



## Device Overview

The 89HPES16T4 is a member of the IDT PRECISE™ family of PCI Express® switching solutions. The PES16T4 is a 16-lane, 4-port peripheral chip that performs PCI Express packet switching with a feature set optimized for high performance applications such as servers, storage, and communications/networking. It provides connectivity and switching functions between a PCI Express upstream port and up to three downstream ports and supports switching between downstream ports.

## Features

- ◆ **High Performance PCI Express Switch**
  - Sixteen 2.5 Gbps PCI Express lanes
  - Four switch ports
  - Upstream port configurable up to x8
  - Downstream ports configurable up to x4
  - Low-latency cut-through switch architecture
  - Support for Max Payload Size up to 2048 bytes
  - One virtual channel
  - Eight traffic classes
  - PCI Express Base Specification Revision 1.1 compliant
- ◆ **Flexible Architecture with Numerous Configuration Options**
  - Automatic per port link width negotiation to x8, x4, x2 or x1
  - Automatic lane reversal on all ports
  - Automatic polarity inversion on all lanes
  - Ability to load device configuration from serial EEPROM
- ◆ **Legacy Support**
  - PCI compatible INTx emulation
  - Bus locking
- ◆ **Highly Integrated Solution**
  - Requires no external components
  - Incorporates on-chip internal memory for packet buffering and queueing
  - Integrates sixteen 2.5 Gbps embedded SerDes with 8B/10B encoder/decoder (no separate transceivers needed)
- ◆ **Reliability, Availability, and Serviceability (RAS) Features**
  - Supports ECRC and Advanced Error Reporting
  - Internal end-to-end parity protection on all TLPs ensures data integrity even in systems that do not implement end-to-end CRC (ECRC)
  - Supports PCI Express Native Hot-Plug, Hot-Swap capable I/O
  - Compatible with Hot-Plug I/O expanders used on PC and server motherboards

## Block Diagram

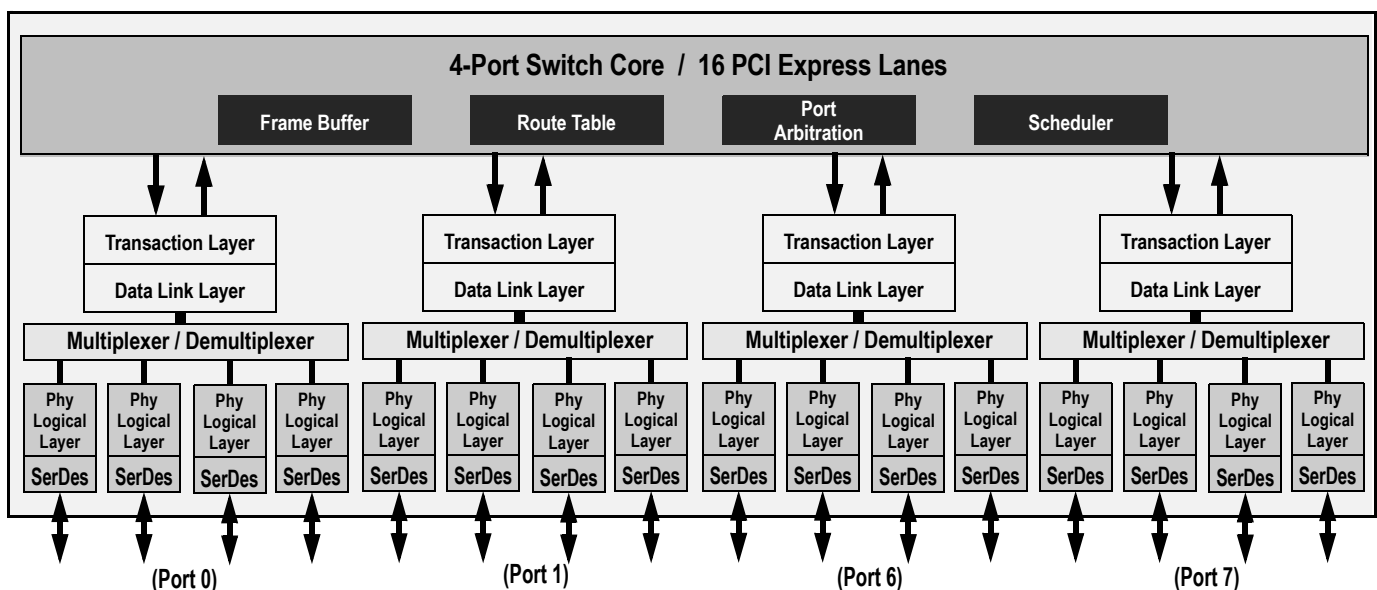


Figure 1 Internal Block Diagram

#### ◆ Power Management

- Utilizes advanced low-power design techniques to achieve low typical power consumption
- Supports PCI Power Management Interface specification (PCI-PM 1.1)
  - Supports device power management states: D0, D3<sub>hot</sub> and D3<sub>cold</sub>
- Unused SerDes are disabled

#### ◆ Testability and Debug Features

- Ability to read and write any internal register via the SMBus

#### ◆ Eleven General Purpose Input/Output Pins

- Each pin may be individually configured as an input or output
- Each pin may be individually configured as an interrupt input
- Some pins have selectable alternate functions

#### ◆ Packaged in a 23mm x 23mm 484-ball BCG with 1mm ball spacing

## Product Description

Utilizing standard PCI Express interconnect, the PES16T4 provides the most efficient I/O connectivity solution for applications requiring high throughput, low latency, and simple board layout with a minimum number of board layers. It provides connectivity for up to 4 ports across 16 integrated serial lanes. Each lane provides 2.5 Gbps of bandwidth in both directions and is fully compliant with PCI Express Base specification revision 1.1.

## SMBus Interface

The PES16T4 contains two SMBus interfaces. The slave interface provides full access to the configuration registers in the PES16T4, allowing every configuration register in the device to be read or written by an external agent. The master interface allows the default configuration register values of the PES16T4 to be overridden following a reset with values programmed in an external serial EEPROM. The master interface is also used by an external Hot-Plug I/O expander.

Six pins make up each of the two SMBus interfaces. These pins consist of an SMBus clock pin, an SMBus data pin, and 4 SMBus address pins. In the slave interface, these address pins allow the SMBus address to which the device responds to be configured. In the master interface, these address pins allow the SMBus address of the serial configuration EEPROM from which data is loaded to be configured. The SMBus address is set up on negation of PERSTN by sampling the corresponding address pins. When the pins are sampled, the resulting address is assigned as shown in Table 1.

Bit	Slave SMBus Address	Master SMBus Address
1	SSMBADDR[1]	MSMBADDR[1]
2	SSMBADDR[2]	MSMBADDR[2]
3	SSMBADDR[3]	MSMBADDR[3]
4	0	MSMBADDR[4]
5	SSMBADDR[5]	1
6	1	0
7	1	1

Table 1 Master and Slave SMBus Address Assignment

As shown in Figure 2, the master and slave SMBuses may be used in a unified or split configuration. In the unified configuration, shown in Figure 2(a), the master and slave SMBuses are tied together and the PES16T4 acts both as a SMBus master as well as a SMBus slave on this bus. This requires that the SMBus master or processor that has access to PES16T4 registers supports SMBus arbitration. In some systems, this SMBus master interface may be implemented using general purpose I/O pins on a processor or micro controller, and may not support SMBus arbitration. To support these systems, the PES16T4 may be configured to operate in a split configuration as shown in Figure 2(b).

In the split configuration, the master and slave SMBuses operate as two independent buses and thus multi-master arbitration is never required. The PES16T4 supports reading and writing of the serial EEPROM on the master SMBus via the slave SMBus, allowing in system programming of the serial EEPROM.

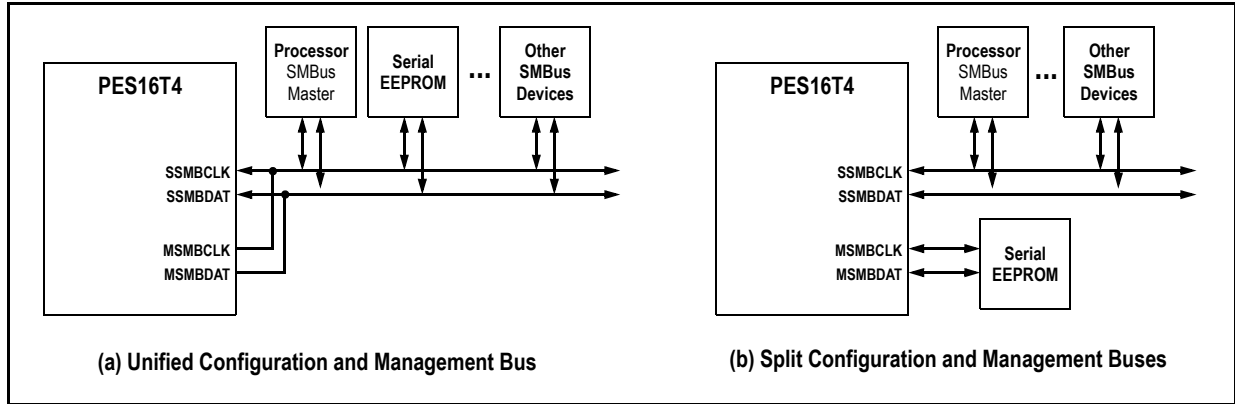


Figure 2 SMBus Interface Configuration Examples

**Hot-Plug Interface**

The PES16T4 supports PCI Express Hot-Plug on each downstream port. To reduce the number of pins required on the device, the PES16T4 utilizes an external I/O expander, such as that used on PC motherboards, connected to the SMBus master interface. Following reset and configuration, whenever the state of a Hot-Plug output needs to be modified, the PES16T4 generates an SMBus transaction to the I/O expander with the new value of all of the outputs. Whenever a Hot-Plug input changes, the I/O expander generates an interrupt which is received on the IOEXPINTN input pin (alternate function of GPIO) of the PES16T4. In response to an I/O expander interrupt, the PES16T4 generates an SMBus transaction to read the state of all of the Hot-Plug inputs from the I/O expander.

