R12**	V_{SS}	**U22**	V_{SS}
N11	V_{SS}	**R13**	V_{SS}	**U23**	PCE5#
N12	V_{SS}	**R14**	V_{SS}	**U24**	PCE4#
N13	V_{SS}	**R15**	V_{SS}	**U25**	PCE3#
N14	V_{SS}	**R16**	V_{SS}	**U26**	PCE2#
N15	V_{SS}	**R21**	V_{CC33}	**V1**	P_AD31
N16	V_{SS}	**R22**	V_{SS}	**V2**	P_GNT#

Table 9. 544-Lead PBGA Package - Alphabetical Ball Listing (Sheet 4 of 5)

Ball	Signal	Ball	Signal	Ball	Signal
V3	V_{CC33}	**Y19**	V_{CC13}	**AB5**	V_{SS}
V4	P_AD30	**Y20**	V_{CC13}	**AB6**	P_AD9
V5	V_{SS}	**Y21**	V_{CC33}	**AB7**	V_{SS}
V6	V_{CC33}	**Y22**	GPIO3	**AB8**	P_AD$
V7	V_{CC13}	**Y23**	GPIO2	**AB9**	V_{SS}
V20	V_{CC13}	**Y24**	GPIO1	**AB10**	P_CBE7#
V21	V_{CC33}	**Y25**	V_{SS}	**AB11**	V_{SS}
V22	PCE0#	**Y26**	GPIO0	**AB12**	P_AD62
V23	NC0	**AA1**	P_AD23	**AB13**	V_{SS}
V24	V_{CC33}	**AA2**	V_{SS}	**AB14**	P_AD54
V25	V_{SS}	**AA3**	V_{CC33}	**AB15**	V_{SS}
V26	PCE1#	**AA4**	P_AD22	**AB16**	P_AD48
W1	P_AD29	**AA5**	P_AD20	**AB17**	V_{SS}
W2	V_{SS}	**AA6**	V_{CC33}	**AB18**	P_AD40
W3	P_AD27	**AA7**	V_{CC33}	**AB19**	V_{SS}
W4	P_AD28	**AA8**	V_{CC33}	**AB20**	P_AD32
W5	P_AD26	**AA9**	V_{CC33}	**AB21**	V_{SS}
W6	V_{CC33}	**AA10**	V_{CC33}	**AB22**	V_{CC33}
W7	V_{CC13}	**AA11**	V_{CC33}	**AB23**	HPI#
W20	V_{CC13}	**AA12**	V_{CC13}	**AB24**	SSCKI
W21	V_{CC33}	**AA13**	V_{CC33}	**AB25**	V_{SS}
W22	V_{SS}	**AA14**	V_{CC13}	**AB26**	SSCKO
W23	GPIO7	**AA15**	V_{CC33}	**AC1**	P_AD17
W24	GPIO6	**AA16**	V_{CC13}	**AC2**	V_{SS}
W25	GPIO5	**AA17**	V_{CC33}	**AC3**	P_FRAME#
W26	GPIO4	**AA18**	V_{CC33}	**AC4**	P_TRDY#
Y1	P_AD25	**AA19**	V_{CC33}	**AC5**	P_AD13
Y2	P_CBE3#	**AA20**	V_{CC33}	**AC6**	P_CBE0#
Y3	P_AD24	**AA21**	V_{CC33}	**AC7**	P_CLK
Y4	P_IDSEL	**AA22**	V_{SS}	**AC8**	P_AD2
Y5	V_{SS}	**AA23**	SFRM	**AC9**	P_AD0
Y6	V_{CC33}	**AA24**	V_{CC33}	**AC10**	P_REQ64#
Y7	V_{CC13}	**AA25**	RXD	**AC11**	P_PAR64
Y8	V_{CC13}	**AA26**	TXD	**AC12**	P_CBE4#
Y9	V_{CC13}	**AB1**	P_AD19	**AC13**	P_AD58
Y10	V_{CC13}	**AB2**	P_AD21	**AC14**	P_AD56
Y17	V_{CC13}	**AB3**	P_AD18	**AC15**	P_AD52
Y18	V_{CC13}	**AB4**	P_AD16	**AC16**	P_AD50

Table 9. 544-Lead PBGA Package - Alphabetical Ball Listing (Sheet 5 of 5)

Ball	Signal	Ball	Signal	Ball	Signal
AC17	P_AD44	**AD21**	V_{CC33}	**AE24**	V_{SS}
AC18	P_AD42	**AD22**	TCK	**AE25**	V_{CC33}
AC19	P_AD36	**AD23**	NC1	**AE26**	V_{CC33}
AC20	P_AD34	**AD24**	V_{CC33}	**AF1**	P_DEVSEL#
AC21	TDO	**AD25**	V_{SS}	**AF2**	P_PERR#
AC22	TRST#	**AD26**	XINT0#	**AF3**	P_SERR#
AC23	V_{SS}	**AE1**	P_IRDY#	**AF4**	P_CBE1#
AC24	XINT3#	**AE2**	V_{SS}	**AF5**	V_{CCPLL1}
AC25	XINT2#	**AE3**	P_PAR	**AF6**	P_AD12
AC26	XINT1#	**AE4**	V_{SS}	**AF7**	P_AD10
AD1	P_CBE2#	**AE5**	P_AD14	**AF8**	P_AD8
AD2	P_STOP#	**AE6**	V_{SS}	**AF9**	P_AD5
AD3	V_{CC33}	**AE7**	V_{CCPLL2}	**AF10**	P_AD1
AD4	P_AD15	**AE8**	V_{SS}	**AF11**	P_CBE6#
AD5	P_AD11	**AE9**	P_AD7	**AF12**	P_AD63
AD6	V_{CC33}	**AE10**	V_{SS}	**AF13**	P_AD59
AD7	P_AD6	**AE11**	P_ACK64#	**AF14**	P_AD55
AD8	P_M66EN	**AE12**	V_{SS}	**AF15**	P_AD51
AD9	V_{CC33}	**AE13**	P_AD61	**AF16**	P_AD47
AD10	P_AD3	**AE14**	V_{SS}	**AF17**	P_AD43
AD11	P_CBE5#	**AE15**	P_AD53	**AF18**	P_AD41
AD12	V_{CC33}	**AE16**	V_{SS}	**AF19**	P_AD37
AD13	P_AD60	**AE17**	P_AD45	**AF20**	P_AD33
AD14	P_AD57	**AE18**	V_{SS}	**AF21**	POR#
AD15	V_{CC33}	**AE19**	P_AD39	**AF22**	TMS
AD16	P_AD49	**AE20**	V_{SS}	**AF23**	PWRDELAY
AD17	P_AD46	**AE21**	TDI	**AF24**	V_{CC33}
AD18	V_{CC33}	**AE22**	V_{SS}	**AF25**	V_{CC33}
AD19	P_AD38	**AE23**	NC2	**AF26**	V_{CC33}
AD20	P_AD35				

Table 10. 544-Lead PBGA Package - Alphabetical Signal Listing (Sheet 1 of 5)

