

QL5432 - Enhanced QuickPCI™ Device



33 MHz/32-bit PCI Master/Target with Embedded Programmable Logic and Dual Port SRAM

last updated 2/5/01

QL5432 - Enhanced QL5232

- Supports all PCI commands (including configuration and MWI)
- Supports fully-customizable byte enables as a master
- Zero-wait-state write and one-wait-state read target interface
- Supports all types of PCI target terminations: disconnect with data transfer, disconnect without data transfer, and retry
- Supports target aborts
- Has 125 more logic cells in FPGA section, but 2 less RAM blocks
- Pin Compatible with QL5232

Device Highlights

High Performance PCI Controller

- 32-bit / 33 MHz PCI Master/Target
- Zero-wait state PCI Master provides 132 MB/s transfer rates
- Zero-wait-state PCI Target Write/One-wait-state PCI Target Read interface
- Supports all PCI commands, including configuration and MWI
- Supports fully-customizable byte enable for master channels
- Target interface supports retry, disconnect with/without data transfer, and target abort
- Programmable back-end interface to optional local processor
- Independent PCI bus (33 MHz) and local bus (up to 160 MHz) clocks
- Fully customizable PCI Configuration Space
- Configurable FIFOs with depths up to 256
- Reference design with driver code (Win 95/98/Win 2000/NT4.0) available
- PCI v2.2 compliant
- Supports Type 0 Configuration Cycles in Target mode
- 3.3V, 5V Tolerant PCI signaling supports Universal PCI Adapter designs
- 3.3V CMOS in 208-pin PQFP and 456-pin PBGA
- Supports endian conversions
- Unlimited/Continuous Burst Transfers supported

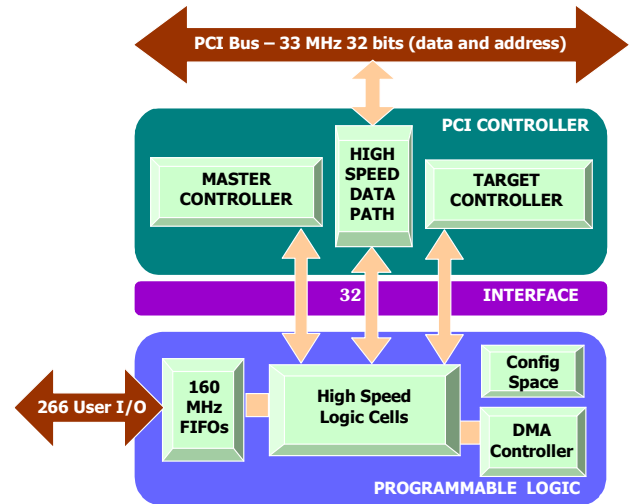


FIGURE 1. QL5432 Diagram

Extendable PCI Functionality

- Support for PCI host-bridge function
- Support for Configuration Space from 0x40 to 0x3FF
- Multi-Function, Expanded Capabilities, & Expansion ROM capable
- Power management, Compact PCI, hot-swap/hot-plug compatible
- PCI v2.2 Power Management Spec compatible
- PCI v2.2 Vital Product Data (VPD) configuration support
- Programmable Interrupt Generator
- I₂O support with local processor
- Mailbox register support

Programmable Logic

- 1427 Logic Cells
- 23,040 RAM bits, up to 266 I/O pins
- 250 MHz 16-bit counters, 275 MHz Datapaths, 160 MHz FIFOs
- All back-end interface and glue-logic can be implemented on chip
- Any combination of FIFOs that require 20 or less QuickLogic RAM Modules
- Six 32-bit busses interface between the PCI Controller and the Programmable Logic

Architecture Overview

The QL5432 device in the QuickLogic QuickPCI ESP (Embedded Standard Product) family provides a complete and customizable PCI interface solution combined with programmable logic. This device eliminates any need for the designer to worry about PCI bus compliance, yet allows for the maximum 32-bit PCI bus bandwidth (132 MB/s).

The programmable logic portion of the device contains 1427 QuickLogic Logic Cells, and 20 QuickLogic Dual-Port RAM Blocks. These configurable RAM blocks can be configured in many width/depth combinations. They can also be combined with logic cells to form FIFOs, or be initialized via Serial EEPROM on power-up and used as ROMs.

The QL5432 device meets PCI 2.2 electrical and timing specifications and has been fully hardware-tested. This device also supports the Win'98 and PC'98 standards. The QL5432 device features 3.3-volt operation with multi-volt compatible I/Os. Thus it can easily operate in 3-volt systems and is fully compatible with 3.3V, 5V or Universal PCI card applications.

PCI Controller

The PCI Controller is a 32-bit/33 MHz PCI 2.2 Compliant Master/Target Controller. It is capable of infinite length Master Write and Read transactions at zero wait states (132 MBytes/second). The Master will never insert wait states during transfers, so data should be supplied or received by FIFOs, which can be configured in the programmable region of the device. The Master is capable of initiating any type of PCI command, including configuration cycles and Memory Write and Invalidate (MWI). This enables the QL5432 device to act as a PCI host. The Master Controller will most often be operated by a DMA Controller in the programmable region of the device. A DMA Controller reference design is available.

The Target interface offers full PCI Configuration Space and flexible target addressing. It supports zero-wait-state target write and one-wait-state target read operations. It also supports retry, disconnect with/without data transfer, and target abort requested by the backend. Any number of 32-bit BARs may be configured, as either memory or I/O space. All required and optional PCI 2.2 Configuration Space registers can be implemented within the programmable region of the device. A reference design of a Target Configuration and Addressing module is provided.

The interface ports are divided into a set of ports for master transactions and a set for target transactions. The Master DMA controller and Target Configuration Space and Address Decoding are done in the programmable logic region of the device. Since these functions are not timing critical, leaving these elements in the programmable region allows the greatest degree of flexibility to the designer. Reference DMA controller, Configuration Space, and Address Decoding blocks are included so that the design cycle can be minimized.

Configuration Space and Address Decode

The configuration space is completely customizable in the programmable region of the device. PCI address and command decoding is performed by logic in the programmable section of the device. This allows support for any size of memory or I/O space for back-end logic. It also allows the user to implement any subset of the PCI commands supported by the QL5432. QuickLogic provides a reference Address Register/Counter and Command Decode block.

DMA Master/Target Control

The customizable DMA controller included with the QuickWorks design software contains the following features:

- Configurable DMA count size for Reads and Writes (up to 30-bits)
- Configurable DMA burst size for PCI (including unlimited/continuous burst)
- Customizable PCI command to use by core
- Customizable Byte Enable signal
- Programmable Arbitration between DMA Read & Write transactions
- DMA Registers may be mapped to any area of Target Memory Space
 - Read Address (32-bit register)
 - Write Address (32-bit register)
 - Read Length (16-bit register) / Write Length (16-bit register)
 - Control and Status (32-bit register, includes 8 bit Burst Length)
- DMA Registers are available to the local design or the PCI bus
- Programmable Interrupt Control to signal end of transfer or other event

Configurable FIFOs

FIFOs may be created with the RAM/FIFO wizard in the QuickWorks tools. The figure below shows the graphical interface used to create these FIFOs.