**General Purpose Input/Output**

The PES16T4 provides 11 General Purpose Input/Output (GPIO) pins that may be used by the system designer as bit I/O ports. Each GPIO pin may be configured independently as an input or output through software control. Some GPIO pins are shared with other on-chip functions. These alternate functions may be enabled via software, SMBus slave interface, or serial configuration EEPROM.

The PES16T4 is based on a flexible and efficient layered architecture. The PCI Express layer consists of SerDes, Physical, Data Link and Trans-action layers in compliance with PCI Express Base specification Revision 1.1. The PES16T4 can operate either as a store and forward or cut-through switch and is designed to switch memory and I/O transactions. It supports eight Traffic Classes (TCs) and one Virtual Channel (VC) with sophisticated resource management to enable efficient switching and I/O connectivity for servers, storage, and embedded applications.

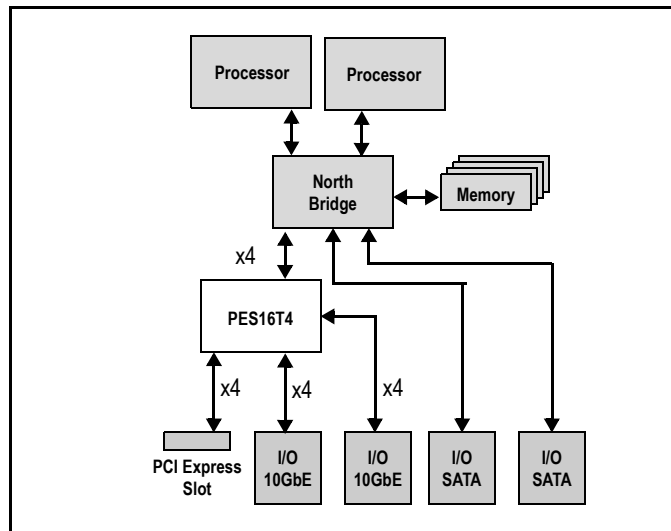


Figure 3 I/O Expansion Application

## Pin Description

The following tables list the functions of the pins provided on the PES16T4. Some of the functions listed may be multiplexed onto the same pin. The active polarity of a signal is defined using a suffix. Signals ending with an "N" are defined as being active, or asserted, when at a logic zero (low) level. All other signals (including clocks, buses, and select lines) will be interpreted as being active, or asserted, when at a logic one (high) level.

**Note:** In the PES16T4, the three downstream ports are labeled port 1, port 6, and port 7.

Signal	Type	Name/Description
PE0RP[3:0] PE0RN[3:0]	I	<b>PCI Express Port 0 Serial Data Receive.</b> Differential PCI Express receive pairs for port 0. Port 0 is the upstream port.
PE0TP[3:0] PE0TN[3:0]	O	<b>PCI Express Port 0 Serial Data Transmit.</b> Differential PCI Express transmit pairs for port 0. Port 0 is the upstream port.
PE1RP[3:0] PE1RN[3:0]	I	<b>PCI Express Port 1 Serial Data Receive.</b> Differential PCI Express receive pairs for port 1. When port 0 is merged with port 1, these signals become port 0 receive pairs for lanes 4 through 7.
PE1TP[3:0] PE1TN[3:0]	O	<b>PCI Express Port 1 Serial Data Transmit.</b> Differential PCI Express transmit pairs for port 1. When port 0 is merged with port 1, these signals become port 0 transmit pairs for lanes 4 through 7.
PE6RP[3:0] PE6RN[3:0]	I	<b>PCI Express Port 6 Serial Data Receive.</b> Differential PCI Express receive pairs for port 6.
PE6TP[3:0] PE6TN[3:0]	O	<b>PCI Express Port 6 Serial Data Transmit.</b> Differential PCI Express transmit pairs for port 6.
PE7RP[3:0] PE7RN[3:0]	I	<b>PCI Express Port 7 Serial Data Receive.</b> Differential PCI Express receive pairs for port 7. When port 6 is merged with port 7, these signals become port 6 receive pairs for lanes 4 through 7.
PE7TP[3:0] PE7TN[3:0]	O	<b>PCI Express Port 7 Serial Data Transmit.</b> Differential PCI Express transmit pairs for port 7. When port 6 is merged with port 7, these signals become port 6 transmit pairs for lanes 4 through 7.
P01MERGEN	I	<b>Port 0 and 1 Merge.</b> P01MERGEN is an active low signal. It is pulled low internally via a 251K ohm resistor. When this pin is low, port 0 is merged with port 1 to form a single x8 port. The Serdes lanes associated with port 1 become lanes 4 through 7 of port 0. When this pin is high, port 0 and port 1 are not merged, and each operates as a single x4 port.
P67MERGEN	I	<b>Port 6 and 7 Merge.</b> P67MERGEN is an active low signal. It is pulled low internally via a 251K ohm resistor. When this pin is low, port 6 is merged with port 7 to form a single x8 port. The Serdes lanes associated with port 7 become lanes 4 through 7 of port 6. When this pin is high, port 6 and port 7 are not merged, and each operates as a single x4 port.
PEREFCLKP[2:1] PEREFCLKN[2:1]	I	<b>PCI Express Reference Clock.</b> Differential reference clock pair input. This clock is used as the reference clock by on-chip PLLs to generate the clocks required for the system logic and on-chip SerDes. The frequency of the differential reference clock is determined by the REFCLKM signal.
REFCLKM	I	<b>PCI Express Reference Clock Mode Select.</b> This signal selects the frequency of the reference clock input. 0x0 - 100 MHz 0x1 - 125 MHz

Table 2 PCI Express Interface Pins

Signal	Type	Name/Description
MSMBADDR[4:1]	I	<b>Master SMBus Address.</b> These pins determine the SMBus address of the serial EEPROM from which configuration information is loaded.
MSMBCLK	I/O	<b>Master SMBus Clock.</b> This bidirectional signal is used to synchronize transfers on the master SMBus. It is active and generating the clock only when the EEPROM or I/O Expanders are being accessed.
MSMBDAT	I/O	<b>Master SMBus Data.</b> This bidirectional signal is used for data on the master SMBus.
SSMBADDR[5,3:1]	I	<b>Slave SMBus Address.</b> These pins determine the SMBus address to which the slave SMBus interface responds.
SSMBCLK	I/O	<b>Slave SMBus Clock.</b> This bidirectional signal is used to synchronize transfers on the slave SMBus.
SSMBDAT	I/O	<b>Slave SMBus Data.</b> This bidirectional signal is used for data on the slave SMBus.

Table 3 SMBus Interface Pins

Signal	Type	Name/Description
GPIO[0]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin.
GPIO[1]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin.
GPIO[2]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin.
GPIO[3]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin.
GPIO[4]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: IOEXPINTN2 Alternate function pin type: Input Alternate function: I/O Expander interrupt 2 input
GPIO[5]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: IOEXPINTN3 Alternate function pin type: Input Alternate function: I/O Expander interrupt 3 input
GPIO[6]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin.
GPIO[7]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: GPEN Alternate function pin type: Output Alternate function: General Purpose Event (GPE) output

Table 4 General Purpose I/O Pins (Part 1 of 2)

Signal	Type	Name/Description
GPIO[8]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: P1RSTN Alternate function pin type: Output Alternate function: Reset output for downstream port 1
GPIO[11]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: P6RSTN Alternate function pin type: Output Alternate function: Reset output for downstream port 6
GPIO[12]	I/O	<b>General Purpose I/O.</b> This pin can be configured as a general purpose I/O pin. Alternate function pin name: P7RSTN Alternate function pin type: Output Alternate function: Reset output for downstream port 7

Table 4 General Purpose I/O Pins (Part 2 of 2)

Signal	Type	Name/Description
CCLKDS	I	<b>Common Clock Downstream.</b> When the CCLKDS pin is asserted, it indicates that a common clock is being used between the downstream device and the downstream port.
CCLKUS	I	<b>Common Clock Upstream.</b> When the CCLKUS pin is asserted, it indicates that a common clock is being used between the upstream device and the upstream port.
MSMBSMODE	I	<b>Master SMBus Slow Mode.</b> The assertion of this pin indicates that the master SMBus should operate at 100 KHz instead of 400 KHz. This value may not be overridden.
PERSTN	I	<b>Fundamental Reset.</b> Assertion of this signal resets all logic inside PES16T4 and initiates a PCI Express fundamental reset.
RSTHALT	I	<b>Reset Halt.</b> When this signal is asserted during a PCI Express fundamental reset, PES16T4 executes the reset procedure and remains in a reset state with the Master and Slave SMBuses active. This allows software to read and write registers internal to the device before normal device operation begins. The device exits the reset state when the RSTHALT bit is cleared in the SWCTL register by an SMBus master.
SWMODE[2:0]	I	<b>Switch Mode.</b> These configuration pins determine the PES16T4 switch operating mode. These pins should be static and not change after the negation of PERSTN. 0x0 - Normal switch mode 0x1 - Normal switch mode with Serial EEPROM initialization 0x2 - through 0xF Reserved

Table 5 System Pins

Signal	Type	Name/Description
JTAG_TCK	I	<b>JTAG Clock.</b> This is an input test clock used to clock the shifting of data into or out of the boundary scan logic or JTAG Controller. JTAG_TCK is independent of the system clock with a nominal 50% duty cycle.
JTAG_TDI	I	<b>JTAG Data Input.</b> This is the serial data input to the boundary scan logic or JTAG Controller.
JTAG_TDO	O	<b>JTAG Data Output.</b> This is the serial data shifted out from the boundary scan logic or JTAG Controller. When no data is being shifted out, this signal is tri-stated.
JTAG_TMS	I	<b>JTAG Mode.</b> The value on this signal controls the test mode select of the boundary scan logic or JTAG Controller.
JTAG_TRST_N	I	<b>JTAG Reset.</b> This active low signal asynchronously resets the boundary scan logic and JTAG TAP Controller. An external pull-up on the board is recommended to meet the JTAG specification in cases where the tester can access this signal. However, for systems running in functional mode, one of the following should occur: <ul style="list-style-type: none"> <li>1) actively drive this signal low with control logic</li> <li>2) statically drive this signal low with an external pull-down on the board</li> </ul>

Table 6 Test Pins

Signal	Type	Name/Description
V <sub>DD</sub> CORE	I	<b>Core V<sub>DD</sub>.</b> Power supply for core logic.
V <sub>DD</sub> IO	I	<b>I/O V<sub>DD</sub>.</b> LVTTTL I/O buffer power supply.
V <sub>DD</sub> PE	I	<b>PCI Express Digital Power.</b> PCI Express digital power used by the digital power of the SerDes.
V <sub>DD</sub> APE	I	<b>PCI Express Analog Power.</b> PCI Express analog power used by the PLL and bias generator.
V <sub>TT</sub> PE	I	<b>PCI Express Termination Power.</b>
V <sub>SS</sub>	I	<b>Ground.</b>

Table 7 Power and Ground Pins

## Pin Characteristics

**Note:** Some input pads of the PES16T4 do not contain internal pull-ups or pull-downs. Unused inputs should be tied off to appropriate levels. This is especially critical for unused control signal inputs which, if left floating, could adversely affect operation. Also, any input pin left floating can cause a slight increase in power consumption.