Signal	Ball	Signal	Ball	Signal	Ball
A2	N23	**BE2#**	F22	**DQ34**	A4
A3	M22	**BE3#**	E23	**DQ35**	A2
AD0	N24	**BLAST#**	R25	**DQ36**	C5
AD1	N26	**DEN#**	R26	**DQ37**	D5
AD2	N25	**DQ0**	A25	**DQ38**	A3
AD3	M26	**DQ1**	C23	**DQ39**	B2
AD4	M23	**DQ2**	B22	**DQ40**	E4
AD5	L24	**DQ3**	E21	**DQ41**	F4
AD6	L26	**DQ4**	B24	**DQ42**	G5
AD7	L25	**DQ5**	A24	**DQ43**	G4
AD8	K23	**DQ6**	A22	**DQ44**	E3
AD9	K26	**DQ7**	D22	**DQ45**	E1
AD10	K24	**DQ8**	A21	**DQ46**	G1
AD11	J23	**DQ9**	D20	**DQ47**	G3
AD12	J26	**DQ10**	E19	**DQ48**	H2
AD13	J25	**DQ11**	D18	**DQ49**	H1
AD14	H23	**DQ12**	C20	**DQ50**	K1
AD15	H26	**DQ13**	B20	**DQ51**	L3
AD16	H24	**DQ14**	A19	**DQ52**	J5
AD17	G24	**DQ15**	D19	**DQ53**	J4
AD18	G26	**DQ16**	D16	**DQ54**	K2
AD19	G25	**DQ17**	C16	**DQ55**	K4
AD20	F26	**DQ18**	A15	**DQ56**	M4
AD21	F23	**DQ19**	D14	**DQ57**	M1
AD22	E24	**DQ20**	A17	**DQ58**	N3
AD23	E26	**DQ21**	B16	**DQ59**	P1
AD24	E25	**DQ22**	E15	**DQ60**	L1
AD25	D23	**DQ23**	C14	**DQ61**	M2
AD26	D26	**DQ24**	C13	**DQ62**	N1
AD27	D24	**DQ25**	D12	**DQ63**	P4
AD28	C26	**DQ26**	D11	**DQS0**	A23
AD29	C25	**DQ27**	C11	**DQS1**	A20
AD30	B26	**DQ28**	A13	**DQS2**	A16
AD31	A26	**DQ29**	B12	**DQS3**	E11
ADS#	P24	**DQ30**	A11	**DQS4**	B4
ALE	P26	**DQ31**	D10	**DQS5**	F2
BE0#	L23	**DQ32**	D6	**DQS6**	J1
BE1#	G23	**DQ33**	A5	**DQS7**	N5

Table 10. 544-Lead PBGA Package - Alphabetical Signal Listing (Sheet 2 of 5)

Signal	Ball	Signal	Ball	Signal	Ball
DQS8	B8	**P_AD14**	AE5	**P_AD52**	AC15
FWE#	P22	**P_AD15**	AD4	**P_AD53**	AE15
GPIO0	Y26	**P_AD16**	AB4	**P_AD54**	AB14
GPIO1	Y24	**P_AD17**	AC1	**P_AD55**	AF14
GPIO2	Y23	**P_AD18**	AB3	**P_AD56**	AC14
GPIO3	Y22	**P_AD19**	AB1	**P_AD57**	AD14
GPIO4	W26	**P_AD20**	AA5	**P_AD58**	AC13
GPIO5	W25	**P_AD21**	AB2	**P_AD59**	AF13
GPIO6	W24	**P_AD22**	AA4	**P_AD60**	AD13
GPIO7	W23	**P_AD23**	AA1	**P_AD61**	AE13
HOLD	T24	**P_AD24**	Y3	**P_AD62**	AB12
HOLDA	T23	**P_AD25**	Y1	**P_AD63**	AF12
HPI#	AB23	**P_AD26**	W5	**P_CBE0#**	AC6
M_CK0	R5	**P_AD27**	W3	**P_CBE1#**	AF4
M_CK0#	R4	**P_AD28**	W4	**P_CBE2#**	AD1
M_CK1	R1	**P_AD29**	W1	**P_CBE3#**	Y2
M_CK1#	T1	**P_AD30**	V4	**P_CBE4#**	AC12
M_CK2	P3	**P_AD31**	V1	**P_CBE5#**	AD11
M_CK2#	P2	**P_AD32**	AB20	**P_CBE6#**	AF11
M_RST#	D21	**P_AD33**	AF20	**P_CBE7#**	AB10
NC0	V23	**P_AD34**	AC20	**P_CLK**	AC7
NC1	AD23	**P_AD35**	AD20	**P_DEVSEL#**	AF1
NC2	AE23	**P_AD36**	AC19	**P_FRAME#**	AC3
P_ACK64#	AE11	**P_AD37**	AF19	**P_GNT#**	V2
P_AD0	AC9	**P_AD38**	AD19	**P_IDSEL**	Y4
P_AD1	AF10	**P_AD39**	AE19	**P_INTA#**	T3
P_AD2	AC8	**P_AD40**	AB18	**P_INTB#**	T2
P_AD3	AD10	**P_AD41**	AF18	**P_INTC#**	U4
P_AD4	AB8	**P_AD42**	AC18	**P_INTD#**	U1
P_AD5	AF9	**P_AD43**	AF17	**P_IRDY#**	AE1
P_AD6	AD7	**P_AD44**	AC17	**P_M66EN**	AD8
P_AD7	AE9	**P_AD45**	AE17	**P_PAR**	AE3
P_AD8	AF8	**P_AD46**	AD17	**P_PAR64**	AC11
P_AD9	AB6	**P_AD47**	AF16	**P_PERR#**	AF2
P_AD10	AF7	**P_AD48**	AB16	**P_REQ#**	U3
P_AD11	AD5	**P_AD49**	AD16	**P_REQ64#**	AC10
P_AD12	AF6	**P_AD50**	AC16	**P_RST#**	U5
P_AD13	AC5	**P_AD51**	AF15	**P_SERR#**	AF3

Table 10. 544-Lead PBGA Package - Alphabetical Signal Listing (Sheet 3 of 5)

Signal	Ball	Signal	Ball	Signal	Ball
P_STOP#	AD2	**SCB4**	E9	V_{CC13}	J20
P_TRDY#	AC4	**SCB5**	D9	**V_{CC13}**	K7
PB_CLK	T26	**SCB6**	E7	**V_{CC13}**	K20
PB_RST#	T22	**SCB7**	C7	**V_{CC13}**	U7
PCE0#	V22	**SCKE0**	A18	**V_{CC13}**	U20
PCE1#	V26	**SCKE1**	B18	**V_{CC13}**	V7
PCE2#	U26	**SCE0#**	L5	**V_{CC13}**	W7
PCE3#	U25	**SCE1#**	L4	**V_{CC13}**	W20
PCE4#	U24	**SDQM0**	C22	**V_{CC13}**	Y7
PCE5#	U23	**SDQM1**	C19	**V_{CC13}**	Y8
POR#	AF21	**SDQM2**	D15	**V_{CC13}**	Y9
PWRDELAY	AF23	**SDQM3**	A12	**V_{CC13}**	Y10
SRAS#	D1	**SDQM4**	C4	**V_{CC13}**	Y17
RCOMP	T4	**SDQM5**	F1	**V_{CC13}**	Y19
RCVENI#	D7	**SDQM6**	K3	**V_{CC13}**	Y20
RCVENO#	B6	**SDQM7**	N4	**V_{CC13}**	M21
RDYRCV#	R23	**SDQM8**	A8	**V_{CC13}**	P21
RXD	AA25	**SFRM**	AA23	**V_{CC13}**	T21
SA0	B1	**SSCKI**	AB24	**V_{CC13}**	V20
SA1	A1	**SSCKO**	AB26	**V_{CC13}**	Y18
SA2	A10	**TCK**	AD22	**V_{CC13}**	AA12
SA3	B10	**TDI**	AE21	**V_{CC13}**	AA14
SA4	C10	**TDO**	AC21	**V_{CC13}**	AA16
SA5	E13	**TMS**	AF22	**V_{CC25}**	C3
SA6	D13	**TRST#**	AC22	**V_{CC25}**	C6
SA7	B14	**TXD**	AA26	**V_{CC25}**	C9
SA8	A14	**V_{CC25}**	F20	**V_{CC25}**	C12
SA9	C17	**V_{CC13}**	G7	**V_{CC25}**	C15
SA10	C1	**V_{CC13}**	G8	**V_{CC25}**	C18
SA11	D17	**V_{CC13}**	G9	**V_{CC25}**	C21
SA12	E17	**V_{CC13}**	G10	**V_{CC25}**	C24
SBA0	D2	**V_{CC13}**	G17	**V_{CC25}**	E5
SBA1	D3	**V_{CC13}**	G18	**V_{CC25}**	F3
SCAS#	H3	**V_{CC13}**	G19	**V_{CC25}**	F6
SCB0	A9	**V_{CC13}**	G20	**V_{CC25}**	F7
SCB1	C8	**V_{CC13}**	H7	**V_{CC25}**	F8
SCB2	D8	**V_{CC13}**	H20	**V_{CC25}**	F9
SCB3	A7	**V_{CC13}**	J7	**V_{CC25}**	F10