FIFOs may be designed up to 256 deep. With 20 RAM cells available in the QL5432, that allows for up to 10 FIFOs at 64 deep (36 wide), 5 FIFOs at 128 deep (36 wide), 2 FIFOs at 256 deep (40 wide), or 1 FIFO at 512 deep (40 wide).



FIGURE 2: Graphical Interface to create FIFO

PCI Interface Symbol

The figure below shows the interface symbol you would use in your schematic design in order to attach the local interface programmable logic design to the PCI core. If you were designing with a top-level Verilog or VHDL file, then you would use a structural instantiation of this PCI32N block, instead of a graphical symbol.

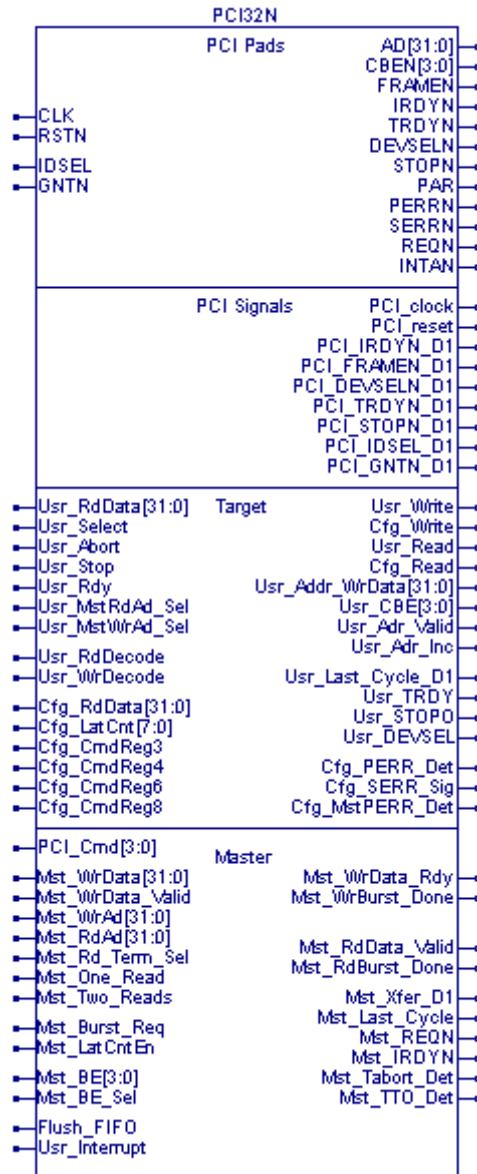


FIGURE 3: PCI Interface Symbol

PCI Master Interface

The internal signals used to interface with the PCI controller in the QL5432 are listed below, along with a description of each signal. The direction of the signal indicates if it is an input provided by the local interface (i) or an output provided by the PCI controller (o). Signals that end with the character 'N' should be considered active-low (for example, Mst_IRDYN).

PCI_Cmd[3:0]	I	PCI command to be used for the master transaction. This signal must remain unchanged throughout the period when Mst_Burst_Req is active. PCI commands considered as reads include Interrupt Acknowledge, I/O Read, Memory Read, Configuration Read, Memory Read Multiple, Memory Read Line. PCI commands considered as writes include Special Cycle, I/O Write, Memory Write, Configuration Write, Memory Write and Invalidate. Users should make sure that only valid PCI commands are supplied.
Mst_Burst_Req	I	Request use of the PCI bus. When it is active, the core requests the PCI bus and then generates a master transaction. This signal should be held active until all requested data are transferred on the PCI bus and deactivated in the 2nd clock cycle following the last data transfer on PCI (to avoid being considered as requesting a new transaction).
Mst_WrAd[31:0]	I	Address for master DMA writes. This address must be treated as valid from the beginning of a DMA write until the DMA write operation is complete. It should be incremented (by 4 bytes) each time data is transferred on the PCI bus.
Mst_RdAd[31:0]	I	Address for master DMA reads. This address must be treated as valid from the beginning of a DMA read until the DMA read operation is complete. It should be incremented (by 4 bytes) each time data is transferred on the PCI bus.
Mst_WrData[31:0]	I	Data for master DMA writes (to PCI bus).
Mst_BE[3:0]	I	Byte enables for master DMA reads and writes. Active-low.
Mst_WrData_Valid	I	Data and byte enable valid on Mst_WrData[31:0] (for master write only) and Mst_BE[3:0] (for both master read and write).
Mst_WrData_Rdy	O	Data receive acknowledge for Mst_WrData[31:0] (for master write only) and Mst_BE[3:0] (for both). This serves as the PUSH control for the internal FIFO and the POP control for the external FIFO (in FPGA region) which provides data and byte enables to the PCI32 core.
Mst_BE_Sel	I	Byte enable select for master transactions. When low, Mst_BE[3:0] should remain constant throughout the entire transfer (when Mst_Burst_Req is active) and it is used for every data phase of the master transaction. When high, Mst_BE[3:0] pushed into internal FIFO (along with data in case of master write) is used. Should be held constant throughout the transaction.
Mst_WrBurst_Done	O	Master write transaction is completed. Active for only one clock cycle.
Mst_Rd_Term_Sel	I	Master read termination mode select when Mst_BE_Sel is high. When both Mst_BE_Sel and Mst_Rd_Term_Sel are high, master read termination happens when the internal FIFO is empty, and Mst_Two_Reads and Mst_One_Read are ignored. When either signal is low, Mst_Two_Reads and Mst_One_Read are used to signal end of master read. Should be held constant throughout the transaction.
Mst_One_Read	I	This signals to the PCI32 core that only one data transfer remains to be read in the burst read.
Mst_Two_Reads	I	Two data transfers remain to be read in the burst read. It is not used for single-data-phase master read transactions.
Mst_RdData_Valid	O	Master read data valid on Mst_WrData[31:0]. This serves as the PUSH control for the external FIFO (in FPGA region) that receives data from the PCI32 core.
Mst_RdBurst_Done	O	Master read transaction is completed. Active for only one clock cycle.
Flush_FIFO	I	Internal FIFO flush. FIFO flushed immediately after it is active (synchronized with PCI clock).
Mst_LatCntEn	I	Enable Latency Counter. Set to 0 to ignore the Latency Timer in the PCI configuration space (offset 0Ch). For full PCI compliance, this port should be always set to 1.
Mst_Xfer_D1	O	Data was transferred on the previous PCI clock. Useful for updating DMA transfer counts on DMA Read operations.
Mst_Last_Cycle	O	Active during the last data transfer of a master transaction.
Mst_REQN	O	Copy of the PCI REQN signal generated by QL5x33 as PCI master. Not usually used in the back-end design.

