21555 Non-Transparent PCI-to-PCI Bridge

Datasheet

Product Features

- Full compliance with the *PCI local Bus Specification*, Revision 2.2, plus:
  - —PCI Power Management support
  - —Vital Product Data (VPD) support
  - —CompactPCI Distributed Hot-Swap support
- 3.3-V operation with 5.0-V tolerant I/O
- Selectable asynchronous or synchronous primary and secondary interface clocks
- Concurrent primary and secondary bus operation
- Fully compliant with the *Advanced Configuration Power Interface* (ACPI) specification
- Fully compliant with the *PCI Bus Power Management* specification
- Queuing of multiple transactions in either direction
- 256 bytes of posted write (data and address) buffering in each direction
- 256 bytes of read data buffering in each direction
- Four delayed transaction entries in each direction
- Two dedicated I2O delayed transaction entries
- Two sets of standard PCI Configuration registers corresponding to the primary and secondary interface; each set is accessible from either the primary or secondary interface
- Direct offset address translation for downstream memory and I/O transactions
- Hardware enable for secondary bus central functions
- IEEE Standard 1149.1 boundary-scan JTAG interface
- Four primary interface base address configuration registers for downstream forwarding, with size and prefetchability programmable for all four address ranges
- Three secondary interface address configuration registers specifying local address ranges for upstream forwarding, with size and prefetchability programmable for all three address ranges
- Inverse decoding above the 4 GB address boundary for upstream DACs
- Ability to generate Type 0 and Type 1 configuration commands on the primary or secondary interface via configuration or I/O CSR accesses
- Ability to generate I/O commands on the primary or secondary interface via I/O CSR accesses
- I2O message unit
- Doorbell registers for software generation of primary and secondary bus interrupts, 16 bits per interface
- Eight Dwords of scratchpad registers
- Generic own bit (can memory-map) semaphore
- Parallel flash ROM interface with primary bus expansion ROM base address register
- Serial ROM interface
- Secondary bus arbiter support for up to nine external devices at 33 MHz and up to four external devices at 66 MHz (in addition to the 21555)
- Secondary bus clock output for synchronous operation
- Four 32-bit base address configuration registers mapping the 21555 control and status registers (CSRs)
- Available in 33 MHz and 66 MHz versions

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1.0 Introduction

Intel's 21555 is a PCI peripheral device that performs PCI bridging functions for embedded and intelligent I/O applications. The 21555 has a 64-bit primary interface, a 64-bit secondary interface, and 66-MHz capability. The 21554 a related PCI peripheral device, has a 64-bit primary interface, a 64-bit secondary interface, and 33-MHz capability."

The 21555 is a "non-transparent" PCI-to-PCI bridge that acts as a gateway to an intelligent subsystem. It allows a local processor to independently configure and control the local subsystem. The 21555 implements an I2O message unit that enables any local processor to function as an intelligent I/O processor (IOP) in an I2O-capable system. Because the 21555 is architecture independent, it works with any host and local processors that support a PCI bus. This architecture independence enables vendors to leverage existing investments while moving products to PCI technology.

Unlike a transparent PCI-to-PCI bridge, the 21555 is specifically designed to bridge between two processor domains. The processor domain on the primary interface of the 21555 is also referred to as the host domain, and its processor is the host processor. The secondary bus interfaces to the local domain and the local processor. Special features include support of independent primary and secondary PCI clocks, independent primary and secondary address spaces, and address translation between the primary (host) and secondary (local) domains.

The 21555 enables add-in card vendors to present to the host system a higher level of abstraction than is possible with a transparent PCI-to-PCI bridge. The 21555 uses a Type 0 configuration header, which presents the entire subsystem as a single "device" to the host processor. This allows loading of a single device driver for the entire subsystem, and independent local processor initialization and control of the subsystem devices. Because the 21555 uses a Type 0 configuration header, it does not require hierarchical PCI-to-PCI bridge configuration code.

The 21555 forwards transactions between the primary and secondary PCI buses as does a transparent PCI-to-PCI bridge. In contrast to a transparent PCI-to-PCI bridge, however, the 21555 can translate the address of a forwarded transaction from a system address to a local address, or vice versa. This mechanism allows the 21555 to hide subsystem resources from the host processor and to resolve any resource conflicts that may exist between the host and local subsystems.

The 21555 operates at 3.3 V and is also 5.0-V I/O tolerant. Adapter cards designed using the 21555 can be keyed as universal, thus permitting use in either a 5-V or 3-V slot.

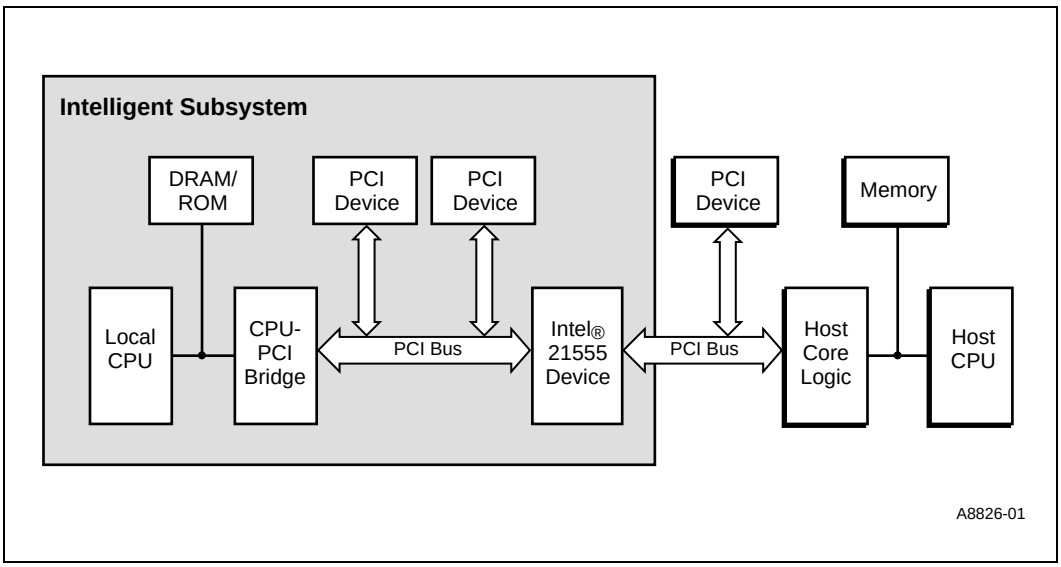
1.1 Comparing 21555 and Standard PCI-to-PCI Bridge

The 21555 is functionally similar to a standard PCI-to-PCI bridge (PPB) in that both provide a connection path between devices attached to two independent PCI buses. A 21555 and a PPB allow the electrical loading of devices on one PCI bus to be isolated from the other bus while permitting concurrent operation on both buses. Because the *PCI Local Bus Specification* restricts PCI option cards to a single electrical load, the ability of PPBs and the 21555 to spawn PCI buses enables the design of multi device PCI option cards. The key difference between a PPB and the 21555 is that the presence of a PPB in a connection path between the host processor and a device is transparent to devices and device drivers, while the presence of the 21555 is not. This difference enables the 21555 to provide features that better support the use of intelligent controllers in the subsystem.

It was a primary goal of the PCI-to-PCI bridge architecture that a PPB be transparent to devices and device drivers. For example, no changes are needed to a device driver when a PCI peripheral is located behind a PPB. Once configured during system initialization, a PPB operates without the aid of a device driver. A PPB does not require a device driver of its own since it does not have any resources that must be managed by software during run-time. This requirement for transparency forced the usage of a flat addressing model across PCI-to-PCI bridges. This means that a given physical address exists at only one location in the PCI bus hierarchy and that this location may be accessed by any device attached at any point in the PCI bus hierarchy. As a consequence, it is not possible for a PPB to isolate devices or address ranges from access by devices on the opposite interface of a PPB. The PPB architecture assumes that the resources of any device in a PCI system are configured and managed by the host processor.