Table 10. 544-Lead PBGA Package - Alphabetical Signal Listing (Sheet 4 of 5)

Signal	Ball	Signal	Ball	Signal	Ball
V_{CC25}	F11	V_{CC33}	AA21	V_{SS}	B3
V_{CC25}	F12	V_{CC33}	AA24	V_{SS}	B5
V_{CC25}	F13	V_{CC33}	AB22	V_{SS}	B7
V_{CC25}	F14	V_{CC33}	AD24	V_{SS}	B9
V_{CC25}	F15	V_{CC33}	AA3	V_{SS}	B11
V_{CC25}	F16	V_{CC33}	AA6	V_{SS}	B13
V_{CC25}	F17	V_{CC33}	AA7	V_{SS}	B15
V_{CC25}	F18	V_{CC33}	AA8	V_{SS}	B17
V_{CC25}	F19	V_{CC33}	AA9	V_{SS}	B19
V_{CC25}	F21	V_{CC33}	AA10	V_{SS}	B21
V_{CC25}	G6	V_{CC33}	AA11	V_{SS}	B23
V_{CC25}	H6	V_{CC33}	AA13	V_{SS}	B25
V_{CC25}	J3	V_{CC33}	AA15	V_{SS}	C2
V_{CC25}	J6	V_{CC33}	AA17	V_{SS}	D25
V_{CC25}	K6	V_{CC33}	AA18	V_{SS}	D4
V_{CC25}	L6	V_{CC33}	AA19	V_{SS}	E2
V_{CC25}	M3	V_{CC33}	AA20	V_{SS}	E6
V_{CC25}	M6	V_{CC33}	AD3	V_{SS}	E8
V_{CC25}	N6	V_{CC33}	AD6	V_{SS}	E10
V_{CC25}	P6	V_{CC33}	AD9	V_{SS}	E12
V_{CC25}	R3	V_{CC33}	AD12	V_{SS}	E14
V_{CC25}	R6	V_{CC33}	AD15	V_{SS}	E16
V_{CC33}	F24	V_{CC33}	AD18	V_{SS}	E18
V_{CC33}	G21	V_{CC33}	AD21	V_{SS}	E20
V_{CC33}	H21	V_{CC33}	AE25	V_{SS}	E22
V_{CC33}	J21	V_{CC33}	AE26	V_{SS}	F5
V_{CC33}	J24	V_{CC33}	AF24	V_{SS}	F25
V_{CC33}	K21	V_{CC33}	AF25	V_{SS}	G2
V_{CC33}	L21	V_{CC33}	AF26	V_{SS}	G22
V_{CC33}	M24	V_{CC33}	T6	V_{SS}	H5
V_{CC33}	N21	V_{CC33}	U6	V_{SS}	H25
V_{CC33}	R21	V_{CC33}	V3	V_{SS}	J2
V_{CC33}	R24	V_{CC33}	V6	V_{SS}	J22
V_{CC33}	U21	V_{CC33}	W6	V_{SS}	K5
V_{CC33}	V21	V_{CC33}	Y6	V_{SS}	K25
V_{CC33}	V24	V_{CCPLL1}	AF5	V_{SS}	L2
V_{CC33}	W21	V_{CCPLL2}	AE7	V_{SS}	L11
V_{CC33}	Y21	V_{REF}	A6	V_{SS}	L12

Table 10. 544-Lead PBGA Package - Alphabetical Signal Listing (Sheet 5 of 5)

Signal	Ball	Signal	Ball	Signal	Ball
V_{SS}	L13	V_{SS}	R11	**V_{SS}**	AB15
V_{SS}	L14	**V_{SS}**	R12	**V_{SS}**	AB17
V_{SS}	L15	**V_{SS}**	R13	**V_{SS}**	AB19
V_{SS}	L16	**V_{SS}**	R14	**V_{SS}**	AB21
V_{SS}	L22	**V_{SS}**	R15	**V_{SS}**	AB25
V_{SS}	M5	**V_{SS}**	R16	**V_{SS}**	AC2
V_{SS}	M11	**V_{SS}**	R22	**V_{SS}**	AC23
V_{SS}	M12	**V_{SS}**	T5	**V_{SS}**	AD25
V_{SS}	M13	**V_{SS}**	T11	**V_{SS}**	AE2
V_{SS}	M14	**V_{SS}**	T12	**V_{SS}**	AE4
V_{SS}	M15	**V_{SS}**	T13	**V_{SS}**	AE6
V_{SS}	M16	**V_{SS}**	T14	**V_{SS}**	AE8
V_{SS}	M25	**V_{SS}**	T15	**V_{SS}**	AE10
V_{SS}	N2	**V_{SS}**	T16	**V_{SS}**	AE12
V_{SS}	N11	**V_{SS}**	T25	**V_{SS}**	AE14
V_{SS}	N12	**V_{SS}**	U2	**V_{SS}**	AE16
V_{SS}	N13	**V_{SS}**	U22	**V_{SS}**	AE18
V_{SS}	N14	**V_{SS}**	V5	**V_{SS}**	AE20
V_{SS}	N15	**V_{SS}**	V25	**V_{SS}**	AE22
V_{SS}	N16	**V_{SS}**	W2	**V_{SS}**	AE24
V_{SS}	N22	**V_{SS}**	W22	**SWE#**	H4
V_{SS}	P5	**V_{SS}**	Y5	**WIDTH00**	K22
V_{SS}	P11	**V_{SS}**	Y25	**WIDTH01**	H22
V_{SS}	P12	**V_{SS}**	AA2	**W/R#**	P23
V_{SS}	P13	**V_{SS}**	AA22	**XINT0#**	AD26
V_{SS}	P14	**V_{SS}**	AB5	**XINT1#**	AC26
V_{SS}	P15	**V_{SS}**	AB7	**XINT2#**	AC25
V_{SS}	P16	**V_{SS}**	AB9	**XINT3#**	AC24
V_{SS}	P25	**V_{SS}**	AB11		
V_{SS}	R2	**V_{SS}**	AB13		

3.2 Package Thermal Specifications

The device is specified for operation when T_C (case temperature) is within the range of 0°C to 105°C, depending on operating conditions. Refer to the "Thermal Data for the 544-lead PBGA package" application note for more information regarding maximum case temperatures on the 544-lead PBGA package. Case temperature may be measured in any environment to determine whether the processor is within specified operating range. Measure the case temperature at the center of the top surface, opposite the ballpad.

3.2.1 Thermal Specifications

This section defines the terms used for thermal analysis.

3.2.1.1 Ambient Temperature

Ambient temperature, T_A, is the temperature of the ambient air surrounding the package. In a system environment, ambient temperature is the temperature of the air upstream from the package.

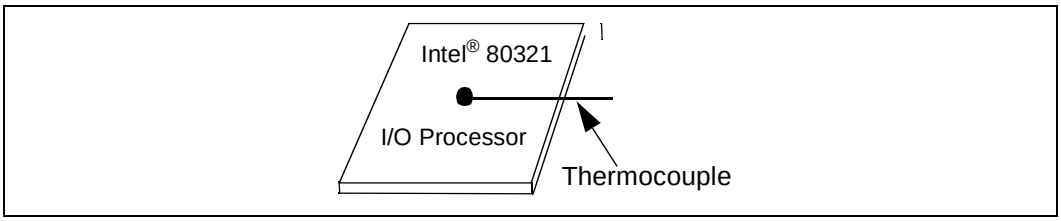
3.2.1.2 Case Temperature

When measuring case temperature, attention to detail is required to ensure accuracy. When a thermocouple is used, calibrate it before taking measurements. Errors may result when the measured surface temperature is affected by the surrounding ambient air temperature. Such errors may be due to a poor thermal contact between thermocouple junction and the surface, heat loss by radiation, or conduction through thermocouple leads.