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Mst_IRDYN	O	Copy of the PCI IRDYN signal generated by QL5x33 as PCI master. Valid only when QL5x33 is the PCI master. Kept low otherwise. Not usually used in the back-end design.
Mst_Tabort_Det	O	Target abort detected during master transaction. This is normally an error condition to be handled in the DMA controller.
Mst_TTO_Det	O	Target timeout detected (no response from target). This is normally an error condition to be handled in the DMA controller.

PCI Target Interface

Usr_Addr_WrData[31:0]	O	Target address, and target write data. During all target accesses, the address is presented on Usr_Addr_WrData[31:0] at the same time Usr_Adr_Valid is active. During target write transactions, this port also presents valid write data to the PCI configuration space or user logic when Usr_Adr_Inc is active.
Usr_CBE[3:0]	O	PCI command and byte enables. During target accesses, the PCI command is presented on Usr_CBE[3:0] at the same time Usr_Adr_Valid is active. This port also presents active-low byte enables to the PCI configuration space or user logic.
Usr_Adr_Valid	O	Indicates the beginning of a PCI transaction, and that a target address is valid on Usr_Addr_WrData[31:0] and the PCI command is valid on Usr_CBE[3:0]. When this signal is active, the target address must be latched and decoded to determine if this address belongs to the device's memory or I/O space. Also, the PCI command must be decoded to determine the type of PCI transaction. On subsequent clocks of a target access, this signal is low, indicating that address is NOT present on Usr_Addr_WrData[31:0].
Usr_Adr_Inc	O	Indicates that the target address should be incremented, because the previous data transfer has completed. During burst target accesses, the target address is only presented to the back-end logic at the beginning of the transaction (when Usr_Adr_Valid is active), and must therefore be latched and incremented (by 4) for subsequent data transfers. Note that during target write transactions, Usr_Adr_Inc indicates valid data on Usr_Addr_WrData[31:0] that must be accepted by the backend logic (regardless of the state of Usr_Rdy). During read transactions, Usr_Adr_Inc signals to the backend that the PCI core has presented the read data on the PCI bus (TRDYN asserted).
Usr_RdDecode	I	This signal should be the combinatorial decode of the "user read" command from Usr_CBE[3:0]. This command may be mapped from any of the PCI "read" commands, such as Memory Read, Memory Read Line, Memory Read Multiple, I/O Read, etc. It is internally gated with Usr_Adr_Valid.
Usr_WrDecode	I	This signal should be the combinatorial decode of the "user write" command from Usr_CBE[3:0]. This command may be mapped from any of the PCI "write" commands, such as Memory Write or I/O Write. It is internally gated with Usr_Adr_Valid.
Usr_Select	I	This signal should be driven active when the address on Usr_Addr_WrData[31:0] has been decoded and determined to be within the address space of the device. Usr_Addr_WrData[31:0] must be compared to each of the valid Base Address Registers in the PCI configuration space. Also, this signal must be gated by the Memory Access Enable or I/O Access Enable registers in the PCI configuration space (Command Register bits 1 or 0 at offset 04h). Internally gated with Usr_Adr_Valid.
Usr_Write	O	This signal is active throughout a "user write" transaction, which has been decoded by Usr_WrDecode at the beginning of the transaction. The write strobe for individual DWORDs of data (on Usr_Addr_WrData[31:0]) during a user write transaction should be generated by logically ANDing this signal with Usr_Adr_Inc.
Cfg_Write	O	This signal is active throughout a "configuration write" transaction. The write strobe for individual DWORDs of data (on Usr_Addr_WrData[31:0]) during a configuration write transaction should be generated by logically ANDing this signal with Usr_Adr_Inc.
Usr_Read	O	This signal is active throughout a "user read" transaction, which has been decoded by Usr_RdDecode at the beginning of the transaction.
Cfg_Read	O	This signal is active throughout a "configuration read" transaction.
Cfg_RdData[31:0]	I	Data from the PCI configuration registers, required to be presented during PCI configuration reads.
Usr_RdData[31:0]	I	Data from the back-end user logic, required to be presented during PCI user reads.

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Cfg_CmdReg3	I	Bits 3 from the Command Register in the PCI configuration space (offset 04h). Enable Special Cycle monitoring. If high, the core reports data parity error in Special Cycles through SERRN if Cfg_CmdReg8 is active.
Cfg_CmdReg4	I	Bits 4 from the Command Register in the PCI configuration space (offset 04h). Memory Write and Invalidate (MWI) Enable. If high, the core generates MWI transactions as requested by the backend. Otherwise it uses Memory Write instead even if MWI is requested.
Cfg_CmdReg6	I	Bits 6 from the Command Register in the PCI configuration space (offset 04h). Parity Error Response. If high, the core uses PERRN to report data parity errors. Otherwise it never drives it.
Cfg_CmdReg8	I	Bits 8 from the Command Register in the PCI configuration space (offset 04h). SERRN Enable. If high, the cores uses SERRN to report address parity errors if Cfg_CmdReg6 is high.
Cfg_LatCnt[7:0]	I	8-bit value of the Latency Timer in the PCI configuration space (offset 0Ch).
Usr_MstRdAd_Sel	I	Used when a target read operation should return the value set on the Mst_RdAd[31:0] pins. This select pin saves on logic which would otherwise need to be used to multiplex Mst_RdAd[31:0] into the Usr_RdData[31:0] bus. When this signal is asserted, the data on Usr_RdData[31:0] is ignored.
Usr_MstWrAd_Sel	I	Used when a target read operation should return the value set on the Mst_WrAd[31:0] pins. This select pin saves on logic which would otherwise need to be used to multiplex Mst_WrAd[31:0] into the Usr_RdData[31:0] bus. When this signal is asserted, the data on Usr_RdData[31:0] is ignored.
Cfg_PERR_Det	O	Parity error detected on the PCI bus. When this signal is active, bit 15 of the Status Register must be set in the PCI configuration space (offset 04h).
Cfg_SERR_Sig	O	System error asserted on the PCI bus. When this signal is active, the Signalled System Error bit, bit 14 of the Status Register, must be set in the PCI configuration space (offset 04h).
Cfg_MstPERR_Det	O	Data parity error detected on the PCI bus by the master. When this signal is active, bit 8 of the Status Register must be set in the PCI configuration space (offset 04h).
Usr_TRDY	O	Inverted copy of the TRDYN signal as driven by the PCI target interface. Valid only within a target access.
Usr_STOPO	O	Inverted copy of the STOPN signal as driven by the PCI target interface. Valid only within a target access.
Usr_DEVSEL	O	Inverted copy of the DEVSELN signal as driven by the PCI target interface. Valid only within a target access.
Usr_Last_Cycle_D1	O	Active one clock cycle after the last data phase (may not with data transfer) occurs on PCI and inactive one clock cycle afterwards.
Usr_Rdy	I	Used to delay (add wait states to) a target PCI transaction when the backend needs additional time to provide data (read) or accept data (write). Subject to PCI latency restrictions.
Usr_Stop	I	Used to prematurely stop a PCI target access on the next PCI clock.
Usr_Abort	I	Used to signal Target Abort on PCI when the backend has fatal error and is unable to complete a transaction. Rarely used.
Usr_Interrupt	I	Used to signal an interrupt on the PCI bus