However, there are applications where the transparency of a PCI-to-PCI bridge is not desired. For example, Figure 1 shows a hypothetical PCI add-in card used for an intelligent subsystem application.

Figure 1. 21555 Intelligent Controller Application



Assume that the local processor on the add-in card is used to manage the resources of the devices attached to the add-in card's local PCI bus. Assume also that it is desirable to restrict access to these same resources from other PCI bus masters in the system and from the host processor. In addition, there is a need to resolve address conflicts that may exist between the host system and the local processor. The non transparency of the 21555 is perfectly suited to this kind of configuration, where a transparent PCI-to-PCI bridge is problematic.

Because the 21555 is not transparent, the device driver for the add-in card must be aware of the presence of the 21555 and manage its resources appropriately. The 21555 allows the entire subsystem to appear as a single virtual device to the host. This enables configuration software to identify the appropriate driver for the subsystem.

With a transparent PCI-to-PCI bridge, a driver does not need to know about the presence of the bridge and manage its resources. The subsystem appears to the host system as individual PCI devices on a secondary PCI bus, not as a single virtual device.

Table 1 shows a comparison between a 21555 and a standard transparent PCI-to-PCI bridge.

Table 1. 21555 and PPB Feature Comparison

Feature	21555	PCI-to-PCI Bridge
Transaction forwarding	Adheres to PPB ordering rules.	Adheres to PPB ordering rules.
	Uses posted writes and delayed transactions.	Uses posted writes and delayed transactions.
	Adheres to PPB transaction error and parity error guidelines, although some errors may be reported differently.	Adheres to PPB transaction error and parity error guidelines.
Address decoding	Base address registers are used to define independent downstream and upstream forwarding windows.	PPB base and limit address registers are used to define downstream forwarding windows.
	Inverse decoding is only used for upstream transactions above the 4 GB boundary.	Inverse decoding for upstream forwarding.
Address translation	Supported for both memory and I/O transactions.	No translation, a flat address model is assumed.
Configuration	Downstream devices are not visible to host.	Downstream devices are visible to host.
	Does not require hierarchical configuration code (Type 0 configuration header).	Requires hierarchical configuration code (Type 1 configuration header).
	Does not respond to Type 1 configuration transactions.	Forwards and converts Type 1 configuration transactions.
	Supports configuration access from the secondary bus. Implements separate set of configuration registers for the secondary interface.	Does not support configuration access from the secondary bus. Same set of configuration registers is used to control both primary and secondary interfaces.
Run-time resources	Includes features such as doorbell interrupts, I2O message unit, and so on, that must be managed by the device driver.	Typically has only configuration registers; no device driver is required.
Clocks	Generates secondary bus clock output.	Generates one or more secondary bus clock outputs.
	Asynchronous secondary clock input is also supported.	
Secondary bus central functions	Implements secondary bus arbiter. This function can be disabled.	Implements secondary bus arbiter.
	Drives secondary bus AD, C/BE#, and PAR during reset. This function can be disabled.	Drives secondary bus AD, C/BE#, and PAR during reset.

1.2 Architectural Overview

The 21555 consists of the following function blocks:

Data Buffers

Data buffers include the buffers along with the associated data path control logic. Delayed transaction buffers contain the compare functionality for completing delayed transactions. The blocks also contain the watchdog timers associated with the buffers. The data buffers are as follows:

- Four-entry downstream delayed transaction buffer
- Four-entry upstream delayed transaction buffer
- 256-byte downstream posted write buffer
- 256-byte upstream posted write buffer
- 256-byte downstream read data buffer
- 256-byte upstream read data buffer
- Two downstream I2O delayed transaction entries

Registers

The following register blocks also contain address decode and translation logic, I2O message unit, and interrupt control logic:

- Primary interface header Type 0 configuration registers
- Secondary interface header Type 0 configuration registers
- Device-specific configuration registers
- Memory and I/O mapped control and status registers

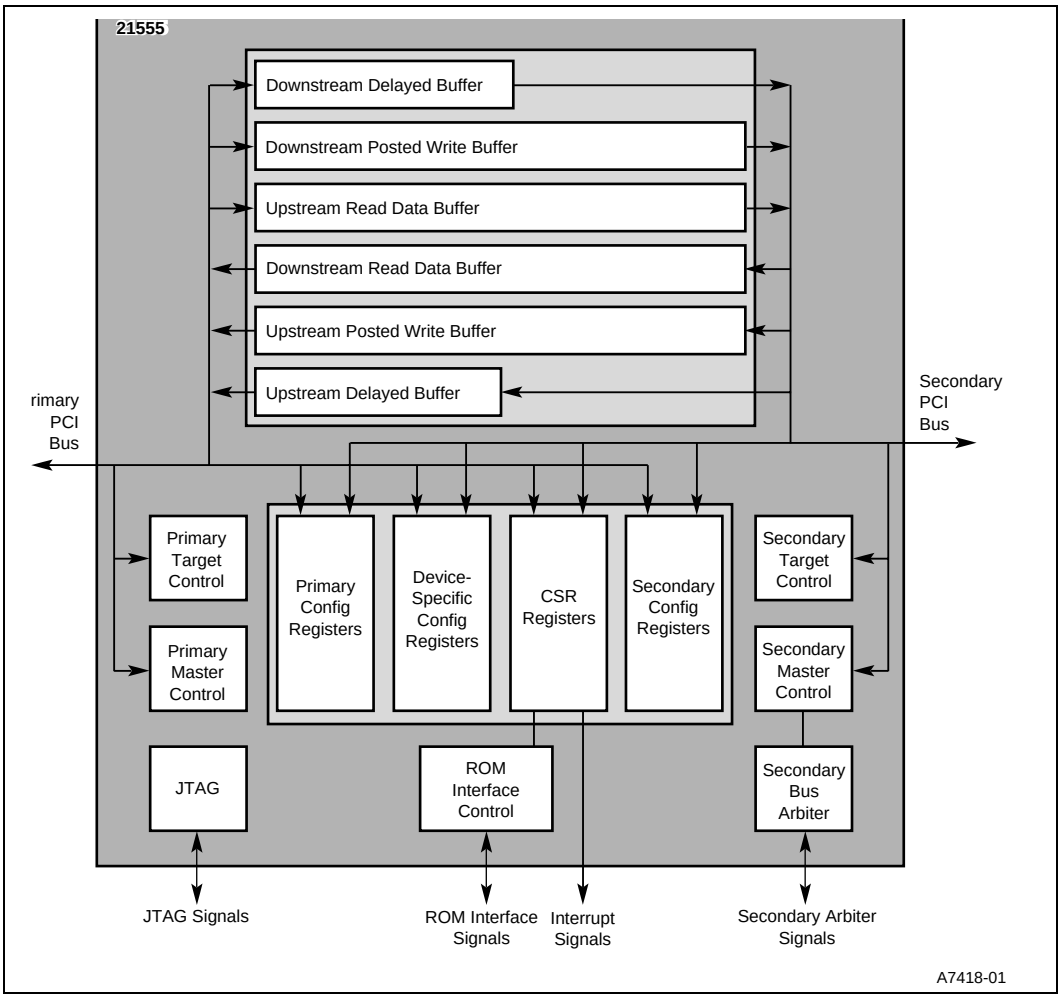
Control Logic

The 21555 has the following control logic:

- Primary PCI target control logic
- Primary PCI master control logic
- Secondary PCI target control logic
- Secondary PCI master control logic
- ROM interface control logic for both serial and parallel ROM connections (interfaces between the ROM registers and ROM signals)
- Secondary PCI bus arbiter interface to secondary bus device request and grant lines, as well as the 21555 secondary master control logic
- JTAG control logic

Figure 2 shows the 21555 microarchitecture.