Function	Pin Name	Type	Buffer	I/O Type	Internal Resistor <sup>1</sup>	Notes
PCI Express Interface	PE0RN[3:0]	I	CML	Serial Link		
	PE0RP[3:0]	I				
	PE0TN[3:0]	O				
	PE0TP[3:0]	O				
	PE1RN[3:0]	I				
	PE1RP[3:0]	I				
	PE1TN[3:0]	O				
	PE1TP[3:0]	O				
	PE6RN[3:0]	I				
	PE6RP[3:0]	I				
	PE6TN[3:0]	O				
	PE6TP[3:0]	O				
	PE7RN[3:0]	I				
	PE7RP[3:0]	I				
	PE7TN[3:0]	O				
	PE7TP[3:0]	O				
	PEREFCLKN[2:1]	I			LVPECL/ CML	Diff. Clock Input
	PEREFCLKP[2:1]	I				
REFCLKM	I	LVTTTL	Input	pull-down		
SMBus	MSMBADDR[4:1]	I	LVTTTL	Input	pull-up	
	MSMBCLK	I/O		STI <sup>2</sup>		pull-up on board
	MSMBDAT	I/O		STI		pull-up on board
	SSMBADDR[5,3:1]	I		Input	pull-up	
	SSMBCLK	I/O		STI		pull-up on board
	SSMBDAT	I/O		STI		pull-up on board
General Purpose I/O	GPIO[12,11,8:0]	I/O	LVTTTL	High Drive	pull-up	
System Pins	CCLKDS	I	LVTTTL	Input	pull-up	
	CCLKUS	I			pull-up	
	MSMBSMODE	I			pull-down	
	PERSTN	I				
	P01MERGEN	I			pull-down	
	P67MERGEN	I			pull-down	
	RSTHALT	I			pull-down	
	SWMODE[2:0]	I			pull-down	

Table 8 Pin Characteristics (Part 1 of 2)



Function	Pin Name	Type	Buffer	I/O Type	Internal Resistor <sup>1</sup>	Notes
EJTAG / JTAG	JTAG_TCK	I	LVTTTL	STI	pull-up	
	JTAG_TDI	I		STI	pull-up	
	JTAG_TDO	O				
	JTAG_TMS	I		STI	pull-up	
	JTAG_TRST_N	I		STI	pull-up	External pull-down

Table 8 Pin Characteristics (Part 2 of 2)

<sup>1</sup> Internal resistor values under typical operating conditions are 54K  $\Omega$  for pull-up and 251K  $\Omega$  for pull-down.

<sup>2</sup> Schmitt Trigger Input (STI).

## Logic Diagram — PES16T4

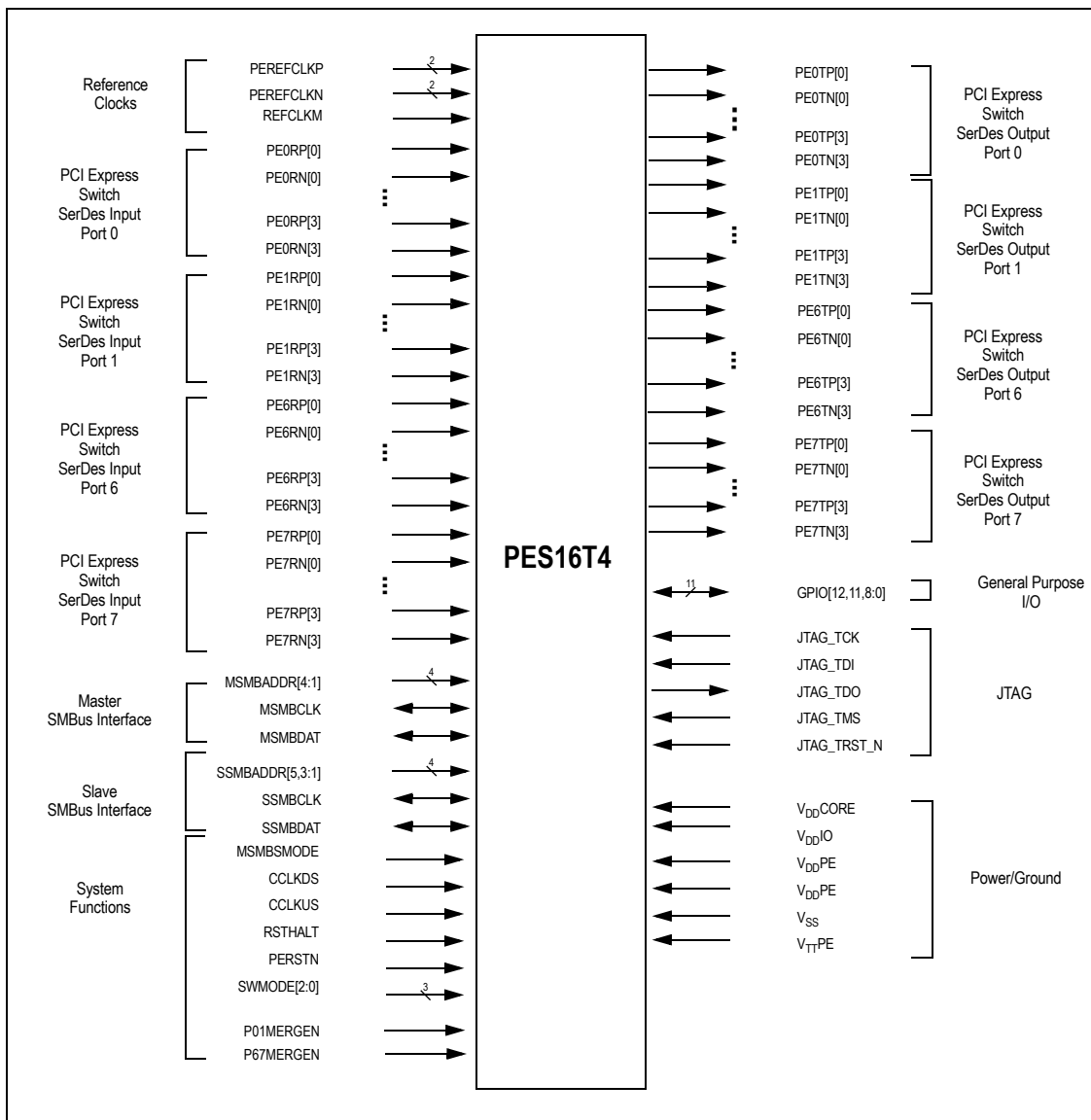


Figure 4 PES16T4 Logic Diagram

## System Clock Parameters

Values based on systems running at recommended supply voltages and operating temperatures, as shown in Tables 13 and 14.

Parameter	Description	Min	Typical	Max	Unit
Refclk <sub>FREQ</sub>	Input reference clock frequency range	100		125 <sup>1</sup>	MHz
Refclk <sub>DC</sub> <sup>2</sup>	Duty cycle of input clock	40	50	60	%
T <sub>R</sub> , T <sub>F</sub>	Rise/Fall time of input clocks			0.2*RCUI	RCUI <sup>3</sup>
V <sub>SW</sub>	Differential input voltage swing <sup>4</sup>	0.6		1.6	V
T <sub>jitter</sub>	Input clock jitter (cycle-to-cycle)			125	ps
R <sub>T</sub>	Termination Resistor		110		Ohms

**Table 9 Input Clock Requirements**

<sup>1</sup> The input clock frequency will be either 100 or 125 MHz depending on signal REFCLKM.

<sup>2</sup> ClkIn must be AC coupled. Use 0.01 — 0.1 μF ceramic capacitors.

<sup>3</sup> RCUI (Reference Clock Unit Interval) refers to the reference clock period.

<sup>4</sup> AC coupling required.

## AC Timing Characteristics

Parameter	Description	Min <sup>1</sup>	Typical <sup>1</sup>	Max <sup>1</sup>	Units
<b>PCIe Transmit</b>					
UI	Unit Interval	399.88	400	400.12	ps
T <sub>TX-EYE</sub>	Minimum Tx Eye Width	0.7	.9		UI
T <sub>TX-EYE-MEDIAN-TO-MAX-JITTER</sub>	Maximum time between the jitter median and maximum deviation from the median			0.15	UI
T <sub>TX-RISE</sub> , T <sub>TX-FALL</sub>	D+ / D- Tx output rise/fall time	50	90		ps
T <sub>TX-IDLE-MIN</sub>	Minimum time in idle	50			UI
T <sub>TX-IDLE-SET-TO-IDLE</sub>	Maximum time to transition to a valid Idle after sending an Idle ordered set			20	UI
T <sub>TX-IDLE-TO-DIFF-DATA</sub>	Maximum time to transition from valid idle to diff data			20	UI
T <sub>TX-SKEW</sub>	Transmitter data skew between any 2 lanes		500	1300	ps
<b>PCIe Receive</b>					
UI	Unit Interval	399.88	400	400.12	ps
T <sub>RX-EYE (with jitter)</sub>	Minimum Receiver Eye Width (jitter tolerance)	0.4			UI
T <sub>RX-EYE-MEDIUM TO MAX JITTER</sub>	Max time between jitter median & max deviation			0.3	UI
T <sub>RX-IDLE-DET-DIFF-ENTER TIME</sub>	Unexpected Idle Enter Detect Threshold Integration Time			10	ms
T <sub>RX-SKEW</sub>	Lane to lane input skew			20	ns

**Table 10 PCIe AC Timing Characteristics**

<sup>1</sup> Minimum, Typical, and Maximum values meet the requirements under PCI Specification 1.1

Signal	Symbol	Reference Edge	Min	Max	Unit	Timing Diagram Reference
<b>GPIO</b>						
GPIO[10:0] <sup>1</sup>	Tpw <sup>2</sup>	None	50	—	ns	

**Table 11 GPIO AC Timing Characteristics**

<sup>1</sup> GPIO signals must meet the setup and hold times if they are synchronous or the minimum pulse width if they are asynchronous.