To minimize measurement errors:

- Use a 35 gauge K-type thermocouple or equivalent.
- Attach the thermocouple bead or junction to the package top surface at a location corresponding to the center of the die (Figure 6). The center of the die gives a more accurate measurement and less variation as the boundary condition changes.
- Attach the thermocouple bead at a 0° angle with respect to the package as shown in Figure 6, when no heatsink is attached.

Figure 6. Thermocouple Attachment - No Heatsink



3.2.1.3 Thermal Resistance

The thermal resistance value for the case-to-ambient, θ_{CA}, is used as a measure of the cooling solution's thermal performance.

3.2.2 Thermal Analysis

Table 11 lists the case-to-ambient thermal resistances of the 80321 for different air flow rates with and without a heat sink.

To calculate T_A, the maximum ambient temperature to conform to a particular case temperature:

$$T_A = T_C - P\ (\theta_{CA})$$

Compute P by multiplying I_{CC} and V_{CC}. Values for θ_{JC} and θ_{CA} are given in Table 11.

Junction temperature (T_J) is commonly used in reliability calculations. T_J can be calculated from θ_{JC} (thermal resistance from junction to case) using the following equation:

$$T_J = T_C + P\ (\theta_{JC})$$

Similarly, when T_A is known, the corresponding case temperature (T_C) can be calculated as follows:

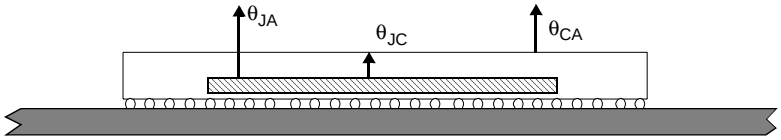
$$T_C = T_A + P\ (\theta_{CA})$$

The θ_{JA} (Junction to Ambient) for this package is currently estimated at 16.87° C/Watt with no airflow and no heatsink.

$$\theta_{JA} = \theta_{JC} + \theta_{CA}$$

Table 11. 544-Lead PBGA Package Thermal Characteristics

Thermal Resistance — °C/Watt								
Parameter	**Airflow — ft/min (m/sec)**							
	0 (0)	50 (0.25)	100 (0.50)	200 (1.01)	300 (1.52)	400 (2.03)	600 (3.04)	800 (4.06)
θ_{JC} (Junction-to-Case)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
θ_{CA} (Case-to-Ambient) Without Heatsink	15.87	14.72	13.99	12.94	12.20	11.73	10.90	10.39



NOTES:
1. This table applies to a H-PBGA device soldered directly onto a board.
2. Estimated value.

3.3 Socket Information

Table 12 and Table 13 provide vendor details for socket-headers and burn-in sockets for the 80321. This is neither an endorsement nor a warranty of the performance of any of the listed products and/or companies.

3.3.1 Socket-Header Vendor

Table 12. Socket-Header Vendor

Company	Factory Representative	Phone/Fax #	Part #	
			BGA 544-Pin Header	BGA 544-Pin Socket Carrier
Adapter Technologies 214-218 South 4th Street Perkasie, PA 18944	John Miller	215 258-5750 215 258-5760	TBD	TBD

3.3.2 Burn-in Socket Vendor

Table 13. Burn-in Socket Vendor

Company	Factory Representative	Phone #	Burn-in Socket Part #
Yamaichi 2235 Zanker Road San Jose, CA 95131	Steve Drake	TBD	NP276-67613. AC-14847

3.3.3 Shipping Tray Vendor

Table 14. Shipping Tray Vendor

Company	Factory Representative	Phone #	Shipping Tray Part #
Daewon Semiconductor	Sunna Chung	82.31.794.2001	127-3535-919, Rev. D

3.3.4 Logic Analyzer Interposer Vendor

Table 15. Logic Analyzer Interposer Vendor

Company	Factory Representative	Phone/Fax #	Part #
Delphi Connection Systems 17150 Von Kaman Avenue Irvine, CA 92614-0968	Bob Betz	949 660-6968 949 660-5825	TBD

3.3.5 JTAG Emulator Vendor

Table 16. JTAG Emulator Vendor

Company	Part #
ARM, Ltd. www.arm.com	Multi-ICE Interface Unit ARM KP1-0019A
WindRiver HSI www.windriver.com	visionPROBE/visionICE for Intel® XScale™ microarchitecture

4.0 Electrical Specifications

4.1 Absolute Maximum Ratings

Parameter	Maximum Rating
Storage Temperature	–55°C to +125°C
Case Temperature Under Bias	0°C to +105°C
Supply Voltage V_{CC33} wrt. V_{SS}	–0.5V to +4.1V
Supply Voltage V_{CC25} wrt. V_{SS}	–0.5V to +3.6V
Supply Voltage V_{CC13} wrt. V_{SS}	–0.5V to +2.1V
Voltage on Any Ball wrt. V_{SS}	–0.5V to V_{CCP} + 0.5V

NOTICE: This data sheet contains information on products in the design phase of development. Do not finalize a design with this information. Revised information will be published when the product becomes available. The specifications are subject to change without notice. Contact your local Intel representative before finalizing a design.

†**WARNING:** *Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.*

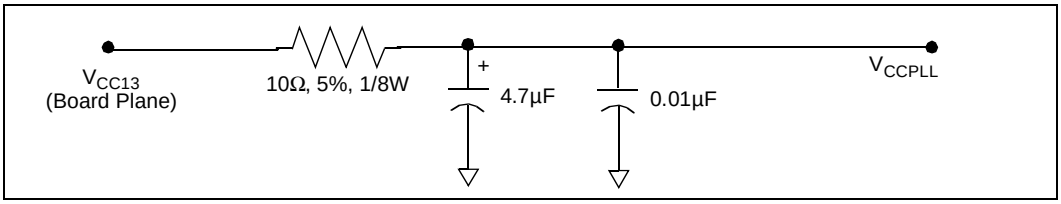
Table 17. Operating Conditions

Symbol	Parameter	Min	Max	Units	Notes
V_{CC33}	3.3V PCI Supply Voltage	3.0	3.6	V	
V_{CC25}	2.5V DDR Supply Voltage	2.3	2.7	V	
V_{CC13}	1.3V CORE Supply Voltage	1.235	1.365	V	
V_{CCPLL1}	PLL Supply Voltage	V_{CC13}	V_{CC13}	V	
V_{CCPLL2}	PLL Supply Voltage	V_{CC13}	V_{CC13}	V	
V_{REF}	Memory I/O Reference Voltage	V_{CC25} /2 - 0.05	V_{CC25} /2 + 0.05	V	
F_{P_CLK}	Input Clock Frequency	16	133	MHz	
T_C	Case Temperature Under Bias	0	105	°C	

4.2 V_{CCPLL} Pin Requirements

To reduce clock skew, the V_{CCPLL1}, V_{CCPLL2}, V_{SSPLL1} and V_{SSPLL2} balls for the Phase Lock Loop (PLL) circuit are isolated on the package. The lowpass filter, as shown in Figure 7, reduces noise induced clock jitter and its effects on timing relationships in system designs. The 4.7 µF capacitor must be (low ESR solid tantalum), the 0.01 µF capacitor must be of the type X7R and the node connecting V_{CCPLL} must be as short as possible. The VSSPLL balls should be connected to the board ground plane.