Figure 2. 21555 Microarchitecture



2.0 Pin Assignment

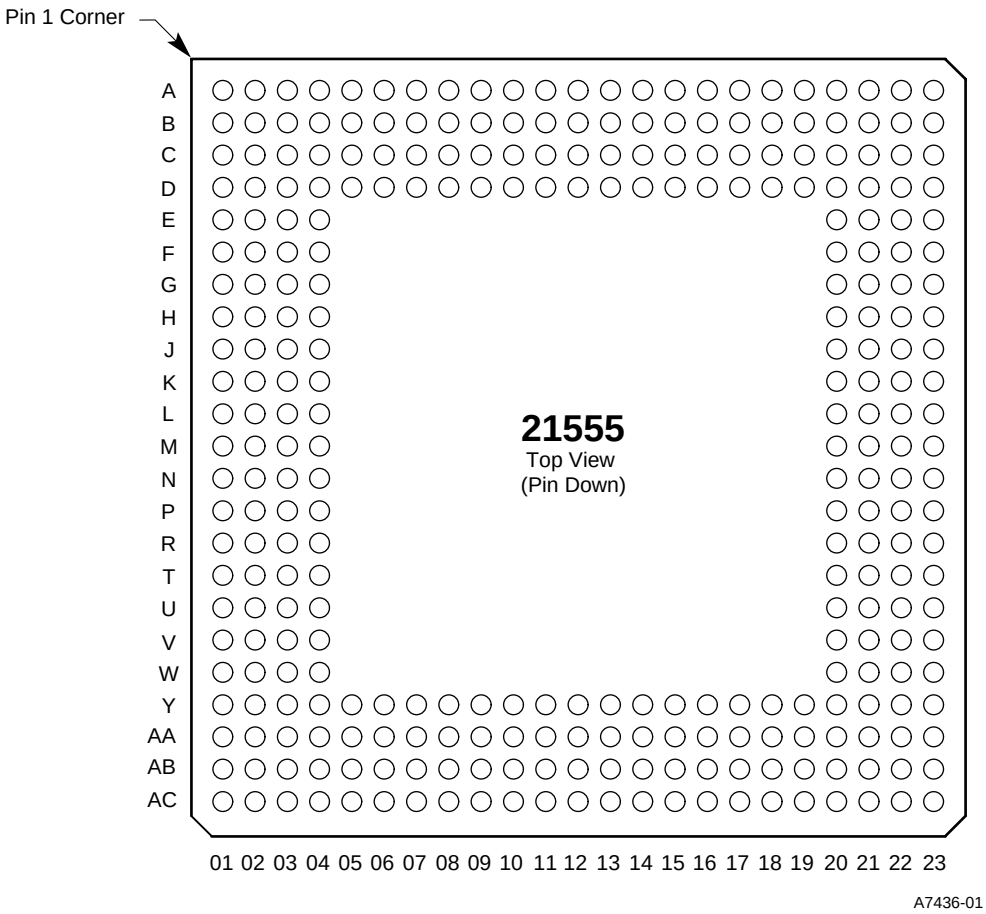
This chapter describes the 21555 pin assignment and lists the pins according to location and in alphabetic order.

Figure 3 shows the 21555 304-point ball grid array (PBGA), representing the pins in vertical rows labeled numerically, and horizontal rows labeled alphabetically. Table 2 defines the signal type abbreviations used in the signal and pin tables for this specification. Table 3 and Table 4 use these alphanumerics to identify pin assignments.

Table 2. Signal Type Abbreviations

Signal Type	Description
I	Standard input only.
O	Standard output only.
TS	Tristate bidirectional.
STS	Sustained tristate. Active low signal must be pulled high for one clock cycle when deasserting.
OD	Standard open drain.

Figure 3. 21555 PBGA Cavity Down View



2.1 Pin Location List (Alphanumeric)

Table 3 lists the 21555 pins in order of location, showing the location code, signal name, and signal type of each pin.

Figure 3 provides the map for identifying the pin location codes, listed in alphanumeric order in the PBGA Location column.

Table 2 defines the signal type abbreviations used in the Type column.

Table 3. 21555 Pin Location List (Alphanumeric) (Sheet 1 of 5)

PBGA Location	Signal Name	Type	PBGA Location	Signal Name	Type
A1	s_req_l[4]	I	AA7	p_ad[12]	TS
A2	s_req_l[3]	I	AA8	p_ad[10]	TS
A3	s_req_l[1]	I	AA9	p_cbe_l[0]	TS
A4	s_ad[29]	TS	AA10	p_ad[5]	TS
A5	s_ad[27]	TS	AA11	vss	P
A6	s_ad[25]	TS	AA12	vdd	P
A7	s_cbe_l[3]	TS	AA13	vss	P
A8	s_ad[22]	TS	AA14	p_cbe_l[7]	TS
A9	s_ad[20]	TS	AA15	p_cbe_l[4]	TS
A10	s_ad[16]	TS	AA16	vdd	P
A11	s_frame_l	STS	AA17	p_ad[58]	TS
A12	s_devsel_l	STS	AA18	p_ad[54]	TS
A13	s_par	TS	AA19	vss	P
A14	s_ad[13]	TS	AA20	vdd	P
A15	s_ad[10]	TS	AA21	p_ad[46]	TS
A16	s_m66ena	I	AA22	p_ad[42]	TS
A17	s_cbe_l[0]	TS	AA23	vdd	P
A18	s_ad[6]	TS	AB1	p_ad[16]	TS
A19	s_ad[3]	TS	AB2	vss	P
A20	s_ad[1]	TS	AB3	p_trdy_l	STS
A21	s_req64_l	STS	AB4	p_stop_l	STS
A22	vdd	P	AB5	p_serr_l	OD
A23	s_cbe_l[6]	TS	AB6	p_ad[15]	TS
AA1	p_ad[18]	TS	AB7	vss	P
AA2	vss	P	AB8	vss	P
AA3	p_ad[17]	TS	AB9	p_ad[8]	TS
AA4	vss	P	AB10	p_ad[6]	TS
AA5	vdd	P	AB11	vdd	P
AA6	p_par	TS	AB12	p_ad[1]	TS

Table 3. 21555 Pin Location List (Alphanumeric) (Sheet 2 of 5)

PBGA Location	Signal Name	Type
AB13	p_ad[0]	TS
AB14	p_cbe_l[6]	TS
AB15	p_ad[63]	TS
AB16	p_ad[60]	TS
AB17	vss	P
AB18	p_ad[55]	TS
AB19	p_ad[53]	TS
AB20	p_ad[51]	TS
AB21	p_ad[48]	TS
AB22	vss	P
AB23	vdd	P
AC1	vdd	P
AC2	vdd	P
AC3	p_frame_l	STS
AC4	p_devsel_l	STS
AC5	p_perr_l	STS
AC6	p_cbe_l[1]	TS
AC7	p_ad[14]	TS
AC8	p_ad[11]	TS
AC9	p_m66ena	I
AC10	p_ad[7]	TS
AC11	p_ad[3]	TS
AC12	p_ad[2]	TS
AC13	p_ack64_l	STS
AC14	p_cbe_l[5]	TS
AC15	p_ad[61]	TS
AC16	p_ad[59]	TS
AC17	p_ad[56]	TS
AC18	vdd	P
AC19	p_ad[52]	TS
AC20	p_ad[50]	TS
AC21	p_ad[47]	TS
AC22	p_ad[45]	TS
AC23	p_ad[44]	TS
B1	vdd	P
B2	vss	P
B3	s_req_l[0]	I
B4	vdd	P
B5	s_ad[26]	TS
B6	s_ad[24]	TS
B7	s_idsel	I
B8	vss	P
B9	s_ad[18]	TS
B10	vss	P
B11	vss	P
B12	s_trdy_l	STS
B13	s_serr_l	OD
B14	s_ad[14]	TS
B15	s_ad[12]	TS
B16	vdd	P
B17	s_ad[9]	TS
B18	s_ad[7]	TS
B19	s_ad[4]	TS
B20	vdd	P
B21	vss	P
B22	vss	P
B23	vdd	P
C1	s_req_l[6]	I
C2	s_req_l[7]	I
C3	s_req_l[2]	I
C4	s_ad[31]	TS
C5	s_ad[28]	TS
C6	vss	P
C7	s_ad[23]	TS
C8	s_ad[21]	TS
C9	s_ad[17]	TS
C10	vdd	P
C11	s_irdy_l	STS
C12	s_stop_l	STS
C13	s_perr_l	STS
C14	s_ad[15]	TS
C15	vdd	P
C16	vss	P
C17	vss	P