<sup>2</sup> The values for this symbol were determined by calculation, not by testing.

Signal	Symbol	Reference Edge	Min	Max	Unit	Timing Diagram Reference
<b>JTAG</b>						
JTAG_TCK	Tper_16a	none	50.0	—	ns	See Figure 5.
	Thigh_16a, Tlow_16a		10.0	25.0	ns	
JTAG_TMS <sup>1</sup> , JTAG_TDI	Tsu_16b	JTAG_TCK rising	2.4	—	ns	
	Thld_16b		1.0	—	ns	
JTAG_TDO	Tdo_16c	JTAG_TCK falling	—	20	ns	
	Tdz_16c <sup>2</sup>		—	20	ns	
JTAG_TRST_N	Tpw_16d <sup>2</sup>	none	25.0	—	ns	

**Table 12 JTAG AC Timing Characteristics**

<sup>1</sup> The JTAG specification, IEEE 1149.1, recommends that JTAG\_TMS should be held at 1 while the signal applied at JTAG\_TRST\_N changes from 0 to 1. Otherwise, a race may occur if JTAG\_TRST\_N is deasserted (going from low to high) on a rising edge of JTAG\_TCK when JTAG\_TMS is low, because the TAP controller might go to either the Run-Test/Idle state or stay in the Test-Logic-Reset state.

<sup>2</sup> The values for this symbol were determined by calculation, not by testing.

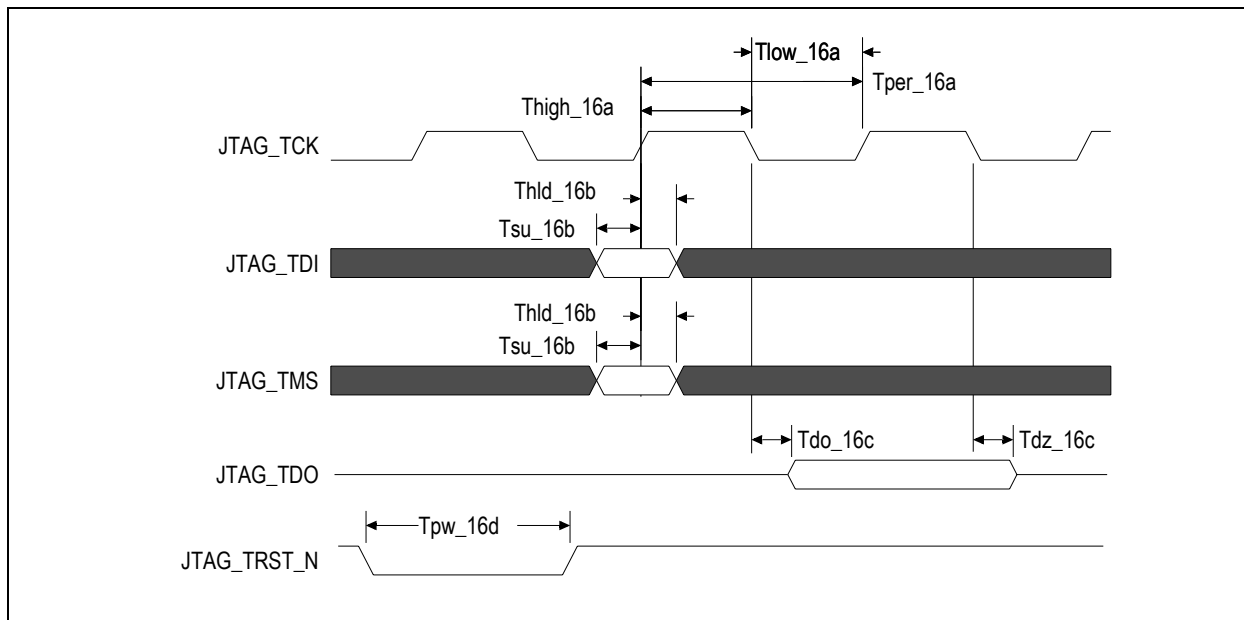


Figure 5 JTAG AC Timing Waveform

## Recommended Operating Supply Voltages

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V <sub>DD</sub> CORE	Internal logic supply	0.9	1.0	1.1	V
V <sub>DD</sub> I/O	I/O supply except for SerDes LVPECL/CML	3.0	3.3	3.6	V
V <sub>DD</sub> PE	PCI Express Digital Power	0.9	1.0	1.1	V
V <sub>DD</sub> APE	PCI Express Analog Power	0.9	1.0	1.1	V
V <sub>TT</sub> PE	PCI Express Serial Data Transmit Termination Voltage	1.425	1.5	1.575	V
V <sub>SS</sub>	Common ground	0	0	0	V

Table 13 PES16T4 Operating Voltages

## Power-Up Sequence

This section describes the sequence in which various voltages must be applied to the part during power-up to ensure proper functionality. For the PES16T4, the power-up sequence must be as follows:

1. V<sub>DD</sub>I/O — 3.3V
2. V<sub>DD</sub>Core, V<sub>DD</sub>PE, V<sub>DD</sub>APE — 1.0V
3. V<sub>TT</sub>PE — 1.5V

When powering up, each voltage level must ramp and stabilize prior to applying the next voltage in the sequence to ensure internal latch-up issues are avoided. There are no maximum time limitations in ramping to valid power levels. The power-down sequence must be in the reverse order of the power-up sequence.

## Recommended Operating Temperature

Grade	Temperature
Commercial	0°C to +70°C Ambient

Table 14 PES16T4 Operating Temperatures

## Power Consumption

Typical power is measured under the following conditions: 25°C Ambient, 35% total link usage on all ports, typical voltages defined in Table 13 (and also listed below).

Maximum power is measured under the following conditions: 70°C Ambient, 85% total link usage on all ports, maximum voltages defined in Table 13 (and also listed below).

Number of active Lanes per Port		Core Supply		PCIe Digital Supply		PCIe Analog Supply		PCIe Termination Supply		I/O Supply		Total	
		Typ 1.0V	Max 1.1V	Typ 1.0V	Max 1.1V	Typ 1.0V	Max 1.1V	Typ 1.5V	Max 1.575V	Typ 3.3V	Max 3.6V	Typ Power	Max Power
4/4/4/4	mA	598	756	730	873	308	342	371	436	1	1	2.2W	2.9W
	Watts	0.6	0.83	0.73	0.96	0.31	0.38	0.56	0.69	0.004	0.004		
4/4/1/1	mA	528	642	548	631	279	298	220	270	1	1	1.69W	2.2W
	Watts	0.53	0.71	0.55	0.69	0.28	0.33	0.33	0.43	0.003	0.003		

Table 15 PES16T4 Power Consumption

## Thermal Considerations

This section describes thermal considerations for the PES16T4 (23mm<sup>2</sup> BCG484 package). The data in Table 16 below contains information that is relevant to the thermal performance of the PES16T4 switch.

Symbol	Parameter	Value	Units	Conditions
$T_{J(max)}$	Junction Temperature	125	°C	Maximum
$T_{A(max)}$	Ambient Temperature	70	°C	Maximum for commercial-rated products
$\theta_{JA(effective)}$	Effective Thermal Resistance, Junction-to-Ambient	11.5	°C/W	Zero air flow
		9.6	°C/W	1 m/S air flow
		9.0	°C/W	2 m/S air flow
$\theta_{JB}$	Thermal Resistance, Junction-to-Board	10.9	°C/W	
$\theta_{JC}$	Thermal Resistance, Junction-to-Case	5	°C/W	
P	Power Dissipation of the Device	2.9	Watts	Maximum

Table 16 Thermal Specifications for PES16T4, 23x23mm BCG484 Package

**Note:** The parameter  $\theta_{JA(eff)}$  is not the *absolute* thermal resistance for the package as defined by JEDEC (JESD-51). Because resistance can vary with the number of board layers, size of the board, and airflow,  $\theta_{JA(eff)}$  is the *effective* thermal resistance. The values for effective  $\theta_{JA}$  given above are based on a 10-layer, standard height, full length (4.3"x12.2") PCIe add-in card.

## Heat Sink

Table 17 lists heat sink requirements for the PES16T4 under three common usage scenarios. As shown in this table, a heat sink is not required in most cases.

Air Flow	Board Size	Board Layers	Heat Sink Requirement
Zero	3.9"x6.2" (ExpressModule form factor) or larger	6 or more	No heat sink required
Zero	Any	10 or more	No heat sink required
1 m/S or more	Any	Any	No heat sink required

Table 17 Heat Sink Requirements Based on Air Flow and Board Characteristics

## Thermal Usage Examples

The junction-to-ambient thermal resistance is a measure of a device's ability to dissipate heat from the die to its surroundings in the absence of a heat sink. The general formula to determine  $\theta_{JA}$  is:

$$\theta_{JA} = (T_J - T_A) / P$$

Thermal reliability of a device is generally assured when the actual value of  $T_J$  in the specific system environment being considered is less than the maximum  $T_J$  specified for the device. Using an ambient temperature of 70°C and assuming a system with 1m/S airflow, the actual value of  $T_J$  is:

$$T_{J(actual)} = T_A + P * \theta_{JA(eff)} = 70^\circ C + 2.9W * 9.6W/\rho C = 98^\circ C$$

The actual  $T_J$  of 98°C is well below the maximum  $T_J$  of 125°C specified for the device (shown in Table 16). Therefore, no heat sink is needed in this scenario. The formula is also useful from a system design perspective. It can be used to determine if a heat sink should be added to the device based on some desired value of  $T_J$ . For example, if for reliability purposes the desired  $T_J$  is 100°C, then the maximum allowable  $T_A$  is:

$$T_{A(allowed)} = T_{J(desired)} - (P * \theta_{JA(effective)})$$

$$T_{A(allowed)} = 100^\circ C - (2.9W * 9.6W/\rho C) = 100^\circ C - 28^\circ C = 72^\circ C$$

An appropriate level of increased air flow and/or a heat sink can be added to achieve this lower ambient temperature. Please contact [ssdhelp@idt.com](mailto:ssdhelp@idt.com) for further assistance.