PCI Internal Signals

PCI_clock	O	PCI clock.
PCI_reset	O	PCI reset signal.
PCI_IRDYN_D1	O	Copy of the IRDYN signal from the PCI bus, delayed by one clock.
PCI_FRAMEN_D1	O	Copy of the FRAMEN signal from the PCI bus, delayed by one clock.
PCI_DEVSELN_D1	O	Copy of the DEVSELN signal from the PCI bus, delayed by one clock.
PCI_TRDYN_D1	O	Copy of the TRDYN signal from the PCI bus, delayed by one clock.
PCI_STOPN_D1	O	Copy of the STOPN signal from the PCI bus, delayed by one clock.
PCI_IDSEL_D1	O	Copy of the IDSEL signal from the PCI bus, delayed by one clock.

RAM Module Features

The QL5432 device has twenty 1,152-bit RAM modules, for a total of 23,040 RAM bits. Using two “mode” pins, designers can configure each module into 64 (deep) x18 (wide), 128x9, 256x4, or 512x2 blocks. See the figure below. The blocks are also easily cascadable to increase their effective width or depth.

The RAM modules are “dual-ported”, with completely independent READ and WRITE ports and separate READ and WRITE clocks. The READ ports support asynchronous and synchronous operation, while the WRITE ports support synchronous operation. Each port has 18 data lines and 9 address lines, allowing word lengths of up to 18 bits and address spaces of up to 512 words. Depending on the mode selected, however, some higher order data or address lines may not be used.

The Write Enable (WE) line acts as a clock enable for synchronous write operation. The Read Enable (RE) acts as a clock enable for synchronous READ operation (ASYNCRD input low), or as a flow-through enable for asynchronous READ operation (ASYNCRD input high).

Designers can cascade multiple RAM modules to increase the depth or width allowed in single modules by connecting corresponding address lines together and dividing the words between modules. This approach allows up to 512-deep configurations as large as 40 bits wide in the QL5432 device.

A similar technique can be used to create depths greater than 512 words. In this case address signals higher than the eighth bit are encoded onto the write enable (WE) input for WRITE operations. The READ data outputs are multiplexed together using encoded higher READ address bits for the multiplexer SELECT signals.

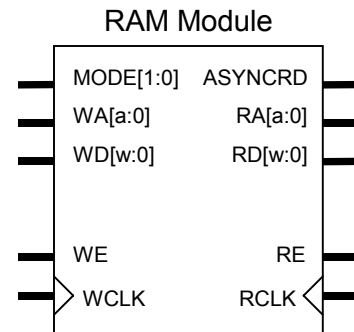


FIGURE 4: RAM Module

	Address Buses [a:0]	Data Buses [w:0]
64x18	[5:0]	[17:0]
128x9	[6:0]	[8:0]
256x4	[7:0]	[3:0]
512x2	[8:0]	[1:0]

JTAG Support

JTAG pins support IEEE standard 1149.1a to provide boundary scan capability for the QL5432 device. Six pins are dedicated to JTAG and programming functions on each QL5432 device, and are unavailable for general design input and output signals. TDI, TDO, TCK, TMS, and TRSTB are JTAG pins. A sixth pin, STM, is used only for programming.

Development Tool Support

Software support for the QL5432 device is available through the QuickWorks® development package. This turnkey PC-based QuickWorks® package, shown in Figure 5, provides a complete ESP software solution with design entry, logic synthesis, place and route, and simulation. QuickWorks® includes VHDL, Verilog, schematic, and mixed-mode entry with fast and efficient logic synthesis provided by the integrated Synplicity Synplify Lite™ tool, specially tuned to take advantage of the QL5432 architecture. QuickWorks also provides functional and timing simulation for guaranteed timing and source-level debugging.

The UNIX-based QuickTools™ package is a subset of QuickWorks® and provides a solution for designers who use schematic-only design flow third-party tools for design entry, synthesis, or simulation. QuickTools™ reads EDIF netlists and provides support for all QuickLogic devices. QuickTools™ also supports a wide range of third-party modeling and simulation tools.

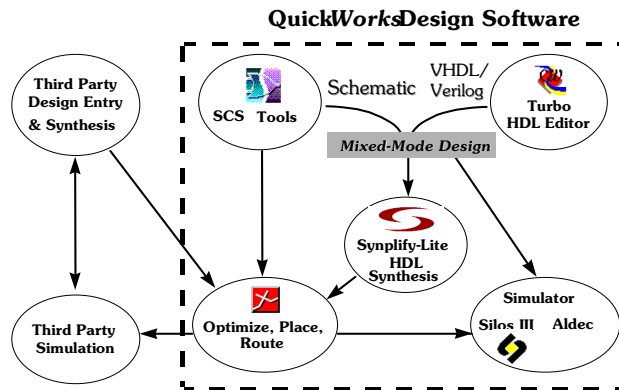


FIGURE 5: QuickWorks® Tool Suite

Electrical Specifications

Absolute Maximum Ratings

VCC Voltage	-0.5 to 4.6V	DC Input Current	±20 mA
VCCIO Voltage	-0.5 to 7.0V	ESD Pad Protection	±2000V
Input Voltage	-0.5V to VCCIO +0.5V	Storage Temperature	-65°C to + 150°C
Latch-up Immunity	±200mA	Lead Temperature	300°C

Operating Range

Symbol	Parameter	Industrial		Commercial		Unit	
		Min	Max	Min	Max		
VCC	Supply Voltage	3.0	3.6	3.0	3.6	V	
VCCIO	I/O Input Tolerance Voltage	3.0	5.5	3.0	5.25	V	
TA	Ambient Temperature	-40	85	0	70	°C	
K	Delay Factor	-A Speed Grade	0.43	0.95	0.46	0.93	

DC Characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
VIH	Input HIGH Voltage		0.5VCC	VCCIO+0.5	V
VIL	Input LOW Voltage		-0.5	0.3VCC	V
VOH	Output HIGH Voltage	IOH = -12 mA	2.4		V
		IOH = -500 µA	0.9VCC		V
VOL	Output LOW Voltage	IOL = 16 mA		0.45	V
		IOL = 1.5 mA		0.1VCC	V
II	I or I/O Input Leakage Current	VI = VCCIO or GND	-10	10	µA
IOZ	3-State Output Leakage Current	VI = VCCIO or GND	-10	10	µA
CI	Input Capacitance [1]			10	pF
IOS	Output Short Circuit Current [2]	VO = GND	-15	-180	mA
		VO = VCC	40	210	mA
ICC	D.C. Supply Current [3]	VI, VIO = VCCIO or GND	0.50 (typ)	2	mA
ICCIO	D.C. Supply Current on VCCIO		0	100	µA

Notes:

- [1] Capacitance is sample tested only.
- [2] Only one output at a time. Duration should not exceed 30 seconds.
- [3] For -A commercial grade device only. Maximum ICC is 3 mA for all industrial grade devices. For AC conditions, contact QuickLogic Customer Engineering.