Table 3. 21555 Pin Location List (Alphanumeric) (Sheet 3 of 5)

PBGA Location	Signal Name	Type	PBGA Location	Signal Name	Type
C18	s_ad[5]	TS	F1	s_gnt_l[6]	TS
C19	s_ad[2]	TS	F2	s_gnt_l[7]	TS
C20	s_ack64_l	STS	F3	s_gnt_l[5]	TS
C21	s_cbe_l[5]	TS	F4	vss	P
C22	s_par64	TS	F20	vss	P
C23	s_cbe_l[4]	TS	F21	vss	P
D1	s_gnt_l[1]	TS	F22	s_ad[56]	TS
D2	s_gnt_l[2]	TS	F23	s_ad[57]	TS
D3	s_req_l[8]	I	G1	s_gnt_l[8]	TS
D4	s_req_l[5]	I	G2	vss	P
D5	s_ad[30]	TS	G3	s_clk	I
D6	vdd	P	G4	s_clk_o	O
D7	vdd	P	G20	vdd	P
D8	vss	P	G21	s_ad[53]	TS
D9	s_ad[19]	TS	G22	s_ad[54]	TS
D10	vdd	P	G23	s_ad[55]	TS
D11	s_cbe_l[2]	TS	H1	s_rst_l	O
D12	vss	P	H2	s_inta_l	OD
D13	s_cbe_l[1]	TS	H3	tdi	I
D14	vdd	P	H4	vdd	P
D15	s_ad[11]	TS	H20	vdd	P
D16	vss	P	H21	s_ad[50]	TS
D17	s_ad[8]	TS	H22	s_ad[51]	TS
D18	vdd	P	H23	s_ad[52]	TS
D19	s_ad[0]	TS	J1	tdo	O
D20	s_cbe_l[7]	TS	J2	tck	I
D21	vss	P	J3	trst_l	I
D22	s_ad[61]	TS	J4	tms	I
D23	s_ad[62]	TS	J20	vdd	P
E1	s_rst_in_l	I	J21	s_ad[47]	TS
E2	s_gnt_l[4]	TS	J22	s_ad[48]	TS
E3	s_gnt_l[3]	TS	J23	s_ad[49]	TS
E4	s_gnt_l[0]	TS	K1	sr_cs	O
E20	s_ad[63]	TS	K2	pr_ad[7]	TS
E21	s_ad[60]	TS	K3	pr_ad[6]	TS
E22	s_ad[58]	TS	K4	vss	P
E23	s_ad[59]	TS	K20	vss	P

Table 3. 21555 Pin Location List (Alphanumeric) (Sheet 4 of 5)

PBGA Location	Signal Name	Type	PBGA Location	Signal Name	Type
k21	s_ad[45]	TS	R3	vdd	P
k22	vss	P	R4	p_clk	I
k23	s_ad[46]	TS	R20	l_stat	TS
L1	pr_ad[4]	TS	R21	s_ad[33]	TS
L2	pr_ad[3]	TS	R22	s_ad[32]	TS
L3	pr_ad[2]	TS	R23	s_pme_l	I
L4	pr_ad[5]	TS	T1	p_ad[30]	TS
L20	s_ad[44]	TS	T2	p_ad[31]	TS
L21	s_ad[42]	TS	T3	p_req_l	TS
L22	s_ad[41]	TS	T4	vdd	P
L23	s_ad[43]	TS	T20	vdd	P
M1	pr_ad[0]	TS	T21	s_vio	I
M2	pr_rd_l	O	T22	p_enum_l	OD
M3	pr_ad[1]	TS	T23	p_pme_l	OD
M4	vdd	P	U1	p_ad[27]	TS
M20	vdd	P	U2	p_ad[29]	TS
M21	vdd	P	U3	vss	P
M22	s_ad[40]	TS	U4	p_ad[28]	TS
M23	vss	P	U20	p_par64	TS
N1	pr_wr_l	O	U21	p_vio	I
N2	pr_ale_l	O	U22	vdd	P
N3	pr_cs_l / pr_rdy	O/I	u23	p_ad[32]	TS
N4	pr_clk	O	V1	p_ad[25]	TS
N20	s_ad[36]	TS	V2	p_ad[26]	TS
N21	s_ad[39]	TS	V3	p_ad[24]	TS
N22	s_ad[38]	TS	V4	vss	P
N23	s_ad[37]	TS	V20	vss	P
P1	p_rst_l	I	V21	p_ad[35]	TS
P2	p_inta_l	OD	V22	p_ad[33]	TS
P3	scan_ena	I	V23	p_ad[34]	TS
P4	vss	P	W1	p_idsel	I
P20	vss	P	W2	p_cbe_l[3]	TS
P21	s_ad[35]	TS	W3	p_ad[23]	TS
P22	s_ad[34]	TS	W4	p_ad[20]	TS
P23	vss	P	W20	p_ad[40]	TS
R1	p_gnt_l	I	W21	p_ad[38]	TS
R2	vss	P	W22	p_ad[36]	TS

Table 3. 21555 Pin Location List (Alphanumeric) (Sheet 5 of 5)

PBGA Location	Signal Name	Type	PBGA Location	Signal Name	Type
W23	p_ad[37]	TS	y12	vss	P
y1	p_ad[21]	TS	y13	p_req64_l	STS
y2	p_ad[22]	TS	y14	vdd	P
y3	p_ad[19]	TS	y15	p_ad[62]	TS
y4	p_cbe_l[2]	TS	y16	vss	P
y5	p_irdy_l	STS	y17	p_ad[57]	TS
y6	vdd	P	y18	vdd	P
y7	p_ad[13]	TS	y19	p_ad[49]	TS
y8	vss	P	y20	p_ad[43]	TS
y9	p_ad[9]	TS	y21	p_ad[41]	TS
y10	vdd	P	y22	p_ad[39]	TS
y11	p_ad[4]	TS	y23	vss	P

2.2 Pin Signal List (Alphanumeric)

Table 4 lists the 21555 signals in alphanumeric order, showing the name, location code, and type of each signal.

Figure 3 provides the map for identifying the pin location codes that are listed under PBGA Location column.

Table 2 defines the signal type abbreviations used in the Type column.