## DC Electrical Characteristics

Values based on systems running at recommended supply voltages, as shown in Table 13.

**Note:** See Table 8, Pin Characteristics, for a complete I/O listing.

I/O Type	Parameter	Description	Min <sup>1</sup>	Typ <sup>1</sup>	Max <sup>1</sup>	Unit	Conditions
Serial Link	<b>PCIe Transmit</b>						
	$V_{TX-DIFFp-p}$	Differential peak-to-peak output voltage	800		1200	mV	
	$V_{TX-DE-RATIO}$	De-emphasized differential output voltage	-3		-4	dB	
	$V_{TX-DC-CM}$	DC Common mode voltage	-0.1	1	3.7	V	
	$V_{TX-CM-ACP}$	RMS AC peak common mode output voltage			20	mV	
	$V_{TX-CM-DC-active-idle-delta}$	Abs delta of DC common mode voltage between L0 and idle			100	mV	
	$V_{TX-CM-DC-line-delta}$	Abs delta of DC common mode voltage between D+ and D-			25	mV	
	$V_{TX-Idle-DiffP}$	Electrical idle diff peak output			20	mV	
	$V_{TX-RCV-Detect}$	Voltage change during receiver detection			600	mV	
	$RL_{TX-DIFF}$	Transmitter Differential Return loss	12			dB	
	$RL_{TX-CM}$	Transmitter Common Mode Return loss	6			dB	
	$Z_{TX-DEFF-DC}$	DC Differential TX impedance	80	100	120	$\Omega$	
	$Z_{OSE}$	Single ended TX Impedance	40	50	60	$\Omega$	
	Transmitter Eye Diagram	TX Eye Height (De-emphasized bits)	505	650		mV	
Transmitter Eye Diagram	TX Eye Height (Transition bits)	800	950		mV		
Serial Link (cont.)	<b>PCIe Receive</b>						
	$V_{RX-DIFFp-p}$	Differential input voltage (peak-to-peak)	175		1200	mV	
	$V_{RX-CM-AC}$	Receiver common-mode voltage for AC coupling			150	mV	
	$RL_{RX-DIFF}$	Receiver Differential Return Loss	15			dB	
	$RL_{RX-CM}$	Receiver Common Mode Return Loss	6			dB	
	$Z_{RX-DIFF-DC}$	Differential input impedance (DC)	80	100	120	$\Omega$	
	$Z_{RX-COMM-DC}$	Single-ended input impedance	40	50	60	$\Omega$	
	$Z_{RX-COMM-HIGH-Z-DC}$	Powered down input common mode impedance (DC)	200k	350k		$\Omega$	
$V_{RX-IDLE-DET-DIFFp-p}$	Electrical idle detect threshold	65		175	mV		
<b>PCIe REFCLK</b>							
	$C_{IN}$	Input Capacitance	1.5	—		pF	

Table 18 DC Electrical Characteristics (Part 1 of 2)

I/O Type	Parameter	Description	Min <sup>1</sup>	Typ <sup>1</sup>	Max <sup>1</sup>	Unit	Conditions
<b>Other I/Os</b>							
LOW Drive Output	I <sub>OL</sub>		—	2.5	—	mA	V <sub>OL</sub> = 0.4v
	I <sub>OH</sub>		—	-5.5	—	mA	V <sub>OH</sub> = 1.5V
High Drive Output	I <sub>OL</sub>		—	12.0	—	mA	V <sub>OL</sub> = 0.4v
	I <sub>OH</sub>		—	-20.0	—	mA	V <sub>OH</sub> = 1.5V
Schmitt Trigger Input (STI)	V <sub>IL</sub>		-0.3	—	0.8	V	—
	V <sub>IH</sub>		2.0	—	V <sub>DD</sub> I/O + 0.5	V	—
Input	V <sub>IL</sub>		-0.3	—	0.8	V	—
	V <sub>IH</sub>		2.0	—	V <sub>DD</sub> I/O + 0.5	V	—
Capacitance	C <sub>IN</sub>		—	—	8.5	pF	—
Leakage	Inputs		—	—	± 10	μA	V <sub>DD</sub> I/O (max)
	I/O <sub>LEAK</sub> w/o Pull-ups/downs		—	—	± 10	μA	V <sub>DD</sub> I/O (max)
	I/O <sub>LEAK</sub> WITH Pull-ups/downs		—	—	± 80	μA	V <sub>DD</sub> I/O (max)

Table 18 DC Electrical Characteristics (Part 2 of 2)

<sup>1</sup>: Minimum, Typical, and Maximum values meet the requirements under PCI Specification 1.1.



**Package Pinout — 484-BGA Signal Pinout for PES16T4**

The following table lists the pin numbers and signal names for the PES16T4 device.

Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt
A1	V <sub>SS</sub>		B13	V <sub>SS</sub>		D3	SSMBCLK		E15	V <sub>DD</sub> PE	
A2	V <sub>SS</sub>		B14	PE0TP02		D4	V <sub>SS</sub>		E16	V <sub>DD</sub> PE	
A3	V <sub>SS</sub>		B15	V <sub>SS</sub>		D5	PE1RP03		E17	V <sub>SS</sub>	
A4	PE1TN03		B16	PE0TP01		D6	V <sub>SS</sub>		E18	V <sub>DD</sub> APE	
A5	V <sub>SS</sub>		B17	V <sub>SS</sub>		D7	PE1RP02		E19	V <sub>SS</sub>	
A6	PE1TP02		B18	PE0TP00		D8	V <sub>SS</sub>		E20	SWMODE_0	
A7	V <sub>SS</sub>		B19	V <sub>SS</sub>		D9	PE1RN01		E21	SWMODE_1	
A8	PE1TN01		B20	V <sub>SS</sub>		D10	V <sub>SS</sub>		E22	V <sub>DD</sub> CORE	
A9	V <sub>SS</sub>		B21	V <sub>SS</sub>		D11	PE1RP00		F1	V <sub>SS</sub>	
A10	PE1TP00		B22	V <sub>SS</sub>		D12	V <sub>SS</sub>		F2	V <sub>DD</sub> IO	
A11	V <sub>SS</sub>		C1	V <sub>DD</sub> CORE		D13	PE0RP03		F3	V <sub>DD</sub> IO	
A12	PE0TN03		C2	SSMBADDR_3		D14	V <sub>SS</sub>		F4	V <sub>SS</sub>	
A13	V <sub>SS</sub>		C3	SSMBDAT		D15	PE0RN02		F5	V <sub>DD</sub> CORE	
A14	PE0TN02		C4	V <sub>SS</sub>		D16	V <sub>TT</sub> PE		F6	V <sub>DD</sub> IO	
A15	V <sub>SS</sub>		C5	PE1RN03		D17	PE0RP01		F7	V <sub>SS</sub>	
A16	PE0TN01		C6	V <sub>SS</sub>		D18	V <sub>SS</sub>		F8	V <sub>DD</sub> PE	
A17	V <sub>SS</sub>		C7	PE1RN02		D19	PE0RN00		F9	V <sub>DD</sub> APE	
A18	PE0TN00		C8	V <sub>SS</sub>		D20	V <sub>SS</sub>		F10	V <sub>DD</sub> CORE	
A19	V <sub>SS</sub>		C9	PE1RP01		D21	V <sub>DD</sub> IO		F11	V <sub>DD</sub> PE	
A20	V <sub>SS</sub>		C10	V <sub>SS</sub>		D22	V <sub>SS</sub>		F12	V <sub>DD</sub> IO	
A21	V <sub>SS</sub>		C11	PE1RN00		E1	V <sub>DD</sub> CORE		F13	V <sub>DD</sub> PE	
A22	V <sub>SS</sub>		C12	V <sub>SS</sub>		E2	SSMBADDR_1		F14	V <sub>DD</sub> CORE	
B1	V <sub>SS</sub>		C13	PE0RN03		E3	SSMBADDR_5		F15	V <sub>DD</sub> APE	
B2	V <sub>DD</sub> IO		C14	V <sub>SS</sub>		E4	CCLKUS		F16	V <sub>DD</sub> CORE	
B3	V <sub>SS</sub>		C15	PE0RP02		E5	V <sub>SS</sub>		F17	V <sub>DD</sub> IO	
B4	PE1TP03		C16	V <sub>SS</sub>		E6	V <sub>DD</sub> PE		F18	CCLKDS	
B5	V <sub>SS</sub>		C17	PE0RN01		E7	V <sub>TT</sub> PE		F19	RSTHALT	
B6	PE1TN02		C18	V <sub>SS</sub>		E8	V <sub>SS</sub>		F20	PERSTN	
B7	V <sub>SS</sub>		C19	PE0RP00		E9	V <sub>DD</sub> APE		F21	SWMODE_2	
B8	PE1TP01		C20	V <sub>SS</sub>		E10	V <sub>TT</sub> PE		F22	V <sub>SS</sub>	
B9	V <sub>SS</sub>		C21	V <sub>DD</sub> APE		E11	V <sub>DD</sub> PE		G1	V <sub>DD</sub> CORE	
B10	PE1TN00		C22	V <sub>DD</sub> CORE		E12	V <sub>DD</sub> PE		G2	MSMBADDR_4	
B11	V <sub>SS</sub>		D1	V <sub>SS</sub>		E13	V <sub>TT</sub> PE		G3	MSMBCLK	
B12	PE0TP03		D2	SSMBADDR_2		E14	V <sub>DD</sub> APE		G4	MSMBDAT	