AC CHARACTERISTICS at VCC = 3.3V, TA = 25°C (K = 1.00)

(To calculate delays, multiply the appropriate K factor in the “Operating Range” section by the following numbers.)

Logic Cells

Symbol	Parameter	Propagation Delays (ns)				
		Fanout [4]				
		1	2	3	4	8
tPD	Combinatorial Delay [5]	1.4	1.7	2.0	2.3	3.5
tSU	Setup Time [5]	1.8	1.8	1.8	1.8	1.8
tH	Hold Time	0.0	0.0	0.0	0.0	0.0
tCLK	Clock to Q Delay	0.8	1.1	1.4	1.7	2.9
tCWHI	Clock High Time	1.6	1.6	1.6	1.6	1.6
tCWLO	Clock Low Time	1.6	1.6	1.6	1.6	1.6
tSET	Set Delay	1.4	1.7	2.0	2.3	3.5
tRESET	Reset Delay	1.2	1.5	1.8	2.1	3.3
tSW	Set Width	1.9	1.9	1.9	1.9	1.9
tRW	Reset Width	1.8	1.8	1.8	1.8	1.8

RAM Cell Synchronous Write Timing

Symbol	Parameter	Propagation Delays (ns)				
		Fanout [4]				
		1	2	3	4	8
TSWA	WA Setup Time to WCLK	1.0	1.0	1.0	1.0	1.0
THWA	WA Hold Time to WCLK	0.0	0.0	0.0	0.0	0.0
TSWD	WD Setup Time to WCLK	1.0	1.0	1.0	1.0	1.0
THWD	WD Hold Time to WCLK	0.0	0.0	0.0	0.0	0.0
TSWE	WE Setup Time to WCLK	1.0	1.0	1.0	1.0	1.0
THWE	WE Hold Time to WCLK	0.0	0.0	0.0	0.0	0.0
TWCRD	WCLK to RD (WA=RA) [4]	5.0	5.3	5.6	5.9	7.1

Notes:

- [4] Stated timing for worst case Propagation Delay over process variation at VCC=3.3V and TA=25°C. Multiply by the Appropriate Delay Factor, K, for speed grade, voltage and temperature settings as specified in the Operating Range.
- [5] These limits are derived from a representative selection of the slowest paths through the QuickRAM logic cell including typical net delays. Worst case delay values for specific paths should be determined from timing analysis of your particular design.

RAM Cell Synchronous Read Timing

Symbol	Parameter	Propagation Delays (ns) Fanout				
		1	2	3	4	8
TSRA	RA Setup Time to RCLK	1.0	1.0	1.0	1.0	1.0
THRA	RA Hold Time to RCLK	0.0	0.0	0.0	0.0	0.0
TSRE	RE Setup Time to RCLK	1.0	1.0	1.0	1.0	1.0
THRE	RE Hold Time to RCLK	0.0	0.0	0.0	0.0	0.0
TRCRD	RCLK to RD [5]	4.0	4.3	4.6	4.9	6.1

RAM Cell Asynchronous Read Timing

Symbol	Parameter	Propagation Delays (ns) Fanout				
		1	2	3	4	8
RPDRD	RA to RD [5]	3.0	3.3	3.6	3.9	5.1

Input-Only Cells

Symbol	Parameter	Propagation Delays (ns) Fanout [5]						
		1	2	3	4	8	12	24
TIN	High Drive Input Delay	1.5	1.6	1.8	1.9	2.4	2.9	4.4
TINI	High Drive Input, Inverting Delay	1.6	1.7	1.9	2.0	2.5	3.0	4.5
TISU	Input Register Set-Up Time	3.1	3.1	3.1	3.1	3.1	3.1	3.1
TIH	Input Register Hold Time	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TICLK	Input Register Clock To Q	0.7	0.8	1.0	1.1	1.6	2.1	3.6
TIRST	Input Register Reset Delay	0.6	0.7	0.9	1.0	1.5	2.0	3.5
TIESU	Input Register Clock Enable Setup Time	2.3	2.3	2.3	2.3	2.3	2.3	2.3
TIEH	Input Register Clock Enable Hold Time	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Clock Cells

Symbols	Parameter	Propagation Delays (ns) Loads per Half Column [6]							
		1	2	3	4	8	10	12	15
tACK	Array Clock Delay	1.2	1.2	1.3	1.3	1.5	1.6	1.7	1.8
tGCKP	Global Clock Pin Delay	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
tGCKB	Global Clock Buffer Delay	0.8	0.8	0.9	0.9	1.1	1.2	1.3	1.4

Notes:

- [6] The array distributed networks consist of 40 half columns and the global distributed networks consist of 44 half columns, each driven by an independent buffer. The number of half columns used does not affect clock buffer delay. The array clock has up to 8 loads per half column. The global clock has up to 11 loads per half column.

I/O Cell Input Delays

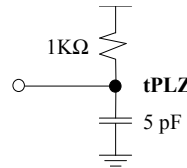
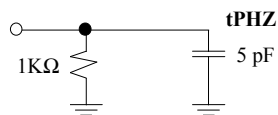
Symbol	Parameter	Propagation Delays (ns)					
		Fanout [5]					
		1	2	3	4	8	10
tI/O	Input Delay (bidirectional pad)	1.3	1.6	1.8	2.1	3.1	3.6
TISU	Input Register Set-Up Time	3.1	3.1	3.1	3.1	3.1	3.1
TIH	Input Register Hold Time	0.0	0.0	0.0	0.0	0.0	0.0
TIOCLK	Input Register Clock To Q	0.7	1.0	1.2	1.5	2.5	3.0
TIORST	Input Register Reset Delay	0.6	0.9	1.1	1.4	2.4	2.9
TIESU	Input Register clock Enable Set-Up Time	2.3	2.3	2.3	2.3	2.3	2.3
TIEH	Input Register Clock Enable Hold Time	0.0	0.0	0.0	0.0	0.0	0.0

I/O Cell Output Delays

Symbol	Parameter	Propagation Delays (ns)				
		Output Load Capacitance (pF)				
		30	50	75	100	150
TOUTLH	Output Delay Low to High	2.1	2.5	3.1	3.6	4.7
TOUTH	Output Delay High to Low	2.2	2.6	3.2	3.7	4.8
TPZH	Output Delay Tri-state to High	1.2	1.7	2.2	2.8	3.9
TPZL	Output Delay Tri-state to Low	1.6	2.0	2.6	3.1	4.2
TPHZ	Output Delay High to Tri-State [8]	2.0				
TPLZ	Output Delay Low to Tri-State [8]	1.2				

Notes:

[7] The following loads are used for tPXZ:



Pin Type Descriptions

The QL5432 Device Pins are indicated in the table below. These are pins on the device, some of which connect to the PCI bus, and others that are programmable as user IO.