Figure 7. V_{CCPLL} Lowpass Filter



4.3 Targeted DC Specifications

Table 18. DC Characteristics

Symbol	Parameter	Min	Max	Units	Notes
V_{IL1}	Input Low Voltage (SDRAM)	-0.3	V_{REF} - 0.15	V	(3,5)
V_{IH1}	Input High Voltage (SDRAM)	V_{REF} + 0.15	V_{CC25} + 0.3	V	(3,5)
V_{IL2}	Input Low Voltage (Misc.)	-0.3	0.8	V	(4)
V_{IH2}	Input High Voltage (Misc.)	2.0	V_{CC33} + 0.3	V	(4)
V_{IL3}	Input Low Voltage (PCI-X)	-0.5	0.35 V_{CC33}	V	(1)
V_{IH3}	Input High Voltage (PCI-X/PCI)	0.5 V_{CC33}	V_{CC33} + 0.5	V	(1)
V_{IL4}	Input Low Voltage (PCI)	-0.5	0.3 V_{CC33}	V	(1)
V_{OL1}	Output Low Voltage (Misc.)		0.4	V	I_{OL} = 6 mA (4)
V_{OH1}	Output High Voltage (Misc.)	2.4		V	I_{OH} = -2 mA (4)
V_{OL2}	Output Low Voltage (SDRAM)		0.35	V	I_{OL} = 15.2 mA (3,5)
V_{OH2}	Output High Voltage (SDRAM)	1.95		V	I_{OH} = -15.2 mA (3,5)
V_{OL3}	Output Low Voltage (PCI-X)		0.1 V_{CC33}	V	I_{OL} = 1500 µA(1)
V_{OH3}	Output HIGH Voltage (PCI-X)	0.9 V_{CC33}		V	I_{OH} = -500 µA(1)
C_{IN}	Input pin Capacitance		8	pF	(1, 2)
C_{CLK}	Clock pin Capacitance	5	8	pF	(1, 2)
L_{PIN}	Ball Inductance		15	nH	(1,2)

NOTES:
1. As required by the *PCI-X Addendum to the PCI Local Bus Specification,* Revision 1.0a.
2. Not tested.
3. SDRAM signals include **MA[12:0]**, **BA[1:0]**, **CAS#**, **CS[1:0]#**, **CKE[1:0]**, **DM[8:0]**, **RAS#**, **WE#**, **RCVENI#**, **RCVENO#**, **M_CK[2:0]**, **M_CK[2:0]#**, **DQ[63:0]**, **DQS[8:0]** and **CB[7:0]**.
4. Miscellaneous signals include all signals that are not PCI or SDRAM signals.
5. Only 2.5V DDR SDRAM is supported.

Table 19. I_{CC} Characteristics

Symbol	Parameter	Typ	Max	Units	Notes
I_{LI1}	Input Leakage Current for each signal except **TCK**, **TMS**, **TRST#**, **TDI**		± 2	µA	$0 \le V_{IN} \le V_{CC}$ (5)
I_{LI2}	Input Leakage Current for **TCK**, **TMS**, **TRST#**, **TDI**	-140	-250	µA	V_{IN} = 0.45 V (1,5)
I_{CC33} Active (Power Supply)	Power Supply Current		0.6	A	(1,2)
I_{CC25} Active (Power Supply)	Power Supply Current		0.5	A	(1,2)
I_{CC13} Active (Power Supply)	Power Supply Current		1.3	A	(1,2)
I_{CC33} Active (Thermal)	Thermal Current	TBD	TBD	A	(1,3)
I_{CC25} Active (Thermal)	Thermal Current	TBD	TBD	A	(1,3)
I_{CC13} Active (Thermal)	Thermal Current	TBD	TBD	A	(1,3)
I_{CC33} Active (Power Modes)	Reset Mode Hi-Z Mode		TBD TBD	A	(4) (4)
I_{CC25} Active (Power Modes)	Reset Mode Hi-Z Mode		TBD TBD	A	(4) (4)
I_{CC13} Active (Power Modes)	Reset Mode Hi-Z Mode		TBD TBD	A	(4) (4)

NOTES:
1. Measured with device operating and outputs loaded to the test condition in Figure 14.
2. I_{CC} Active (Power Supply) value is provided for selecting your system's power supply. It is measured using one of the worst case instruction mixes with $\mathbf{V_{CC33}}$ = 3.6V, $\mathbf{V_{CC25}}$ = 2.7V, $\mathbf{V_{CC13}}$ = 1.365V and ambient temperature = 55 ° C.
3. I_{CC} Active (Thermal) value is provided for your system's thermal management. Typical I_{CC} is measured with $\mathbf{V_{CC33}}$ = 3.3V, $\mathbf{V_{CC25}}$ = 2.5V, $\mathbf{V_{CC13}}$ = 1.3V and ambient temperature = 55 ° C.
4. I_{CC} Test (Power modes) refers to the I_{CC} values that are tested when the device is in Reset mode or ONCE mode with $\mathbf{V_{CC33}}$ = 3.6V, $\mathbf{V_{CC25}}$ = 2.7V, $\mathbf{V_{CC13}}$ = 1.4Vand ambient temperature = 55 ° C.
5. Input leakage currents include hi-Z output leakage for all bi-directional buffers with tri-state outputs.

4.4 Targeted AC Specifications

4.4.1 Clock Signal Timings

Table 20. Clock Timings

Symbol	Parameter	PCI-X 133		PCI-X 100		PCI-X 66		PCI 66		PCI 33		Units	Notes
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max		
T_{F1}	PCI clock Frequency	100	133	66	100	50	66	33	66	16	33	MHz	1
T_{C1}	PCI clock Cycle Time	7.5	10	10	15	15	20	15	30	30	60	ns	1, 3
T_{CH1}	PCI clock High Time	3		3		6		6		11		ns	
T_{CL1}	PCI clock Low Time	3		3		6		6		11		ns	
T_{SR1}	PCI clock Slew Rate	1.5	4	1.5	4	1.5	4	1.5	4	1	4	V/ns	2
Spread Spectrum Requirements													
f_{mod}	PCI clock modulation frequency	30	33	30	33	30	33	30	33			KHz	
f_{spread}	PCI clock frequency spread	-1	0	-1	0	-1	0	-1	0			%	

Symbol	Parameter	PC200		Units	Notes
		Min	Max		
T_{F2}	DDR SDRAM clock Frequency		100	MHz	
T_{C2}	DDR SDRAM clock Cycle Time	10		ns	
T_{CH2}	DDR SDRAM clock High Time	4.5	5.5	ns	
T_{CL2}	DDR SDRAM clock Low Time	4.5	5.5	ns	
T_{CS2}	DDR SDRAM clock Period Stability		±90	ps	
T_{skew2}	DDR SDRAM clock skew for **M_CK[2:0]** and **M_CK[2:0]#**		200	ps	

Symbol	Parameter	PBI 100		PBI 66		PBI 33		Units	Notes
		Min	Max	Min	Max	Min	Max		
T_{F3}	PBI clock Frequency		100		66		33	MHz	
T_{C3}	PBI clock Cycle Time	10		15		30		ns	
T_{CH3}	PBI clock High Time	3		6		11		ns	
T_{CL3}	PBI clock Low Time	3		6		11		ns	
T_{CS3}	PBI clock Period Stability		±90		±90		±90	ps	

NOTES:
1. The clock frequency may not change beyond the spread-spectrum limits except while **P_RST#** is asserted.
2. This slew rate must be met across the minimum peak-to-peak portion of the clock waveform.
3. The minimum clock period must not be violated for any single clock cycle, i.e., accounting for all system jitter.