Table 19 PES16T4 484-pin Signal Pin-Out (Part 1 of 4)

Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt
G5	V <sub>SS</sub>		H20	GPIO_00		K13	V <sub>DD</sub> CORE		M6	V <sub>SS</sub>	
G6	V <sub>DD</sub> CORE		H21	GPIO_01		K14	V <sub>SS</sub>		M7	V <sub>DD</sub> CORE	
G7	V <sub>SS</sub>		H22	V <sub>SS</sub>		K15	V <sub>DD</sub> CORE		M8	V <sub>SS</sub>	
G8	V <sub>SS</sub>		J1	V <sub>DD</sub> CORE		K16	V <sub>SS</sub>		M9	V <sub>DD</sub> CORE	
G9	V <sub>SS</sub>		J2	JTAG_TDO		K17	V <sub>DD</sub> CORE		M10	V <sub>SS</sub>	
G10	V <sub>DD</sub> CORE		J3	JTAG_TMS		K18	V <sub>SS</sub>		M11	V <sub>DD</sub> CORE	
G11	V <sub>SS</sub>		J4	JTAG_TRST_N		K19	GPIO_07	1	M12	V <sub>SS</sub>	
G12	V <sub>SS</sub>		J5	V <sub>SS</sub>		K20	GPIO_06		M13	V <sub>DD</sub> CORE	
G13	V <sub>DD</sub> CORE		J6	V <sub>SS</sub>		K21	GPIO_05	1	M14	V <sub>SS</sub>	
G14	V <sub>SS</sub>		J7	V <sub>SS</sub>		K22	V <sub>SS</sub>		M15	V <sub>DD</sub> CORE	
G15	V <sub>SS</sub>		J8	V <sub>DD</sub> CORE		L1	V <sub>DD</sub> CORE		M16	V <sub>SS</sub>	
G16	V <sub>SS</sub>		J9	V <sub>SS</sub>		L2	V <sub>DD</sub> CORE		M17	V <sub>DD</sub> CORE	
G17	V <sub>SS</sub>		J10	V <sub>DD</sub> CORE		L3	V <sub>SS</sub>		M18	V <sub>SS</sub>	
G18	V <sub>DD</sub> APE		J11	V <sub>SS</sub>		L4	V <sub>DD</sub> CORE		M19	V <sub>SS</sub>	
G19	V <sub>SS</sub>		J12	V <sub>DD</sub> CORE		L5	V <sub>SS</sub>		M20	V <sub>DD</sub> IO	
G20	V <sub>DD</sub> APE		J13	V <sub>SS</sub>		L6	V <sub>DD</sub> CORE		M21	V <sub>SS</sub>	
G21	V <sub>DD</sub> IO		J14	V <sub>SS</sub>		L7	V <sub>SS</sub>		M22	V <sub>SS</sub>	
G22	V <sub>DD</sub> CORE		J15	V <sub>SS</sub>		L8	V <sub>DD</sub> CORE		N1	PEREFCLKP1	
H1	V <sub>SS</sub>		J16	V <sub>SS</sub>		L9	V <sub>SS</sub>		N2	V <sub>SS</sub>	
H2	MSMBADDR_1		J17	V <sub>DD</sub> IO		L10	V <sub>DD</sub> CORE		N3	V <sub>DD</sub> CORE	
H3	MSMBADDR_2		J18	V <sub>DD</sub> CORE		L11	V <sub>SS</sub>		N4	V <sub>DD</sub> CORE	
H4	MSMBADDR_3		J19	GPIO_04	1	L12	V <sub>DD</sub> CORE		N5	V <sub>SS</sub>	
H5	V <sub>DD</sub> CORE		J20	GPIO_03		L13	V <sub>SS</sub>		N6	V <sub>DD</sub> APE	
H6	V <sub>SS</sub>		J21	GPIO_02		L14	V <sub>DD</sub> CORE		N7	V <sub>SS</sub>	
H7	V <sub>DD</sub> CORE		J22	V <sub>DD</sub> CORE		L15	V <sub>SS</sub>		N8	V <sub>DD</sub> CORE	
H8	V <sub>SS</sub>		K1	V <sub>SS</sub>		L16	V <sub>SS</sub>		N9	V <sub>SS</sub>	
H9	V <sub>DD</sub> CORE		K2	V <sub>DD</sub> IO		L17	V <sub>SS</sub>		N10	V <sub>DD</sub> CORE	
H10	V <sub>SS</sub>		K3	JTAG_TDI		L18	V <sub>DD</sub> CORE		N11	V <sub>SS</sub>	
H11	V <sub>DD</sub> CORE		K4	JTAG_TCK		L19	V <sub>SS</sub>		N12	V <sub>DD</sub> CORE	
H12	V <sub>SS</sub>		K5	V <sub>DD</sub> CORE		L20	V <sub>SS</sub>		N13	V <sub>SS</sub>	
H13	V <sub>DD</sub> CORE		K6	V <sub>SS</sub>		L21	V <sub>DD</sub> IO		N14	V <sub>DD</sub> CORE	
H14	V <sub>SS</sub>		K7	V <sub>DD</sub> CORE		L22	V <sub>DD</sub> CORE		N15	V <sub>SS</sub>	
H15	V <sub>DD</sub> CORE		K8	V <sub>SS</sub>		M1	V <sub>SS</sub>		N16	V <sub>SS</sub>	
H16	V <sub>SS</sub>		K9	V <sub>DD</sub> CORE		M2	V <sub>SS</sub>		N17	V <sub>DD</sub> APE	
H17	V <sub>DD</sub> CORE		K10	V <sub>SS</sub>		M3	V <sub>SS</sub>		N18	V <sub>DD</sub> CORE	
H18	V <sub>SS</sub>		K11	V <sub>DD</sub> CORE		M4	V <sub>SS</sub>		N19	V <sub>DD</sub> CORE	
H19	V <sub>SS</sub>		K12	V <sub>SS</sub>		M5	V <sub>DD</sub> CORE		N20	V <sub>DD</sub> CORE	

Table 19 PES16T4 484-pin Signal Pin-Out (Part 2 of 4)

Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt
N21	V <sub>SS</sub>		R14	V <sub>DD</sub> CORE		U7	V <sub>DD</sub> IO		V22	V <sub>DD</sub> CORE	
N22	PEREFCLKN2		R15	V <sub>SS</sub>		U8	V <sub>DD</sub> PE		W1	V <sub>SS</sub>	
P1	PEREFCLKN1		R16	V <sub>SS</sub>		U9	V <sub>DD</sub> APE		W2	V <sub>DD</sub> CORE	
P2	V <sub>SS</sub>		R17	V <sub>DD</sub> IO		U10	V <sub>DD</sub> PE		W3	V <sub>SS</sub>	
P3	V <sub>SS</sub>		R18	V <sub>DD</sub> CORE		U11	V <sub>SS</sub>		W4	V <sub>SS</sub>	
P4	V <sub>SS</sub>		R19	GPIO_08	1	U12	V <sub>DD</sub> IO		W5	PE6RP00	
P5	V <sub>SS</sub>		R20	GPIO_11	1	U13	V <sub>DD</sub> PE		W6	V <sub>SS</sub>	
P6	V <sub>SS</sub>		R21	GPIO_12	1	U14	V <sub>DD</sub> APE		W7	PE6RP01	
P7	V <sub>DD</sub> CORE		R22	V <sub>SS</sub>		U15	V <sub>SS</sub>		W8	V <sub>SS</sub>	
P8	V <sub>SS</sub>		T1	V <sub>DD</sub> CORE		U16	V <sub>DD</sub> IO		W9	PE6RN02	
P9	V <sub>DD</sub> CORE		T2	V <sub>SS</sub>		U17	V <sub>SS</sub>		W10	V <sub>SS</sub>	
P10	V <sub>SS</sub>		T3	V <sub>SS</sub>		U18	V <sub>DD</sub> APE		W11	PE6RP03	
P11	V <sub>DD</sub> CORE		T4	V <sub>SS</sub>		U19	REFCLKM		W12	V <sub>SS</sub>	
P12	V <sub>SS</sub>		T5	V <sub>SS</sub>		U20	MSMBSMODE		W13	PE7RP00	
P13	V <sub>DD</sub> CORE		T6	V <sub>DD</sub> IO		U21	V <sub>SS</sub>		W14	V <sub>SS</sub>	
P14	V <sub>SS</sub>		T7	V <sub>DD</sub> CORE		U22	V <sub>SS</sub>		W15	PE7RN01	
P15	V <sub>DD</sub> CORE		T8	V <sub>SS</sub>		V1	V <sub>DD</sub> CORE		W16	V <sub>TT</sub> PE	
P16	V <sub>SS</sub>		T9	V <sub>SS</sub>		V2	V <sub>SS</sub>		W17	PE7RP02	
P17	V <sub>DD</sub> CORE		T10	V <sub>DD</sub> CORE		V3	V <sub>DD</sub> CORE		W18	V <sub>SS</sub>	
P18	V <sub>SS</sub>		T11	V <sub>SS</sub>		V4	V <sub>SS</sub>		W19	PE7RN03	
P19	V <sub>SS</sub>		T12	V <sub>SS</sub>		V5	V <sub>SS</sub>		W20	V <sub>SS</sub>	
P20	V <sub>SS</sub>		T13	V <sub>DD</sub> CORE		V6	V <sub>DD</sub> PE		W21	V <sub>DD</sub> CORE	
P21	V <sub>SS</sub>		T14	V <sub>SS</sub>		V7	V <sub>TT</sub> PE		W22	V <sub>SS</sub>	
P22	PEREFCLKP2		T15	V <sub>SS</sub>		V8	V <sub>SS</sub>		Y1	V <sub>DD</sub> CORE	
R1	V <sub>SS</sub>		T16	V <sub>SS</sub>		V9	V <sub>DD</sub> APE		Y2	V <sub>SS</sub>	
R2	V <sub>DD</sub> APE		T17	V <sub>DD</sub> CORE		V10	V <sub>TT</sub> PE		Y3	V <sub>DD</sub> CORE	
R3	P01MERGEN		T18	V <sub>SS</sub>		V11	V <sub>DD</sub> PE		Y4	V <sub>SS</sub>	
R4	P67MERGEN		T19	V <sub>SS</sub>		V12	V <sub>DD</sub> PE		Y5	PE6RN00	
R5	V <sub>SS</sub>		T20	V <sub>SS</sub>		V13	V <sub>TT</sub> PE		Y6	V <sub>SS</sub>	
R6	V <sub>DD</sub> IO		T21	V <sub>DD</sub> APE		V14	V <sub>DD</sub> APE		Y7	PE6RN01	
R7	V <sub>SS</sub>		T22	V <sub>DD</sub> CORE		V15	V <sub>DD</sub> PE		Y8	V <sub>SS</sub>	
R8	V <sub>DD</sub> CORE		U1	V <sub>SS</sub>		V16	V <sub>DD</sub> PE		Y9	PE6RP02	
R9	V <sub>SS</sub>		U2	V <sub>DD</sub> CORE		V17	V <sub>SS</sub>		Y10	V <sub>SS</sub>	
R10	V <sub>DD</sub> CORE		U3	V <sub>SS</sub>		V18	V <sub>DD</sub> APE		Y11	PE6RN03	
R11	V <sub>SS</sub>		U4	V <sub>DD</sub> APE		V19	V <sub>SS</sub>		Y12	V <sub>SS</sub>	
R12	V <sub>DD</sub> CORE		U5	V <sub>SS</sub>		V20	V <sub>SS</sub>		Y13	PE7RN00	
R13	V <sub>SS</sub>		U6	V <sub>DD</sub> APE		V21	V <sub>SS</sub>		Y14	V <sub>SS</sub>	