Type	Description
IN	Input. A standard input-only signal
OUT	Totem pole output. A standard active output driver
T/S	Tri-state. A bi-directional, tri-state input/output pin
S/T/S	Sustained Tri-state. An active low tri-state signal driven by one PCI agent at a time. It must be driven high for at least one clock before being disabled (set to Hi-Z). A pull-up needs to be provided by the PCI system central resource to sustain the inactive state once the active driver has released the signal.
O/D	Open Drain. Allows multiple devices to share this pin as a wired-or.

Pin/Bus Name	Type	Function
VCC	IN	Supply pin. Tie to 3.3V supply.
VCCIO	IN	Supply pin for I/O. Set to 3.3V for 3.3V I/O, 5V for 5.0V compliant I/O
GND	IN	Ground pin. Tie to GND on the PCB.
I/O	T/S	Programmable Input/Output/Tri-State/Bi-directional Pin.
GLCK/I	IN	Programmable Global Network or Input-only pin. Tie to VCC or GND if unused.
ACLK/I	IN	Programmable Array Network or Input-only pin. Tie to VCC or GND if unused.
TDI/RSI*	IN	JTAG Data In/Ram Init. Serial Data In. Tie to VCC if unused. Connect to Serial EPROM data for RAM init.
TDO/RCO*	OUT	JTAG Data Out/Ram Init Clock. Leave unconnected if unused. Connect to Serial EPROM clock for RAM init.
TCK	IN	JTAG Clock. Tie to GND if unused.
TMS	IN	JTAG Test Mode Select. Tie to VCC if unused.
TRSTB/RRO*	IN	JTAG Reset/RAM Init. Reset Out. Tie to GND if unused. Connect to Serial EPROM reset for RAM init.
STM	IN	QuickLogic Reserved pin. Tie to GND on the PCB.

* See QuickNote 65 on the QuickLogic web site for information on RAM initialization.

QL5432 External Device Pins

Pin/Bus Name	Type	Function
AD[31:0]	T/S	PCI Address and Data: 32 bit multiplexed address/data bus.
CBEN[3:0]	T/S	PCI Bus Command and Byte Enables: Multiplexed bus which contains byte enables for AD[31:0] or the Bus Command during the address phase of a PCI transaction.
PAR	T/S	PCI Parity: Even Parity across AD[31:0] and C/BEN[3:0] busses. Driven one clock after address or data phases. Master drives PAR on address cycles and PCI writes. The Target drives PAR on PCI reads.
FRAMEN	S/T/S	PCI Cycle Frame: Driven active by current PCI Master during a PCI transaction. Driven low to indicate the address cycle, driven high at the end of the transaction.
DEVSELN	S/T/S	PCI Device Select. Driven by a Target that has decoded a valid base address.
CLK	IN	PCI System Clock Input.
RSTN	IN	PCI System Reset Input
REQN	T/S	PCI Request. Indicates to the Arbiter that this PCI Agent (Initiator) wishes to use the bus. A point to point signal between the PCI Device and the System Arbiter.
GNTN	IN	PCI Grant. Indicates to a PCI Agent (Initiator) that it has been granted access to the PCI bus by the Arbiter. A point to point signal between the PCI device and the System Arbiter.
PERRN	S/T/S	PCI Data Parity Error. Driven active by the initiator or target two clock cycles after a data parity error is detected on the AD and C/BE# busses.
SERRN	O/D	PCI System Error: Driven active when an address cycle parity error, data parity error during a special cycle, or other catastrophic error is detected.
IDSEL	IN	PCI Initialization Device Select. Use to select a specific PCI Agent during System Initialization.
IRDYN	S/T/S	PCI Initiator Ready. Indicates the Initiator's ability to complete a read or write transaction. Data transfer occurs only on clock cycles where both IRDYN and TRDYN are active.
TRDYN	S/T/S	PCI Target Ready. Indicates the Target's ability to complete a read or write transaction. Data transfer occurs only on clock cycles where both IRDYN and TRDYN are active.
STOPN	S/T/S	PCI Stop. Used by a PCI Target to end a burst transaction.
INTAN	O/D	Interrupt A. Asynchronous Active-Low Interrupt Request.