4.4.2 PCI Interface Signal Timings

Table 21. PCI Signal Timings

Symbol	Parameter	PCI-X 133 PCI-X 100		PCI-X 66		PCI 66		PCI 33		Units	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
T_{OV1}	Clock to Output Valid Delay for bused signals	0.7	3.8	0.7	3.8	1	6	2	11	ns	1, 2, 3
T_{OV2}	Clock to Output Valid Delay for point to point signals	0.7	3.8	0.7	3.8	2	6	2	12	ns	1, 2, 3
T_{OF}	Clock to Output Float Delay		7		7		14		28	ns	1, 7
T_{IS1}	Input Setup to clock for bused signals	1.2		1.7		3		7		ns	3, 4, 8
T_{IS2}	Input Setup to clock for point to point signals	1.2		1.7		5		10, 12		ns	3, 4
T_{IH1}	Input Hold time from clock	0.5		0.5		0		0		ns	4
T_{RST}	Reset Active Time	1		1		1		1		ms	
T_{RF}	Reset Active to output float delay		40		40		40		40	ns	5, 6
T_{IS3}	REQ64# to Reset setup time	10		10		10		10		clocks	
T_{IH2}	Reset to REQ64# hold time	0	50	0	50	0	50	0	50	ns	
T_{IS4}	PCI-X initialization pattern to Reset setup time	10		10						clocks	
T_{IH3}	Reset to PCI-X initialization pattern hold time	0	50	0	50					ns	

NOTES:
1. See the timing measurement conditions in Figure 9 “Output Timing Measurement Waveforms” on page 51.
2. See Figure 15 “PCI/PCI-X TOV(max) Rising Edge AC Test Load” on page 55, Figure 16 “PCI/PCI-X TOV(max) Falling Edge AC Test Load” on page 55 and Figure 17 “PCI/PCI-X TOV(min) AC Test Load” on page 56.
3. Setup time for point-to-point signals applies to REQ# and GNT# only. All other signals are bused.
4. See the timing measurement conditions in Figure 10 “Input Timing Measurement Waveforms” on page 52.
5. RST# is asserted and deasserted asynchronously with respect to CLK.
6. All output drivers must be floated when RST# is active.
7. For purposes of Active/Float timing measurements, the HI-Z or “off” state is defined to be when the total current delivered through the component pin is less than or equal to the leakage current specification.
8. Setup time applies only when the device is not driving the pin. Devices cannot drive and receive signals at the same time.

4.4.3 DDR SDRAM Interface Signal Timings

Table 22. DDR SDRAM Signal Timings

Symbol	Parameter	Min	Max	Units	Notes
T_{VB1}	DQ, CB and DM output valid time before associated DQS	1.3		ns	4
T_{VA1}	DQ, CB and DM output valid time after associated DQS	1.3		ns	4
T_{VB2}	DQS output valid time before CK		1.4	ns	4
T_{VA2}	DQS output valid time after CK		1.0	ns	4
T_{VB3}	Address and Control write output valid before CK	4.2		ns	4
T_{VA3}	Address and Control write output valid after CK	3.5		ns	4
T_{VB4}	DQS read input valid time before DQ		1.6	ns	5
T_{VA4}	DQS read input valid time after DQ		1.6	ns	5
T_{VB5}	RCVENO# output valid time before CK		1.4	ns	5
T_{VA5}	RCVENO# output valid time after CK		1.0	ns	5
T_{VB6}	RCVENI# input valid time before DQS	3.0		ns	5

NOTES:
1. See Figure 9 “Output Timing Measurement Waveforms” on page 51.
2. See Figure 10 “Input Timing Measurement Waveforms” on page 52.
3. These output valid times are specified with a 0 pF loading.
4. See Figure 12 “DDR SDRAM Write Timings” on page 53.
5. See Figure 13 “DDR SDRAM Read Timings” on page 54.

4.4.4 Peripheral Bus Interface Signal Timings

Table 23. Peripheral Bus Signal Timings

Sym	Parameter	Min	Max	Units	Notes
T_{OV1}	Output Valid Delay from **PB_CLK**	1	5.5	ns	(1,3)
T_{OF}	Output Float Delay from **PB_CLK**	1	5.5	ns	(1,3)
T_{IS1}	Input Setup to **PB_CLK**	4.9		ns	(2)
T_{IH1}	Input Hold from **PB_CLK**	2		ns	(2)

NOTES:
1. See Figure 9 “Output Timing Measurement Waveforms” on page 51.
2. See Figure 10 “Input Timing Measurement Waveforms” on page 52.
3. See Figure 14 “AC Test Load for all Signals Except PCI and DDR SDRAM” on page 55.

4.4.5 I^2C Interface Signal Timings

Table 24. I^2C Signal Timings (Sheet 1 of 2)

Symbol	Parameter	Std. Mode		Fast Mode		Units	Notes
		Min	Max	Min	Max		
F_{SCL}	**SCL** Clock Frequency	0	100	0	400	KHz	
T_{BUF}	Bus Free Time Between STOP and START Condition	4.7		1.3		µs	(1)

NOTES:
1. See Figure 11 “I^2C Interface Signal Timings” on page 52.
2. Not tested.
3. After this period, the first clock pulse is generated.
4. C_b = the total capacitance of one bus line, in pF.

Table 24. I²C Signal Timings (Sheet 2 of 2)

Symbol	Parameter	Std. Mode		Fast Mode		Units	Notes
		Min	Max	Min	Max		
T_{HDSTA}	Hold Time (repeated) START Condition	4		0.6		µs	(1,3)
T_{LOW}	**SCL** Clock Low Time	4.7		1.3		µs	(1,2)
T_{HIGH}	**SCL** Clock High Time	4		0.6		µs	(1,2)
T_{SUSTA}	Setup Time for a Repeated START Condition	4.7		0.6		µs	(1)
T_{HDDAT}	Data Hold Time	0	3.45	0	0.9	µs	(1)
T_{SUDAT}	Data Setup Time	250		100		ns	(1)
T_{SR}	**SCL** and **SDA** Rise Time		1000	$20+0.1C_b$	300	ns	(1,4)
T_{SF}	**SCL** and **SDA** Fall Time		300	$20+0.1C_b$	300	ns	(1,4)
T_{SUSTO}	Setup Time for STOP Condition	4		0.6		µs	(1)

NOTES:
1. See Figure 11 "I²C Interface Signal Timings" on page 52.
2. Not tested.
3. After this period, the first clock pulse is generated.
4. C_b = the total capacitance of one bus line, in pF.

4.4.6 SSP Interface Signal Timings

Table 25. SSP Signal Timings

Symbol	Parameter	Min	Max	Units	Notes
T_{IS}	Input Setup to **SSCKO**	9		ns	
T_{IH}	Input Hold from **SSCKO**	0		ns	
T_{OV}	Output Valid Delay from **SSCKO**	-1	2	ns	
T_{OV}	Output Valid Delay from **SSCKI** to **SSCKO** in external clock mode.	3	10	ns	

4.4.7 Boundary Scan Test Signal Timings

Table 26. Boundary Scan Test Signal Timings

Symbol	Parameter	Min	Max	Units	Notes
T_{BSF}	**TCK** Frequency	0	66	MHz	
T_{BSCH}	**TCK** High Time	7.5		ns	Measured at 1.5 V (1)
T_{BSCL}	**TCK** Low Time	7.5		ns	Measured at 1.5 V (1)
T_{BSCR}	**TCK** Rise Time		5	ns	0.8 V to 2.0 V (1)
T_{BSCF}	**TCK** Fall Time		5	ns	2.0 V to 0.8 V (1)
T_{BSIS1}	Input Setup to **TCK**	3		ns	(4)
T_{BSIH1}	Input Hold from **TCK**	3		ns	(4)
T_{BSOV1}	**TDO** Output Valid Delay from falling edge of TCK.	1	11	ns	(2, 3)
T_{OF1}	**TDO** Output Float Delay from falling edge of TCK.	1	11	ns	(2, 5)

NOTES:
1. Not tested.
2. Outputs precharged to V_{CC5}.
3. See Figure 9 “Output Timing Measurement Waveforms” on page 51.
4. See Figure 10 “Input Timing Measurement Waveforms” on page 52.
5. A float condition occurs when the output current becomes less than ILO. Float delay is not tested. See Figure 9 “Output Timing Measurement Waveforms” on page 51.