Table 4. 21555 Pin Signal List (Alphanumeric) (Sheet 1 of 5)

Signal Name	PBGA Location	Type	Signal Name	PBGA Location	Type
l_stat	R20	TS	p_ad[27]	U1	TS
p_ack64_l	AC13	STS	p_ad[28]	U4	TS
p_ad[0]	AB13	TS	p_ad[29]	U2	TS
p_ad[1]	AB12	TS	p_ad[30]	T1	TS
p_ad[2]	AC12	TS	p_ad[31]	T2	TS
p_ad[3]	AC11	TS	p_ad[32]	U23	TS
p_ad[4]	Y11	TS	p_ad[33]	V22	TS
p_ad[5]	AA10	TS	p_ad[34]	V23	TS
p_ad[6]	AB10	TS	p_ad[35]	V21	TS
p_ad[7]	AC10	TS	p_ad[36]	W22	TS
p_ad[8]	AB9	TS	p_ad[37]	W23	TS
p_ad[9]	Y9	TS	p_ad[38]	W21	TS
p_ad[10]	AA8	TS	p_ad[39]	Y22	TS
p_ad[11]	AC8	TS	p_ad[40]	W20	TS
p_ad[12]	AA7	TS	p_ad[41]	Y21	TS
p_ad[13]	Y7	TS	p_ad[42]	AA22	TS
p_ad[14]	AC7	TS	p_ad[43]	Y20	TS
p_ad[15]	AB6	TS	p_ad[44]	AC23	TS
p_ad[16]	AB1	TS	p_ad[45]	AC22	TS
p_ad[17]	AA3	TS	p_ad[46]	AA21	TS
p_ad[18]	AA1	TS	p_ad[47]	AC21	TS
p_ad[19]	Y3	TS	p_ad[48]	AB21	TS
p_ad[20]	W4	TS	p_ad[49]	Y19	TS
p_ad[21]	Y1	TS	p_ad[50]	AC20	TS
p_ad[22]	Y2	TS	p_ad[51]	AB20	TS
p_ad[23]	W3	TS	p_ad[52]	AC19	TS
p_ad[24]	V3	TS	p_ad[53]	AB19	TS
p_ad[25]	V1	TS	p_ad[54]	AA18	TS
p_ad[26]	V2	TS	p_ad[55]	AB18	TS

Table 4. 21555 Pin Signal List (Alphanumeric) (Sheet 2 of 5)

Signal Name	PBGA Location	Type	Signal Name	PBGA Location	Type
p_ad[56]	AC17	TS	pr_ad[2]	L3	TS
p_ad[57]	Y17	TS	pr_ad[3]	L2	TS
p_ad[58]	AA17	TS	pr_ad[4]	L1	TS
p_ad[59]	AC16	TS	pr_ad[5]	L4	TS
p_ad[60]	AB16	TS	pr_ad[6]	K3	TS
p_ad[61]	AC15	TS	pr_ad[7]	K2	TS
p_ad[62]	Y15	TS	pr_ale_l	N2	O
p_ad[63]	AB15	TS	pr_clk	N4	O
p_cbe_l[0]	AA9	TS	pr_cs_l / pr_rdy	N3	O/I
p_cbe_l[1]	AC6	TS	pr_rd_l	M2	O
p_cbe_l[2]	Y4	TS	pr_wr_l	N1	O
p_cbe_l[3]	W2	TS	p_vio	U21	I
p_cbe_l[4]	AA15	TS	s_ack64_l	C20	STS
p_cbe_l[5]	AC14	TS	s_ad[0]	D19	TS
p_cbe_l[6]	AB14	TS	s_ad[1]	A20	TS
p_cbe_l[7]	AA14	TS	s_ad[2]	C19	TS
p_clk	R4	I	s_ad[3]	A19	TS
p_devsel_l	AC4	STS	s_ad[4]	B19	TS
p_enum_l	T22	OD	s_ad[5]	C18	TS
p_frame_l	AC3	STS	s_ad[6]	A18	TS
p_gnt_l	R1	I	s_ad[7]	B18	TS
p_idsel	W1	I	s_ad[8]	D17	TS
p_inta_l	P2	OD	s_ad[9]	B17	TS
p_irdy_l	Y5	STS	s_ad[10]	A15	TS
p_m66ena	AC9	I	s_ad[11]	D15	TS
p_par	AA6	TS	s_ad[12]	B15	TS
p_par64	U20	TS	s_ad[13]	A14	TS
p_perr_l	AC5	STS	s_ad[14]	B14	TS
p_pme_l	T23	OD	s_ad[15]	C14	TS
p_req_l	T3	TS	s_ad[16]	A10	TS
p_req64_l	Y13	STS	s_ad[17]	C9	TS
p_rst_l	P1	I	s_ad[18]	B9	TS
p_serr_l	AB5	OD	s_ad[19]	D9	TS
p_stop_l	AB4	STS	s_ad[20]	A9	TS
p_trdy_l	AB3	STS	s_ad[21]	C8	TS
pr_ad[0]	M1	TS	s_ad[22]	A8	TS
pr_ad[1]	M3	TS	s_ad[23]	C7	TS

Table 4. 21555 Pin Signal List (Alphanumeric) (Sheet 3 of 5)

Signal Name	PBGA Location	Type	Signal Name	PBGA Location	Type
s_ad[24]	B6	TS	s_ad[61]	D22	TS
s_ad[25]	A6	TS	s_ad[62]	D23	TS
s_ad[26]	B5	TS	s_ad[63]	E20	TS
s_ad[27]	A5	TS	s_cbe_l[0]	A17	TS
s_ad[28]	C5	TS	s_cbe_l[1]	D13	TS
s_ad[29]	A4	TS	s_cbe_l[2]	D11	TS
s_ad[30]	D5	TS	s_cbe_l[3]	A7	TS
s_ad[31]	C4	TS	s_cbe_l[4]	C23	TS
s_ad[32]	R22	TS	s_cbe_l[5]	C21	TS
s_ad[33]	R21	TS	s_cbe_l[6]	A23	TS
s_ad[34]	P22	TS	s_cbe_l[7]	D20	TS
s_ad[35]	P21	TS	s_clk	G3	I
s_ad[36]	N20	TS	s_clk_o	G4	O
s_ad[37]	N23	TS	s_devsel_l	A12	STS
s_ad[38]	N22	TS	s_frame_l	A11	STS
s_ad[39]	N21	TS	s_gnt_l[0]	E4	TS
s_ad[40]	M22	TS	s_gnt_l[1]	D1	TS
s_ad[41]	L22	TS	s_gnt_l[2]	D2	TS
s_ad[42]	L21	TS	s_gnt_l[3]	E3	TS
s_ad[43]	L23	TS	s_gnt_l[4]	E2	TS
s_ad[44]	L20	TS	s_gnt_l[5]	F3	TS
s_ad[45]	K21	TS	s_gnt_l[6]	F1	TS
s_ad[46]	K23	TS	s_gnt_l[7]	F2	TS
s_ad[47]	J21	TS	s_gnt_l[8]	G1	TS
s_ad[48]	J22	TS	s_idsel	B7	I
s_ad[49]	J23	TS	s_inta_l	H2	OD
s_ad[50]	H21	TS	s_irdy_l	C11	STS
s_ad[51]	H22	TS	s_m66ena	A16	I
s_ad[52]	H23	TS	s_par	A13	TS
s_ad[53]	G21	TS	s_par64	C22	TS
s_ad[54]	G22	TS	s_perr_l	C13	STS
s_ad[55]	G23	TS	s_pme_l	R23	I
s_ad[56]	F22	TS	s_req_l[0]	B3	I
s_ad[57]	F23	TS	s_req_l[1]	A3	I
s_ad[58]	E22	TS	s_req_l[2]	C3	I
s_ad[59]	E23	TS	s_req_l[3]	A2	I
s_ad[60]	E21	TS	s_req_l[4]	A1	I

Table 4. 21555 Pin Signal List (Alphanumeric) (Sheet 4 of 5)