Pinout Diagrams

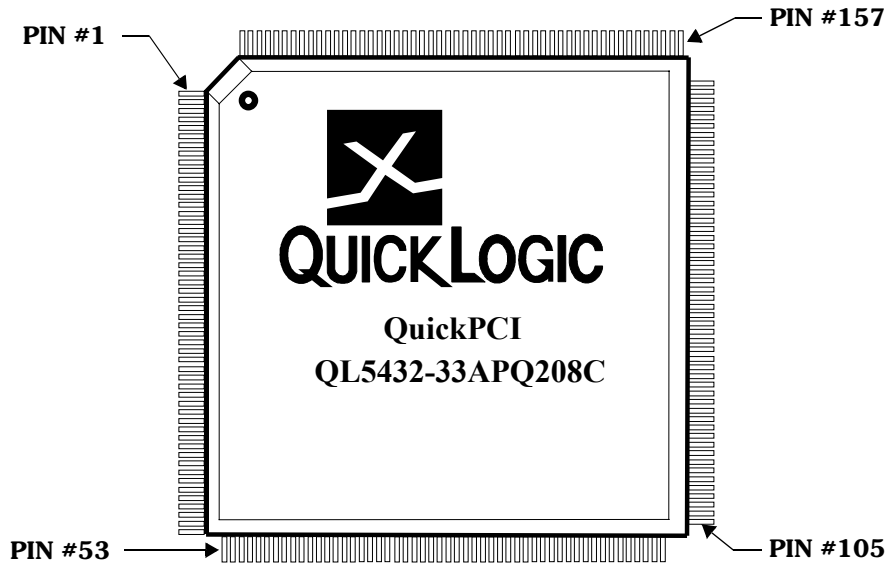


FIGURE 6: 208-pin PQFP

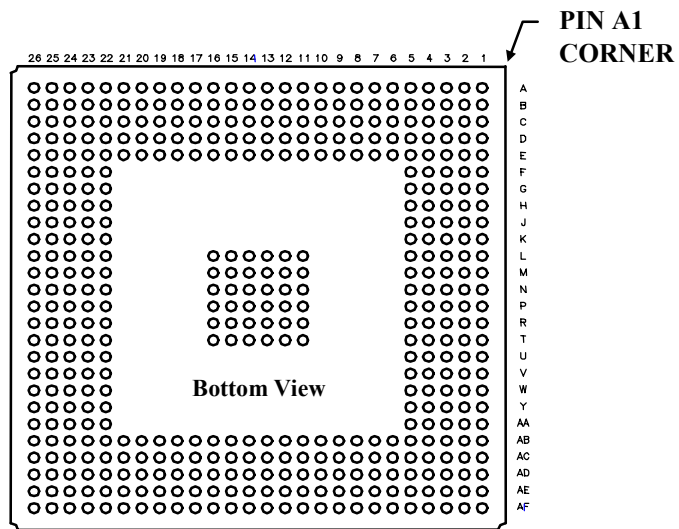


FIGURE 7: 456-pin PBGA

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QL5432 - 208 PQFP Pinout Table

PQ208	FUNCTION	PQ208	FUNCTION	PQ208	FUNCTION	PQ208	FUNCTION	PQ208	FUNCTION
1	I/O	43	GND	85	AD[3]	127	GND	169	I/O
2	I/O	44	IDSEL	86	AD[2]	128	I/O	170	I/O
3	I/O	45	AD[23]	87	AD[1]	129	GCLK/1	171	I/O
4	I/O	46	AD[22]	88	AD[0]	130	ACLK/1	172	I/O
5	I/O	47	AD[21]	89	I/O	131	VCC	173	I/O
6	I/O	48	AD[20]	90	I/O	132	GCLK/1	174	I/O
7	I/O	49	AD[19]	91	I/O	133	GCLK/1	175	I/O
8	I/O	50	AD[18]	92	I/O	134	VCC	176	I/O
9	I/O	51	AD[17]	93	I/O	135	I/O	177	GND
10	VCC	52	AD[16]	94	I/O	136	I/O	178	I/O
11	I/O	53	CBEN[2]	95	GND	137	I/O	179	I/O
12	GND	54	TDI	96	I/O	138	I/O	180	I/O
13	I/O	55	FRAMEN	97	VCC	139	I/O	181	I/O
14	I/O	56	IRDYN	98	I/O	140	I/O	182	GND
15	I/O	57	TRDYN	99	I/O	141	I/O	183	I/O
16	I/O	58	DEVSELN	100	I/O	142	I/O	184	I/O
17	I/O	59	GND	101	I/O	143	I/O	185	I/O
18	I/O	60	STOPN	102	I/O	144	I/O	186	I/O
19	I/O	61	VCC	103	TRSTB	145	VCC	187	VCCIO
20	I/O	62	I/O	104	TMS	146	I/O	188	I/O
21	I/O	63	I/O	105	I/O	147	GND	189	I/O
22	I/O	64	PERRN	106	I/O	148	I/O	190	I/O
23	GND	65	I/O	107	I/O	149	I/O	191	I/O
24	INTAN	66	SERRN	108	I/O	150	I/O	192	I/O
25	RSTN	67	PAR	109	I/O	151	I/O	193	I/O
26	ACLK/1	68	CBEN[1]	110	I/O	152	I/O	194	I/O
27	VCC	69	AD[15]	111	I/O	153	I/O	195	I/O
28	GCLK/1	70	AD[14]	112	I/O	154	I/O	196	I/O
29	CLK	71	AD[13]	113	I/O	155	I/O	197	I/O
30	VCC	72	AD[12]	114	VCC	156	I/O	198	I/O
31	GNTN	73	GND	115	I/O	157	TCK	199	GND
32	REQN	74	AD[11]	116	GND	158	STM	200	I/O
33	AD[31]	75	AD[10]	117	I/O	159	I/O	201	VCC
34	AD[30]	76	AD[9]	118	I/O	160	I/O	202	I/O
35	AD[29]	77	AD[8]	119	I/O	161	I/O	203	I/O
36	AD[28]	78	GND	120	I/O	162	I/O	204	I/O
37	AD[27]	79	CBEN[0]	121	I/O	163	GND	205	I/O
38	AD[26]	80	AD[7]	122	I/O	164	I/O	206	I/O
39	AD[25]	81	AD[6]	123	I/O	165	VCC	207	TDO
40	AD[24]	82	AD[5]	124	I/O	166	I/O	208	I/O
41	VCC	83	VCCIO	125	I/O	167	I/O		
42	CBEN[3]	84	AD[4]	126	I/O	168	I/O		

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QL5432 - 456 PBGA Pinout Table