4.5 AC Timing Waveforms

Figure 8. Clock Timing Measurement Waveforms

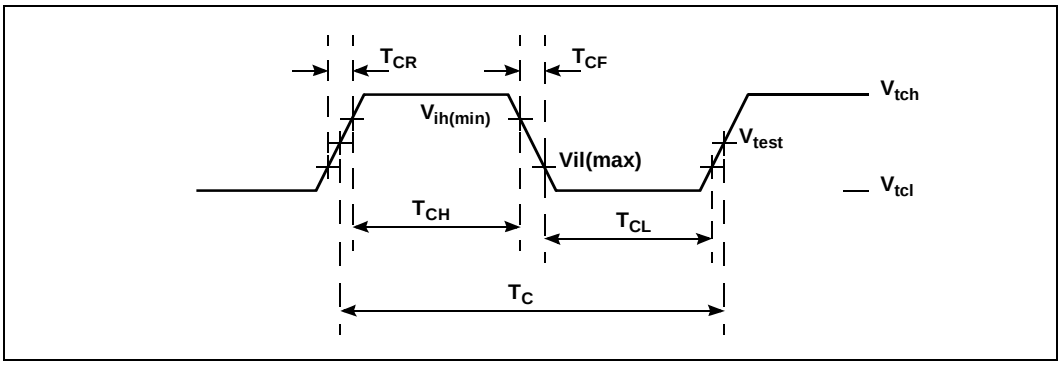


Figure 9. Output Timing Measurement Waveforms

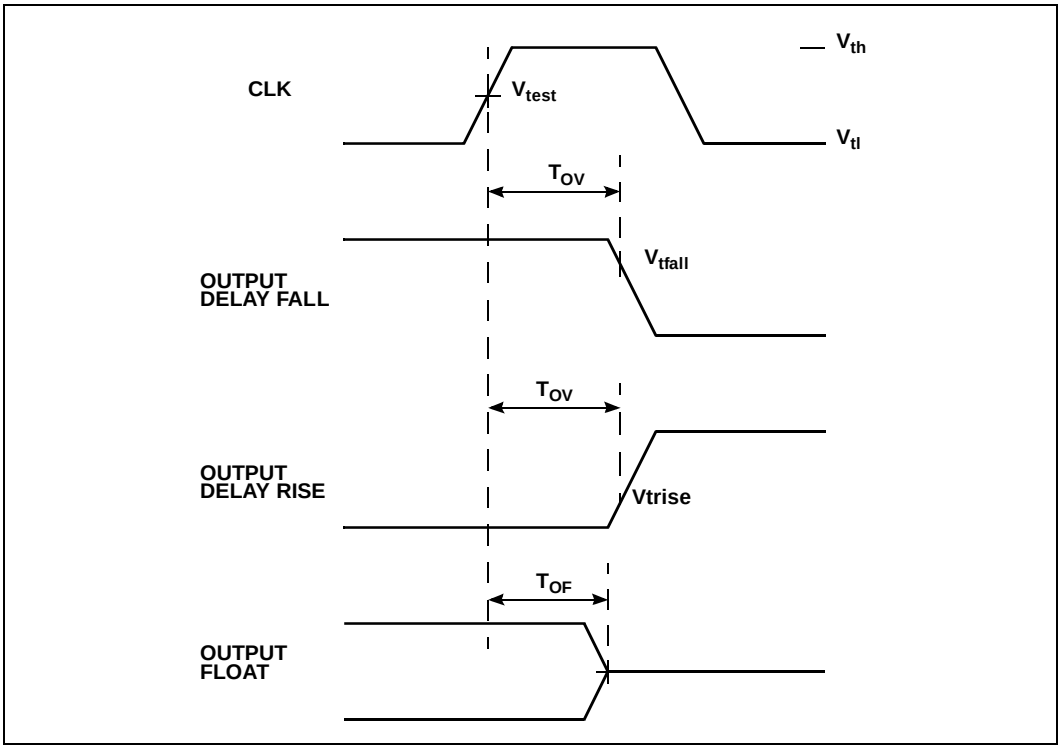


Figure 10. Input Timing Measurement Waveforms

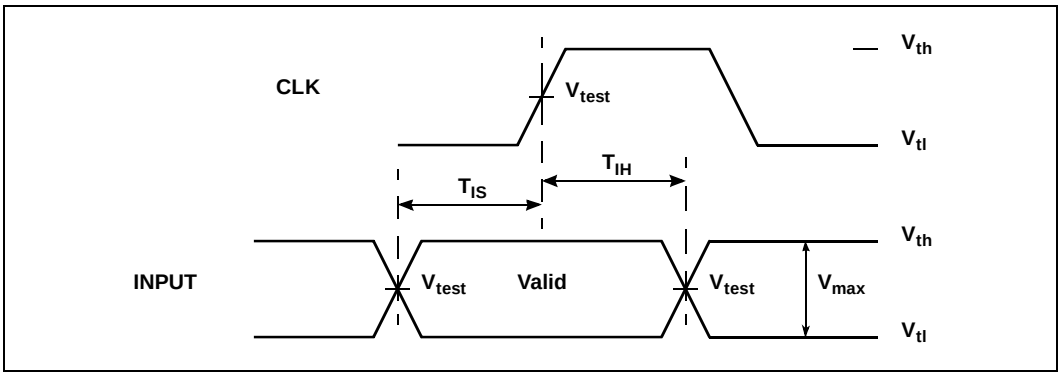


Figure 11. I²C Interface Signal Timings

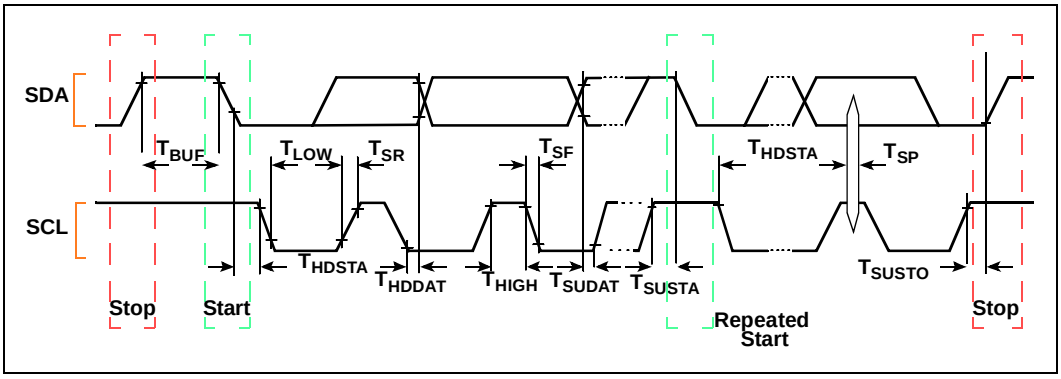


Figure 12. DDR SDRAM Write Timings

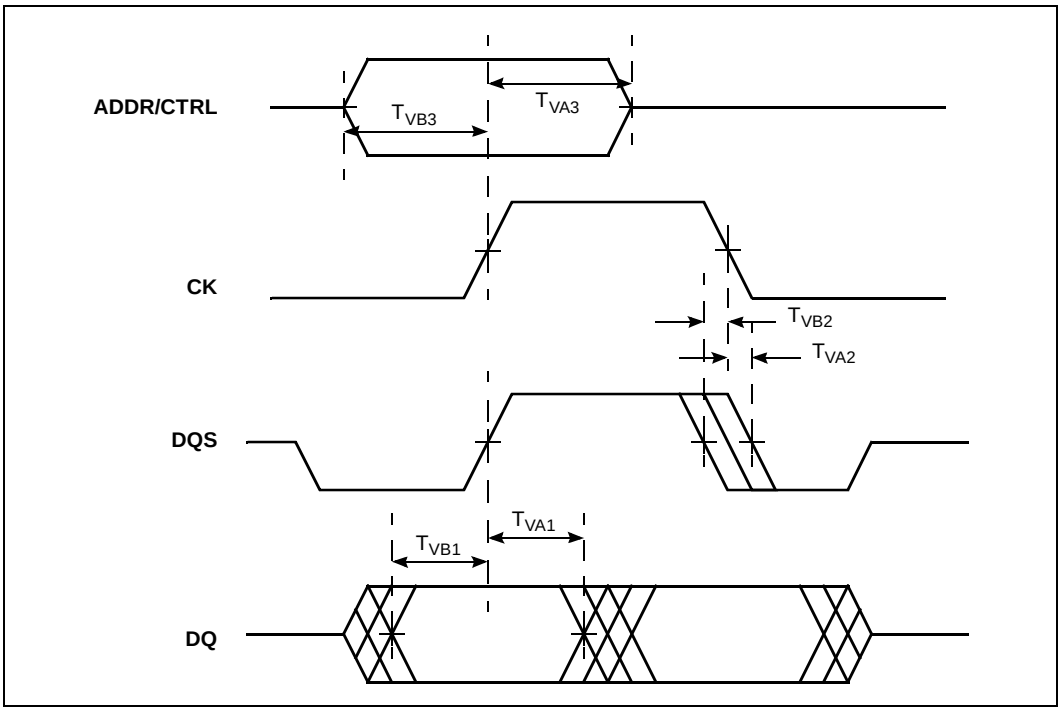
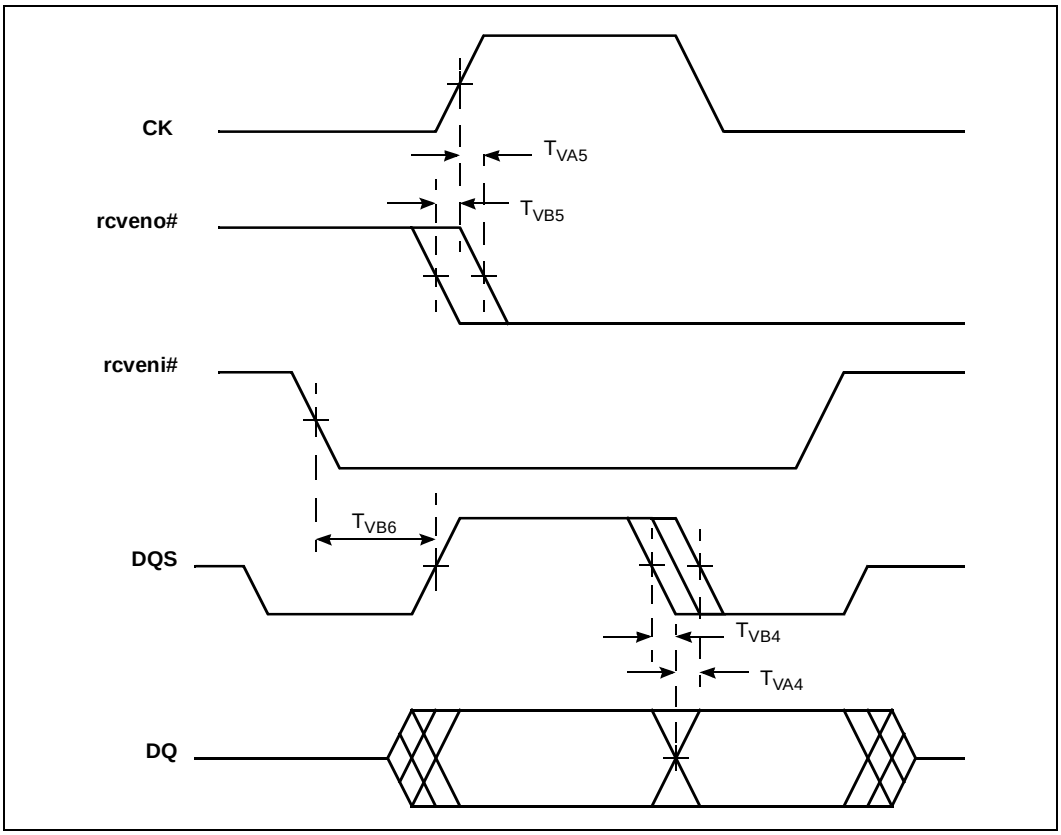


Figure 13. DDR SDRAM Read Timings



4.6 AC Test Conditions

Table 29. AC Measurement Conditions

Symbol	PCI-X	PCI	DDR	PBI	Units	Notes
V_{tch}	0.6 V_{CC33}	0.6 V_{CC33}	-	-	V	
V_{tcl}	0.2 V_{CC33}	0.2 V_{CC33}	-	-	V	