Table 19 PES16T4 484-pin Signal Pin-Out (Part 3 of 4)

Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt	Pin	Function	Alt
Y15	PE7RP01		AA6	PE6TN01		AA19	V <sub>SS</sub>		AB10	PE6TP03	
Y16	V <sub>SS</sub>		AA7	V <sub>SS</sub>		AA20	V <sub>SS</sub>		AB11	V <sub>SS</sub>	
Y17	PE7RN02		AA8	PE6TP02		AA21	V <sub>DD</sub> CORE		AB12	PE7TN00	
Y18	V <sub>SS</sub>		AA9	V <sub>SS</sub>		AA22	V <sub>SS</sub>		AB13	V <sub>SS</sub>	
Y19	PE7RP03		AA10	PE6TN03		AB1	V <sub>SS</sub>		AB14	PE7TN01	
Y20	V <sub>DD</sub> CORE		AA11	V <sub>SS</sub>		AB2	V <sub>SS</sub>		AB15	V <sub>SS</sub>	
Y21	V <sub>SS</sub>		AA12	PE7TP00		AB3	V <sub>SS</sub>		AB16	PE7TN02	
Y22	V <sub>DD</sub> CORE		AA13	V <sub>SS</sub>		AB4	PE6TN00		AB17	V <sub>SS</sub>	
AA1	V <sub>SS</sub>		AA14	PE7TP01		AB5	V <sub>SS</sub>		AB18	PE7TN03	
AA2	V <sub>DD</sub> CORE		AA15	V <sub>SS</sub>		AB6	PE6TP01		AB19	V <sub>SS</sub>	
AA3	V <sub>SS</sub>		AA16	PE7TP02		AB7	V <sub>SS</sub>		AB20	V <sub>SS</sub>	
AA4	PE6TP00		AA17	V <sub>SS</sub>		AB8	PE6TN02		AB21	V <sub>SS</sub>	
AA5	V <sub>SS</sub>		AA18	PE7TP03		AB9	V <sub>SS</sub>		AB22	V <sub>SS</sub>	

Table 19 PES16T4 484-pin Signal Pin-Out (Part 4 of 4)

### Alternate Signal Functions

Pin	GPIO	Alternate
J19	GPIO_04	IOEXPINTN2
K21	GPIO_05	IOEXPINTN3
K19	GPIO_07	GPEN
R19	GPIO_08	P1RSTN
R20	GPIO_11	P6RSTN
R21	GPIO_12	P7RSTN

Table 20 PES16T4 Alternate Signal Functions

**Power Pins**

V <sub>DDCore</sub>	V <sub>DDCore</sub>	V <sub>DDCore</sub>	V <sub>DDCore</sub>	V <sub>DDIO</sub>	V <sub>DDPE</sub>	V <sub>DDAPE</sub>	V <sub>TTPE</sub>
C1	J10	M7	R10	B2	E6	C21	D16
C22	J12	M9	R12	D21	E11	E9	E7
E1	J18	M11	R14	F2	E12	E14	E10
E22	J22	M13	R18	F3	E15	E18	E13
F5	K5	M15	T1	F6	E16	F9	V7
F10	K7	M17	T7	F12	F8	F15	V10
F14	K9	N3	T10	F17	F11	G18	V13
F16	K11	N4	T13	G21	F13	G20	W16
G1	K13	N8	T17	J17	U8	N6	
G6	K15	N10	T22	K2	U10	N17	
G10	K17	N12	U2	L21	U13	R2	
G13	L1	N14	V1	M20	V6	T21	
G22	L2	N18	V3	R6	V11	U4	
H5	L4	N19	V22	R17	V12	U6	
H7	L6	N20	W2	T6	V15	U9	
H9	L8	P7	W21	U7	V16	U14	
H11	L10	P9	Y1	U12		U18	
H13	L12	P11	Y3	U16		V9	
H15	L14	P13	Y20			V14	
H17	L18	P15	Y22			V18	
J1	L22	P17	AA2				
J8	M5	R8	AA21				

Table 21 PES16T4 Power Pins

**Ground Pins**

<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>	<b>V<sub>SS</sub></b>
A1	C16	H6	L15	P8	U3	Y16
A2	C18	H8	L16	P10	U5	Y18
A3	C20	H10	L17	P12	U11	Y21
A5	D1	H12	L19	P14	U15	AA1
A7	D4	H14	L20	P16	U17	AA3
A9	D6	H16	M1	P18	U21	AA5
A11	D8	H18	M2	P19	U22	AA7
A13	D10	H19	M3	P20	V2	AA9
A15	D12	H22	M4	P21	V4	AA11
A17	D14	J5	M6	R1	V5	AA13
A19	D18	J6	M8	R5	V8	AA15
A20	D20	J7	M10	R7	V17	AA17
A21	D22	J9	M12	R9	V19	AA19
A22	E5	J11	M14	R11	V20	AA20
B1	E8	J13	M16	R13	V21	AA22
B3	E17	J14	M18	R15	W1	AB1
B5	E19	J15	M19	R16	W3	AB2
B7	F1	J16	M21	R22	W4	AB3
B9	F4	K1	M22	T2	W6	AB5
B11	F7	K6	N2	T3	W8	AB7
B13	F22	K8	N5	T4	W10	AB9
B15	G5	K10	N7	T5	W12	AB11
B17	G7	K12	N9	T8	W14	AB13
B19	G8	K14	N11	T9	W18	AB15
B20	G9	K16	N13	T11	W20	AB17
B21	G11	K18	N15	T12	W22	AB19
B22	G12	K22	N16	T14	Y2	AB20
C4	G14	L3	N21	T15	Y4	AB21
C6	G15	L5	P2	T16	Y6	AB22
C8	G16	L7	P3	T18	Y8	
C10	G17	L9	P4	T19	Y10	
C12	G19	L11	P5	T20	Y12	
C14	H1	L13	P6	U1	Y14	

Table 22 PES16T4 Ground Pins

**Signals Listed Alphabetically**

Signal Name	I/O Type	Location	Signal Category
CCLKDS	I	F18	System
CCLKUS	I	E4	
GPIO_00	I/O	H20	General Purpose Input/Output
GPIO_01	I/O	H21	
GPIO_02	I/O	J21	
GPIO_03	I/O	J20	
GPIO_04	I/O	J19	
GPIO_05	I/O	K21	
GPIO_06	I/O	K20	
GPIO_07	I/O	K19	
GPIO_08	I/O	R19	
GPIO_11	I/O	R20	
GPIO_12	I/O	R21	
JTAG_TCK	I	K4	
JTAG_TDI	I	K3	
JTAG_TDO	O	J2	
JTAG_TMS	I	J3	
JTAG_TRST_N	I	J4	
MSMBADDR_1	I	H2	SMBus
MSMBADDR_2	I	H3	
MSMBADDR_3	I	H4	
MSMBADDR_4	I	G2	
MSMBCLK	I/O	G3	
MSMBDAT	I/O	G4	
MSMBSMODE	I	U20	System
P01MERGEN	I	R3	PCI Express
P67MERGEN	I	R4	
PE0RN00	I	D19	
PE0RN01	I	C17	
PE0RN02	I	D15	
PE0RN03	I	C13	
PE0RP00	I	C19	
PE0RP01	I	D17	
PE0RP02	I	C15	

Table 23 89PES16T4 Alphabetical Signal List (Part 1 of 4)

Signal Name	I/O Type	Location	Signal Category
PE0RP03	I	D13	PCI Express (Cont.)
PE0TN00	O	A18	
PE0TN01	O	A16	
PE0TN02	O	A14	
PE0TN03	O	A12	
PE0TP00	O	B18	
PE0TP01	O	B16	
PE0TP02	O	B14	
PE0TP03	O	B12	
PE1RN00	I	C11	
PE1RN01	I	D9	
PE1RN02	I	C7	
PE1RN03	I	C5	
PE1RP00	I	D11	
PE1RP01	I	C9	
PE1RP02	I	D7	
PE1RP03	I	D5	
PE1TN00	O	B10	
PE1TN01	O	A8	
PE1TN02	O	B6	
PE1TN03	O	A4	
PE1TP00	O	A10	
PE1TP01	O	B8	
PE1TP02	O	A6	
PE1TP03	O	B4	
PE6RN00	I	Y5	
PE6RN01	I	Y7	
PE6RN02	I	W9	
PE6RN03	I	Y11	
PE6RP00	I	W5	
PE6RP01	I	W7	
PE6RP02	I	Y9	
PE6RP03	I	W11	
PE6TN00	O	AB4	
PE6TN01	O	AA6	
PE6TN02	O	AB8	