PB456	Function	PB456	Function	PB456	Function	PB456	Function	PB456	Function
A1	I/O	B26	STM	D25	I/O	H4	I/O	M14	GND/THERM
A2	I/O	C1	I/O	D26	I/O	H5	NC	M15	GND/THERM
A3	I/O	C2	I/O	E1	I/O	H22	NC	M16	GND/THERM
A4	I/O	C3	I/O	E2	I/O	H23	I/O	M22	NC
A5	I/O	C4	TDO	E3	I/O	H24	I/O	M23	NC
A6	I/O	C5	I/O	E4	I/O	H25	I/O	M24	I/O
A7	I/O	C6	I/O	E5	GND	H26	I/O	M25	I/O
A8	I/O	C7	I/O	E6	VCC	J1	I/O	M26	I/O
A9	I/O	C8	I/O	E7	GND	J2	I/O	N1	CLK
A10	I/O	C9	I/O	E8	NC	J3	I/O	N2	I/O
A11	I/O	C10	I/O	E9	GND	J4	NC	N3	I/O
A12	VCCIO	C11	I/O	E10	I/O	J5	GND	N4	RSTN
A13	I/O	C12	I/O	E11	GND	J22	NC	N5	VCC
A14	I/O	C13	I/O	E12	GND	J23	NC	N11	GND/THERM
A15	I/O	C14	I/O	E13	VCC	J24	I/O	N12	GND/THERM
A16	I/O	C15	I/O	E14	GND	J25	I/O	N13	GND/THERM
A17	I/O	C16	I/O	E15	GND	J26	I/O	N14	GND/THERM
A18	I/O	C17	I/O	E16	GND	K1	I/O	N15	GND/THERM
A19	I/O	C18	I/O	E17	NC	K2	I/O	N16	GND/THERM
A20	I/O	C19	I/O	E18	GND	K3	I/O	N22	GND
A21	I/O	C20	I/O	E19	NC	K4	I/O	N23	I/O
A22	I/O	C21	I/O	E20	GND	K5	VCC	N24	I/O
A23	I/O	C22	I/O	E21	VCC	K22	GND	N25	I/O
A24	I/O	C23	I/O	E22	GND	K23	I/O	N26	I/O
A25	I/O	C24	I/O	E23	I/O	K24	I/O	P1	I/O
A26	I/O	C25	TCK	E24	I/O	K25	I/O	P2	I/O
B1	I/O	C26	I/O	E25	I/O	K26	I/O	P3	I/O
B2	I/O	D1	I/O	E26	I/O	L1	I/O	P4	I/O
B3	I/O	D2	I/O	F1	I/O	L2	I/O	P5	NC
B4	I/O	D3	I/O	F2	I/O	L3	I/O	P11	GND/THERM
B5	I/O	D4	GND	F3	I/O	L4	I/O	P12	GND/THERM
B6	I/O	D5	I/O	F4	NC	L5	NC	P13	GND/THERM
B7	I/O	D6	NC	F5	VCC	L11	GND/THERM	P14	GND/THERM
B8	I/O	D7	I/O	F22	VCC	L12	GND/THERM	P15	GND/THERM
B9	I/O	D8	I/O	F23	NC	L13	GND/THERM	P16	GND/THERM
B10	I/O	D9	GND	F24	I/O	L14	GND/THERM	P22	NC
B11	I/O	D10	I/O	F25	I/O	L15	GND/THERM	P23	GCLK / I
B12	I/O	D11	I/O	F26	I/O	L16	GND/THERM	P24	ACLK / I
B13	I/O	D12	GND	G1	I/O	L22	NC	P25	I/O
B14	I/O	D13	I/O	G2	I/O	L23	I/O	P26	ACLK / I
B15	I/O	D14	I/O	G3	I/O	L24	I/O	R1	I/O
B16	I/O	D15	GND	G4	I/O	L25	I/O	R2	I/O
B17	I/O	D16	I/O	G5	NC	L26	I/O	R3	I/O
B18	I/O	D17	I/O	G22	GND	M1	ACLK / I	R4	NC
B19	I/O	D18	GND	G23	I/O	M2	GCLK/I	R5	NC
B20	I/O	D19	I/O	G24	I/O	M3	I/O	R11	GND/THERM
B21	I/O	D20	I/O	G25	I/O	M4	NC	R12	GND/THERM
B22	I/O	D21	NC	G26	I/O	M5	GND	R13	GND/THERM
B23	I/O	D22	I/O	H1	I/O	M11	GND/THERM	R14	GND/THERM
B24	I/O	D23	GND	H2	I/O	M12	GND/THERM	R15	GND/THERM
B25	I/O	D24	I/O	H3	I/O	M13	GND/THERM	R16	GND/THERM

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456 PBGA Pinout Table Cont'd

PB456	Function	PB456	Function	PB456	Function	PB456	Function
R22	VCC	Y1	I/O	AC6	NC	AE5	AD[27]
R23	NC	Y2	I/O	AC7	AD[22]	AE6	CBEN[3]
R24	I/O	Y3	I/O	AC8	AD[18]	AE7	AD[21]
R25	I/O	Y4	I/O	AC9	NC	AE8	AD[17]
R26	GCLK / I	Y5	I/O	AC10	STOPN	AE9	AD[16]
T1	I/O	Y22	GND	AC11	I/O	AE10	DEVSELN
T2	I/O	Y23	I/O	AC12	NC	AE11	PERRN
T3	I/O	Y24	I/O	AC13	AD[11]	AE12	CBEN[1]
T4	I/O	Y25	I/O	AC14	VCCIO	AE13	AD[12]
T5	VCC	Y26	I/O	AC15	NC	AE14	AD[8]
T11	GND/THERMAL	AA1	I/O	AC16	AD[2]	AE15	AD[5]
T12	GND/THERMAL	AA2	I/O	AC17	I/O	AE16	AD[1]
T13	GND/THERMAL	AA3	NC	AC18	NC	AE17	I/O
T14	GND/THERMAL	AA4	NC	AC19	I/O	AE18	I/O
T15	GND/THERMAL	AA5	VCC	AC20	I/O	AE19	I/O
T16	GND/THERMAL	AA22	VCC	AC21	I/O	AE20	I/O
T22	GND	AA23	NC	AC22	NC	AE21	I/O
T23	I/O	AA24	I/O	AC23	GND	AE22	I/O
T24	I/O	AA25	I/O	AC24	I/O	AE23	NC
T25	I/O	AA26	I/O	AC25	I/O	AE24	TMS
T26	I/O	AB1	I/O	AC26	I/O	AE25	I/O
U1	I/O	AB2	I/O	AD1	I/O	AE26	I/O
U2	I/O	AB3	I/O	AD2	NC	AF1	I/O
U3	I/O	AB4	I/O	AD3	I/O	AF2	I/O
U4	I/O	AB5	GND	AD4	I/O	AF3	REQN
U5	GND	AB6	VCC	AD5	AD[28]	AF4	AD[31]
U22	NC	AB7	NC	AD6	AD[24]	AF5	AD[29]
U23	I/O	AB8	NC	AD7	IDSEL	AF6	AD[25]
U24	I/O	AB9	NC	AD8	AD[20]	AF7	AD[23]
U25	I/O	AB10	VCC	AD9	FRAMEN	AF8	AD[19]
U26	I/O	AB11	GND	AD10	TRDYN	AF9	CBEN[2]
V1	I/O	AB12	NC	AD11	I/O	AF10	IRDYN
V2	I/O	AB13	AD[15]	AD12	PAR	AF11	I/O
V3	I/O	AB14	GND	AD13	AD[13]	AF12	SERRN
V4	NC	AB15	VCC	AD14	AD[9]	AF13	AD[14]
V5	NC	AB16	AD[6]	AD15	CBEN[0]	AF14	AD[10]
V22	GND	AB17	NC	AD16	AD[4]	AF15	AD[7]
V23	NC	AB18	VCC	AD17	I/O	AF16	AD[3]
V24	I/O	AB19	GND	AD18	I/O	AF17	AD[0]
V25	I/O	AB20	NC	AD19	I/O	AF18	I/O
V26	I/O	AB21	VCC	AD20	I/O	AF19	I/O
W1	I/O	AB22	GND	AD21	I/O	AF20	I/O
W2	I/O	AB23	I/O	AD22	I/O	AF21	I/O
W3	I/O	AB24	I/O	AD23	TRSTB	AF22	I/O
W4	I/O	AB25	I/O	AD24	I/O	AF23	I/O
W5	NC	AB26	I/O	AD25	I/O	AF24	I/O
W22	NC	AC1	I/O	AD26	I/O	AF25	I/O
W23	I/O	AC2	I/O	AE1	TDI	AF26	I/O
W24	I/O	AC3	NC	AE2	INTAN		
W25	I/O	AC4	GND	AE3	GNTN		
W26	I/O	AC5	AD[26]	AE4	AD[30]		

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