V_{th}	0.6 V_{CC33}	0.6 V_{CC33}	2.0	2.0	V	
V_{tl}	0.25 V_{CC33}	0.2 V_{CC33}	0.5	0.8	V	
V_{test}	0.4 V_{CC33}	0.4 V_{CC33}	1.25	1.5	V	
V_{trise}	0.285 V_{CC33}	0.285 V_{CC33}	1.25	1.5	V	
V_{tfall}	0.615 V_{CC33}	0.615 V_{CC33}	1.25	1.5	V	
V_{max}	0.4 V_{CC33}	0.4 V_{CC33}	1.5	1.2	V	
Slew Rate	1.5	1.5	1.5	1.5	V/nS	1

1. Input signal slew rate is measured between V_{il} and V_{ih}.

Figure 14. AC Test Load for all Signals Except PCI and DDR SDRAM

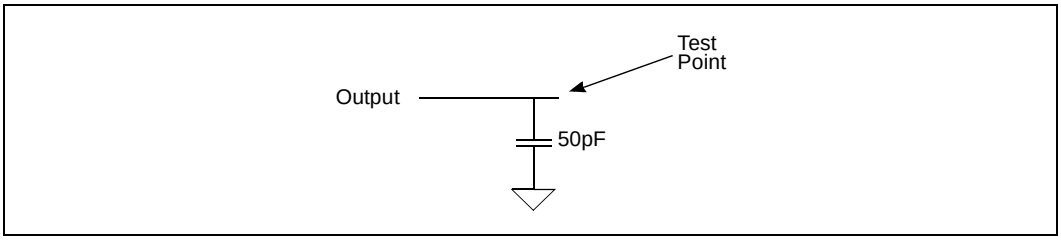


Figure 15. PCI/PCI-X $T_{OV(max)}$ Rising Edge AC Test Load

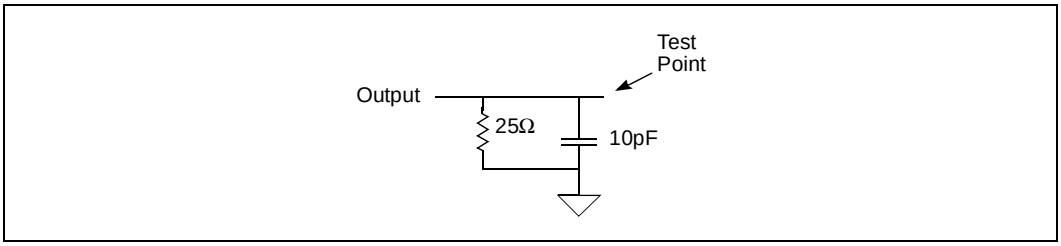


Figure 16. PCI/PCI-X $T_{OV(max)}$ Falling Edge AC Test Load

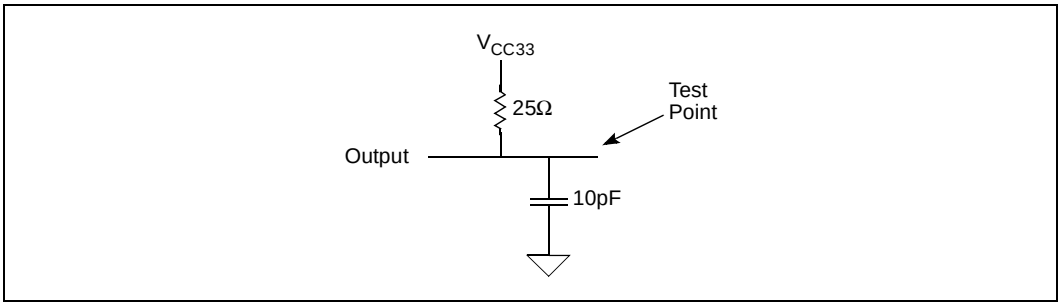


Figure 17. PCI/PCI-X $T_{OV(min)}$ AC Test Load