Signal Name	PBGA Location	Type	Signal Name	PBGA Location	Type
s_req_l[5]	D4	I	vdd	D7	P
s_req_l[6]	C1	I	vdd	D10	P
s_req_l[7]	C2	I	vdd	D14	P
s_req_l[8]	D3	I	vdd	D18	P
s_req64_l	A21	STS	vdd	G20	P
s_rst_in_l	E1	I	vdd	H4	P
s_rst_l	H1	O	vdd	H20	P
s_serr_l	B13	OD	vdd	J20	P
s_stop_l	C12	STS	vdd	M4	P
s_trdy_l	B12	STS	vdd	M20	P
scan_ena	P3	I	vdd	M21	P
sr_cs	K1	O	vdd	R3	P
s_vio	T21	I	vdd	T4	P
tck	J2	I	vdd	T20	P
tdi	H3	I	vdd	U22	P
tdo	J1	O	vdd	Y6	P
tms	J4	I	vdd	Y10	P
trst_l	J3	I	vdd	Y14	P
vdd	A22	P	vdd	Y18	P
vdd	AA5	P	vss	AA2	P
vdd	AA12	P	vss	AA4	P
vdd	AA16	P	vss	AA11	P
vdd	AA20	P	vss	AA13	P
vdd	AA23	P	vss	AA19	P
vdd	AB11	P	vss	AB2	P
vdd	AB23	P	vss	AB7	P
vdd	AC1	P	vss	AB8	P
vdd	AC2	P	vss	AB17	P
vdd	AC18	P	vss	AB22	P
vdd	B1	P	vss	B2	P
vdd	B4	P	vss	B8	P
vdd	B16	P	vss	B10	P
vdd	B20	P	vss	B11	P
vdd	B23	P	vss	B21	P
vdd	C10	P	vss	B22	P
vdd	C15	P	vss	C6	P
vdd	D6	P	vss	C16	P

Table 4. 21555 Pin Signal List (Alphanumeric) (Sheet 5 of 5)

Signal Name	PBGA Location	Type	Signal Name	PBGA Location	Type
vss	C17	P	vss	M23	P
vss	D8	P	vss	P4	P
vss	D12	P	vss	P20	P
vss	D16	P	vss	P23	P
vss	D21	P	vss	R2	P
vss	F4	P	vss	U3	P
vss	F20	P	vss	V4	P
vss	F21	P	vss	V20	P
vss	G2	P	vss	Y8	P
vss	K4	P	vss	Y12	P
vss	K20	P	vss	Y16	P
vss	K22	P	vss	Y23	P

3.0 Electrical Specifications

This section specifies the following electrical behavior of the 21555:

- PCI electrical conformance.
- Absolute maximum ratings.
- DC specifications.
- AC timing specifications.

3.1 PCI Electrical Specification Conformance

The 21555 PCI pins conform to the basic set of PCI electrical specifications in the *PCI Local Bus Specification*, Revision 2.2. See that document for a complete description of the PCI I/O protocol and pin AC specifications.

3.2 Absolute Maximum Ratings

The 21555 is specified to operate at a maximum frequency of 33 MHz or 66 MHz if 66 MHz capable, at a junction temperature (T_j) not to exceed 125°C. Table 5 lists the absolute maximum ratings for the 21555. Stressing the device beyond the absolute maximum ratings may cause permanent damage. These are stress ratings only. Operating beyond the functional operating range is not recommended and extended exposure beyond the functional operating range may affect reliability. Table 6 lists the functional operating range.

Table 5. Absolute Maximum Ratings

Parameter	Minimum	Maximum
Junction temperature, T_j	—	125°C
Supply voltage V_{cc}	—	4.3 V
Maximum voltage applied to signal pins	—	5.5 V
Maximum power, P_{WC}	—	3.0 W
Storage temperature range, T_{stg}	–55°C	125°C

Table 6. Functional Operating Range

Parameter	Minimum	Maximum
Supply voltage, V_{cc}	3.0 V	3.6 V
Operating ambient temperature, T_a	0°C	70°C

3.3 DC Specifications

Table 7 defines the DC parameters met by all 21555 signals under the conditions of the functional operating range.

Note: In Table 7, currents into the chip (chip sinking) are denoted as positive (+) current. Currents from the chip (chip sourcing) are denoted as negative (–) current.

Table 7. DC Parameters

Symbol	Parameter	Condition	Minimum	Maximum	Unit
V_{cc}	Supply voltage	—	3.0	3.6	V
V_{il}	Low-level input voltage[a]	—	–0.5	0.3 V_{cc}	V
V_{ih}	High-level input voltage[a]	—	0.5 V_{cc}	V_{IO} + 0.5 V	V
V_{ol}	Low-level output voltage[b]	I_{out} = 1500 µA	—	0.1 V_{cc}	V
V_{ol5V}	Low-level output voltage[c]	I_{out} = 6 mA	—	0.55	V
V_{oh}	High-level output voltage[b]	I_{out} = –500 µA	0.9 V_{cc}	—	V
V_{oh5V}	High-level output voltage[c]	I_{out} = –2 mA	2.4	—	V
I_{il}	Low-level input leakage current[a,d]	0 <V_{in} <V_{cc}	—	±10	µA
C_{in}	Input pin capacitance	—	—	10.0	pF
C_{IDSEL}	p_idsel pin capacitance	—	—	8.0	pF
C_{clk}	p_clk, s_clk pin capacitance	—	5.0	12.0	pF

a. Guarantees meeting the specification for the 5-V signaling environment.
b. For 3.3-V signaling environment.
c. For 5-V signaling environment.
d. Input leakage currents include high-Z output leakage for all bidirectional buffers with tristate outputs.

3.4 AC Timing Specifications

The next sections specify the AC characteristics met by all 21555 signals under the conditions of the functional operating range:

- Clock timing.
- PCI signal timing.
- Reset timing.
- Serial ROM timing.
- Parallel ROM timing.
- JTAG timing.

3.4.1 Clock Timing Specifications

The AC specifications consist of input requirements and output responses. The input requirements consist of setup and hold times, pulse widths, and high and low times. The output responses are delays from clock to signal. The AC specifications are defined separately for each clock domain within the 21555.

Table 8 and Table 9 specify p_clk and s_clk parameter values for clock signal AC timing, and Figure 4 shows the AC parameter measurements for the p_clk and s_clk signals. See also Figure 5 for a further illustration of signal timing. Unless otherwise indicated, all AC parameters are guaranteed when tested within the functional operating range of Table 6.

Table 8. 33 MHz PCI Clock Signal AC Parameters

Symbol	Parameter	Minimum	Maximum	Unit
T_{cyc}	p_clk,s_clk cycle time	30	∞	ns
T_{high}	p_clk, s_clk high time	11	—	ns
T_{low}	p_clk, s_clk low time	11	—	ns
–	p_clk, s_clk slew rate[a]	1	4	V/ns
T_{sclk}	Delay from p_clk to s_clk[b]	3	15	ns
T_{sclkr}	p_clk rising to s_clk_o rising	0	8	ns
T_{sclkf}	p_clk falling to s_clk_o falling[c]	0	8	ns
T_{dskew}	s_clk_o duty cycle skew from p_clk duty cycle[C]	—	0.75	ns

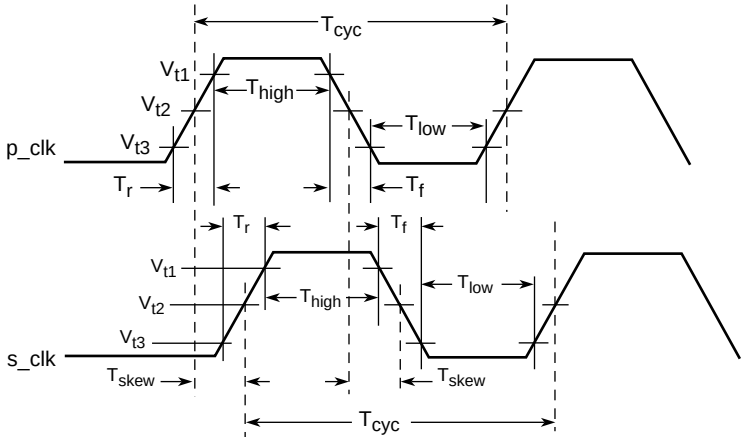
a. 0.2 V_{CC} to 0.6 V_{CC}.
b. Required when the 21555 is operating in synchronous mode.
c. Measured with 30 pF lumped load.

Table 9. 66 MHz PCI Clock Signal AC Parameters

Symbol	Parameter	Minimum	Maximum	Unit
T_{cyc}	p_clk,s_clk cycle time	15	30	ns
T_{high}	p_clk, s_clk high time	6	—	ns
T_{low}	p_clk, s_clk low time	6	—	ns
–	p_clk, s_clk slew rate[a]	1.5	4	V/ns
T_{sclk}	Delay from p_clk to s_clk[b]	3	15	ns
T_{sclkr}	p_clk rising to s_clk_o rising	0	13	ns
T_{sclkf}	p_clk falling to s_clk_o falling[c]	0	13	ns
T_{dskew}	s_clk_o duty cycle skew from p_clk duty cycle[C]	—	0.75	ns

a. 0.2 V_{CC} to 0.6 V_{CC}.
b. Required when the 21555 is operating in synchronous mode.
c. Measured with 30 pF lumped load.

Figure 4. PCI Clock Signal AC Parameter Measurements



Notes:
T_{t1} - 2.0 V for 5-V signals; 0.5 V_{cc} for 3.3-V clocks
T_{t2} - 1.5 V for 5-V signals; 0.4 V_{cc} for 3.3-V clocks
T_{t3} - 0.8 V for 5-V signals; 0.3 V_{cc} for 3.3-V clocks

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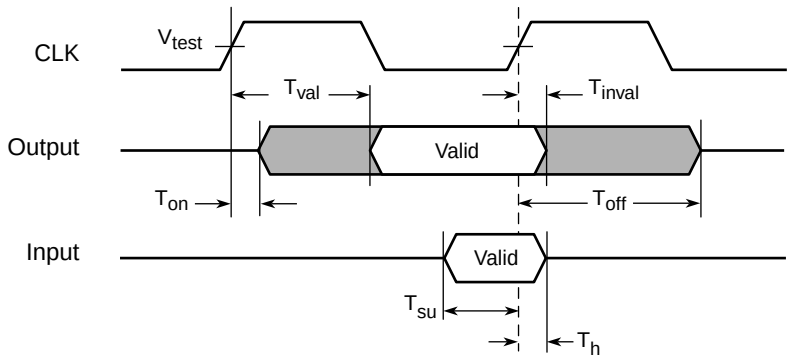
3.4.2 PCI Signal Timing Specifications

Figure 5 and Tables 10 and 11 show the PCI signal timing specifications.

Figure 5. PCI Signal Timing Measurement Conditions



Note: T_{test} - 1.5 V for 5-V signals; 0.4 V_{cc} for 3.3-V signals

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Table 10. 33 MHz PCI Signal Timing Specifications

Symbol	Parameter	Minimum	Maximum	Unit
T_{val}	CLK to signal valid delay — bused signals[a,b,c]	2	11	ns
$T_{val(ptp)}$	CLK to signal valid delay — point-to-point[a,b,c]	2	12	ns
T_{on}	Float to active delay[a,b]	2	—	ns
T_{off}	Active to float delay[a,b]	—	28	ns
T_{su}	Input setup time to CLK — bused signals[a,b,c]	7	—	ns
$T_{su(ptp)}$	Input setup time to CLK—point-to-point[a,b,c]	10, 12	—	ns
T_{h}	Input signal hold time from CLK[a,b]	0	—	ns

a. See Figure 5.
b. All primary interface signals are synchronized to p_clk. All secondary interface signals are synchronized to s_clk.
c. Point-to-point signals are p_req_l, s_req_l[8:0], p_gnt_l, and s_gnt_l[8:0]. Bused signals are p_ad, p_cbe_l, p_par, p_par64, p_perr_l, p_serr_l, p_frame_l, p_irdy_l, p_trdy_l, p_devsel_l, p_stop_l, p_idsel, p_req64_l, p_ack64_l, s_ad, s_cbe_l, s_par, s_par64, s_perr_l, s_serr_l, s_frame_l, s_irdy_l, s_trdy_l, s_devsel_l, s_stop_l, s_req64_l, s_ack64_l, and s_idsel.

Table 11. 66 MHz PCI Signal Timing Specifications

Symbol	Parameter	Minimum	Maximum	Unit
T_{val}	CLK to signal valid delay — bused signals[a,b,c]	2	6	ns
$T_{val(ptp)}$	CLK to signal valid delay — point-to-point[a,b,c]	2	6	ns
T_{on}	Float to active delay[a,b]	2	—	ns
T_{off}	Active to float delay[a,b]	—	14	ns
T_{su}	Input setup time to CLK — bused signals[a,b]	3	—	ns
$T_{su(ptp)}$	Input setup time to CLK—point-to-point[a,b]	5	—	ns
T_{h}	Input signal hold time from CLK[a,b]	0	—	ns

a. See Figure 5.
b. All primary interface signals are synchronized to p_clk. All secondary interface signals are synchronized to s_clk.
c. Point-to-point signals are p_req_l, s_req_l[8:0], p_gnt_l, and s_gnt_l[8:0]. Bused signals are p_ad, p_cbe_l, p_par, p_par64, p_perr_l, p_serr_l, p_frame_l, p_irdy_l, p_trdy_l, p_devsel_l, p_stop_l, p_idsel, p_req64_l, p_ack64_l, s_ad, s_cbe_l, s_par, s_par64, s_perr_l, s_serr_l, s_frame_l, s_irdy_l, s_trdy_l, s_devsel_l, s_stop_l, s_req64_l, s_ack64_l, and s_idsel.

3.4.3 Reset Timing Specifications

Table 12 shows the reset timing specifications for p_rst_l and s_rst_l.

Table 12. Reset Timing Specifications (Sheet 1 of 2)

Symbol	Parameter	Minimum	Maximum	Unit
T_{rst}	p_rst_l active time after power stable	1	—	µs
$T_{rst-clk}$	p_rst_l active time after p_clk stable	100	—	µs
$T_{rst-off}$	p_rst_l active-to-output float delay	—	40	ns
T_{srst}	s_rst_l active after p_rst_l assertion	—	40	ns
$T_{srst-on}$	s_rst_l active time after s_clk stable	100	—	µs
T_{dsrst}	s_rst_l deassertion after p_rst_l deassertion	0	25	Cycles
–	p_rst_l slew rate[a]	50	—	mV/ns

Table 12. Reset Timing Specifications (Sheet 2 of 2)

Symbol	Parameter	Minimum	Maximum	Unit
T_{rrsus}	s_req64_l asserted to s_rst_l deasserted	10*T_{cyc}	—	ns[a]
T_{rrval}	s_rst_l to s_req64_l deasserted delay time	0 T_{cyc}	—	ns[a]
T_{rrsu}	REQ64# to RST# deasserting setup time	T_{cyc}	—	ns
T_{rrh}	REQ64# from RST# deasserting hold time	0	50	ns

a. Applies to rising (deasserting) edge only.

3.4.4 Serial ROM Timing Specifications

Table 13 shows the serial ROM timing specifications.

Table 13. Serial ROM Timing Specifications

Symbol	Parameter	Minimum	Maximum	Unit
T_{scval}	pclk to pr_ad[0] serial ROM clock valid	—	14	ns
T_{son}	pr_ad float to active delay	2	—	ns
T_{soff}	pr_ad active to float delay	—	28	ns
T_{ssu}	pr_ad[1] di to pr_ad[0] serial ROM clock setup time	400	—	ns
T_{sh}	pr_ad[1] to pr_ad[0] serial ROM clock hold time	20	—	ns
T_{smcs}	sr_cs minimum low time	400	—	ns
T_{scyc}	pr_ad[0] serial ROM clock cycle time	1000	—	ns

3.4.5 Parallel ROM Timing Specifications

Table 14 shows the parallel ROM timing specifications.

Table 14. Parallel ROM Timing Specifications

Symbol	Parameter	Minimum	Maximum	Unit
T_{pas}	pr_ale_l setup to pr_clk rising	30	—	ns
T_{pcc}	pr_clk cycle time	60	—	ns
T_{pacs}	pr_ale_l rising to pr_cs_l falling	25	—	ns
T_{pcsl}	pr_cs_l low	200	—	ns
T_{pcrw}	pr_cs_l falling to pr_rd_l or pr_wr_l falling	25	—	ns
T_{prs}	pr_ad setup time to pr_rd_l rising	180	—	ns
T_{prh}	pr_ad hold time from pr_rd_l rising	0	—	ns
T_{prv}	pr_clk rising to pr_ad valid	0	15	ns

3.4.6 JTAG Timing Specifications

Table 15 shows the JTAG timing specifications.

Table 15. JTAG Timing Specifications

Symbol	Parameter	Minimum	Maximum	Unit
T_{jr}	tck frequency	0	5	MHz
T_{jp}	tck period	200	∞	ns
T_{ght}	tck high time	100	—	ns
T_{glt}	tck low time	100	—	ns
T_{jrt}	tck rise time[a]	—	10	ns
T_{gft}	tck fall time[b]	—	10	ns
T_{js}	tdi, tms setup time to tck rising edge	10	—	ns
T_{jh}	tdi, tms hold time from tck rising edge	25	—	ns
T_{jd}	tdo valid delay from tck falling edge[c]	—	30	ns
T_{jfd}	tdo float delay from tck falling edge	—	30	ns

a. Measured between 0.8 V and 2.0 V.
b. Measured between 2.0 V and 0.8 V.
c. C_1=50 pF.

4.0 Mechanical Specifications

The 21555 is contained in an industry-standard 304 PBGA, a four-layer plastic ball grid array package, as shown in Figure 6.

Figure 6. 304 PBGA (Four-Layer) Package

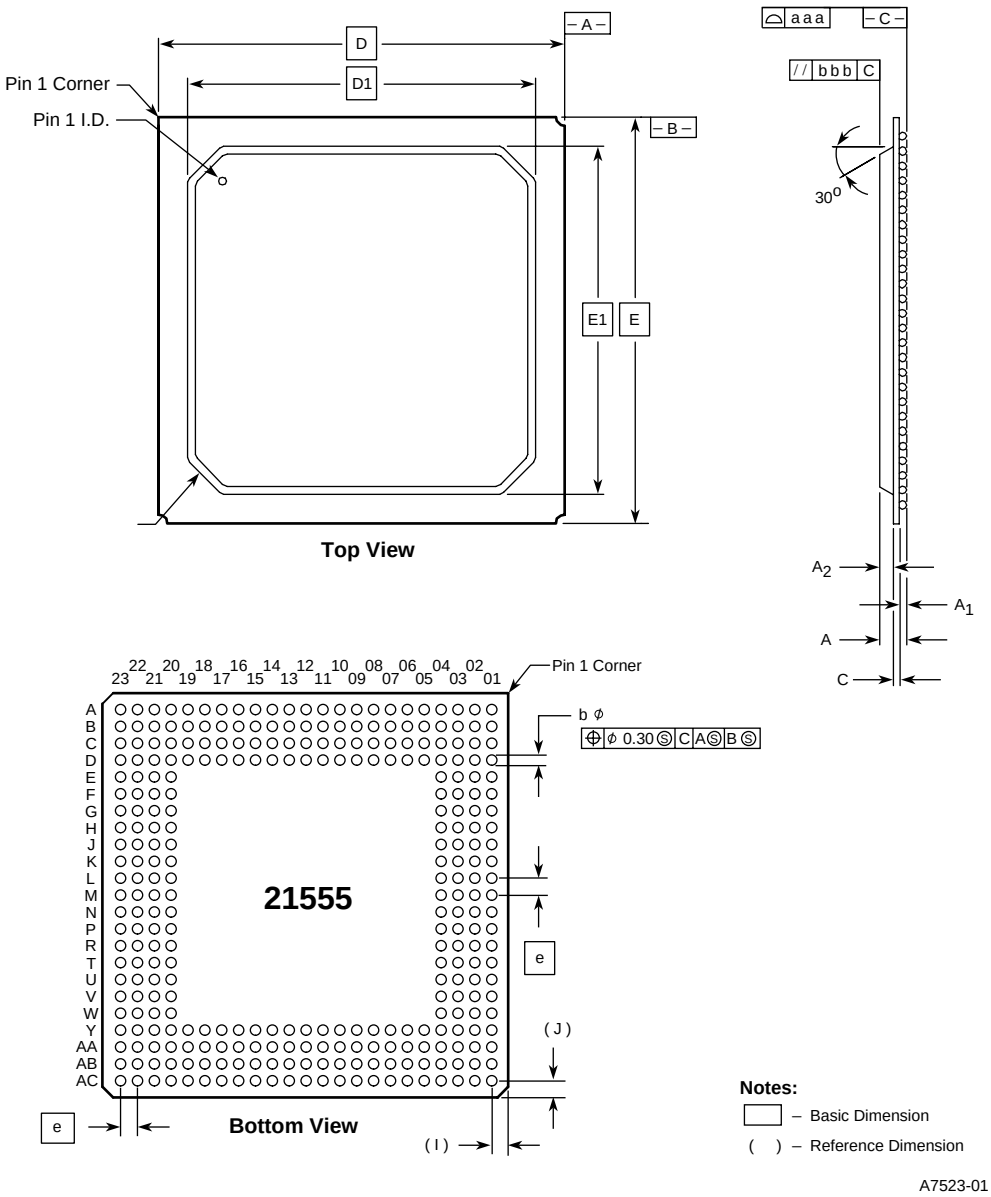

Table 16 lists the package dimensions in millimeters.

Table 16. 304-Point 4-Layer PBGA Package Dimensions

Symbol	Dimension	Minimum Value	Nominal Value	Maximum Value
e	Ball pitch	—	1.27 BSC[a]	—
A	Overall package height	2.12	2.33	2.54
A_1	Package standoff height	0.50	0.60	0.70
A_2	Encapsulation thickness	1.12	1.17	1.22
b	Ball diameter	0.60	0.76	0.90
C	Substrate thickness		0.56 reference[b]	
aaa	Coplanarity	—	—	0.2
bbb	Overall package planarity	—	—	0.15
D	Overall package width	30.80	31.00	31.20
D_1	Overall encapsulation width	—	26.00	26.70
E	Overall package width	30.80	31.00	31.20
E_1	Overall encapsulation width	—	26.00	26.70
I	Location of first row (*x*-direction)	—	1.53 reference[b]	—
J	Location of first row (*y*-direction)	—	1.53 reference[b]	—

a. ANSI Y14.5M-1982 American National Standard Dimensioning and Tolerancing, Section 1.3.2, defines Basic Dimension (BSC) as: A numerical value used to describe the theoretically exact size, profile, orientation, or location of a feature or datum target. It is the basis from which permissible variations are established by tolerances on other dimensions, in notes, or in feature control frames.
b. The value for this measurement is for reference only.