Table 23 89PES16T4 Alphabetical Signal List (Part 2 of 4)



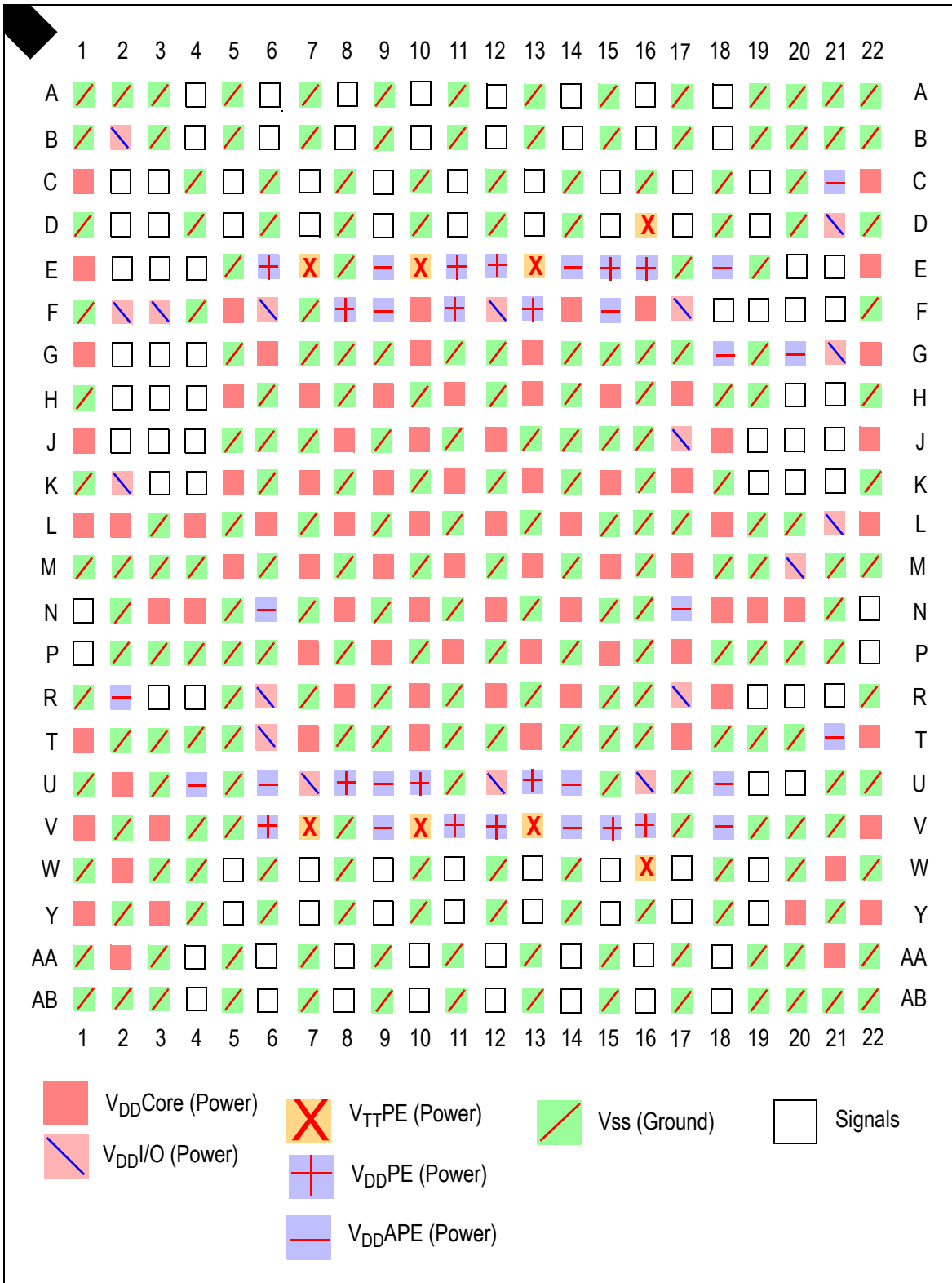
Signal Name	I/O Type	Location	Signal Category
PE6TN03	O	AA10	PCI Express (Cont.)
PE6TP00	O	AA4	
PE6TP01	O	AB6	
PE6TP02	O	AA8	
PE6TP03	O	AB10	
PE7RN00	I	Y13	
PE7RN01	I	W15	
PE7RN02	I	Y17	
PE7RN03	I	W19	
PE7RP00	I	W13	
PE7RP01	I	Y15	
PE7RP02	I	W17	
PE7RP03	I	Y19	
PE7TN00	O	AB12	
PE7TN01	O	AB14	
PE7TN02	O	AB16	
PE7TN03	O	AB18	
PE7TP00	O	AA12	
PE7TP01	O	AA14	
PE7TP02	O	AA16	
PE7TP03	O	AA18	
PEREFCLKN1	I	P1	
PEREFCLKN2	I	N22	
PEREFCLKP1	I	N1	
PEREFCLKP2	I	P22	
PERSTN	I	F20	System
REFCLKM	I	U19	PCI Express
RSTHALT	I	F19	System
SSMBADDR_1	I	E2	SMBus
SSMBADDR_2	I	D2	
SSMBADDR_3	I	C2	
SSMBADDR_5	I	E3	
SSMBCLK	I/O	D3	SMBus
SSMBDAT	I/O	C3	

Table 23 89PES16T4 Alphabetical Signal List (Part 3 of 4)

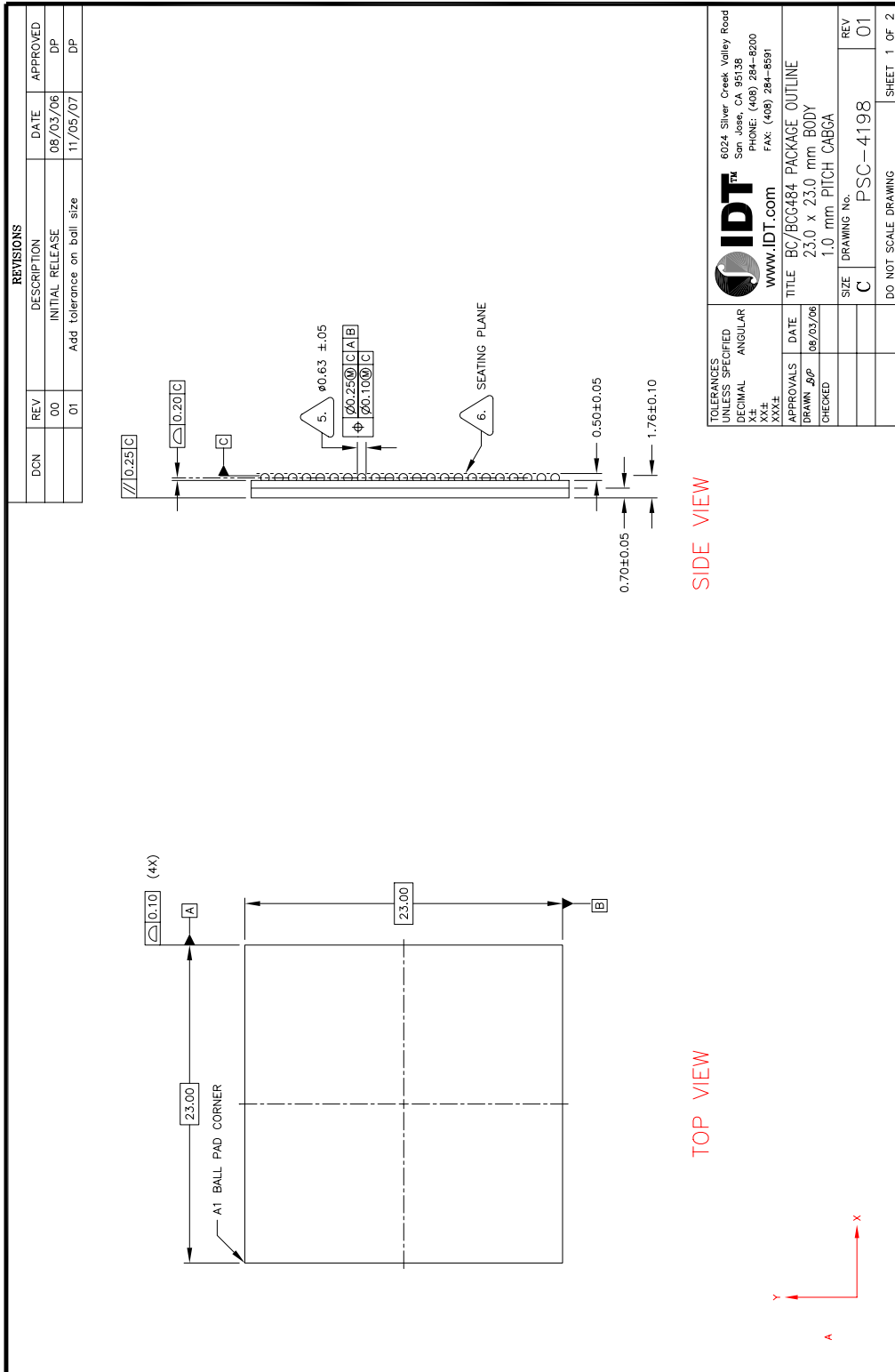
Signal Name	I/O Type	Location	Signal Category
SWMODE_0	I	E20	System
SWMODE_1	I	E21	
SWMODE_2	I	F21	
V <sub>DD</sub> CORE, V <sub>DD</sub> APE, V <sub>DD</sub> IO, V <sub>DD</sub> PE, V <sub>TT</sub> PE	See Table 21 for a listing of power pins.		
V <sub>SS</sub>	See Table 22 for a listing of ground pins.		

Table 23 89PES16T4 Alphabetical Signal List (Part 4 of 4)

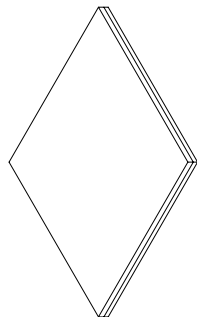
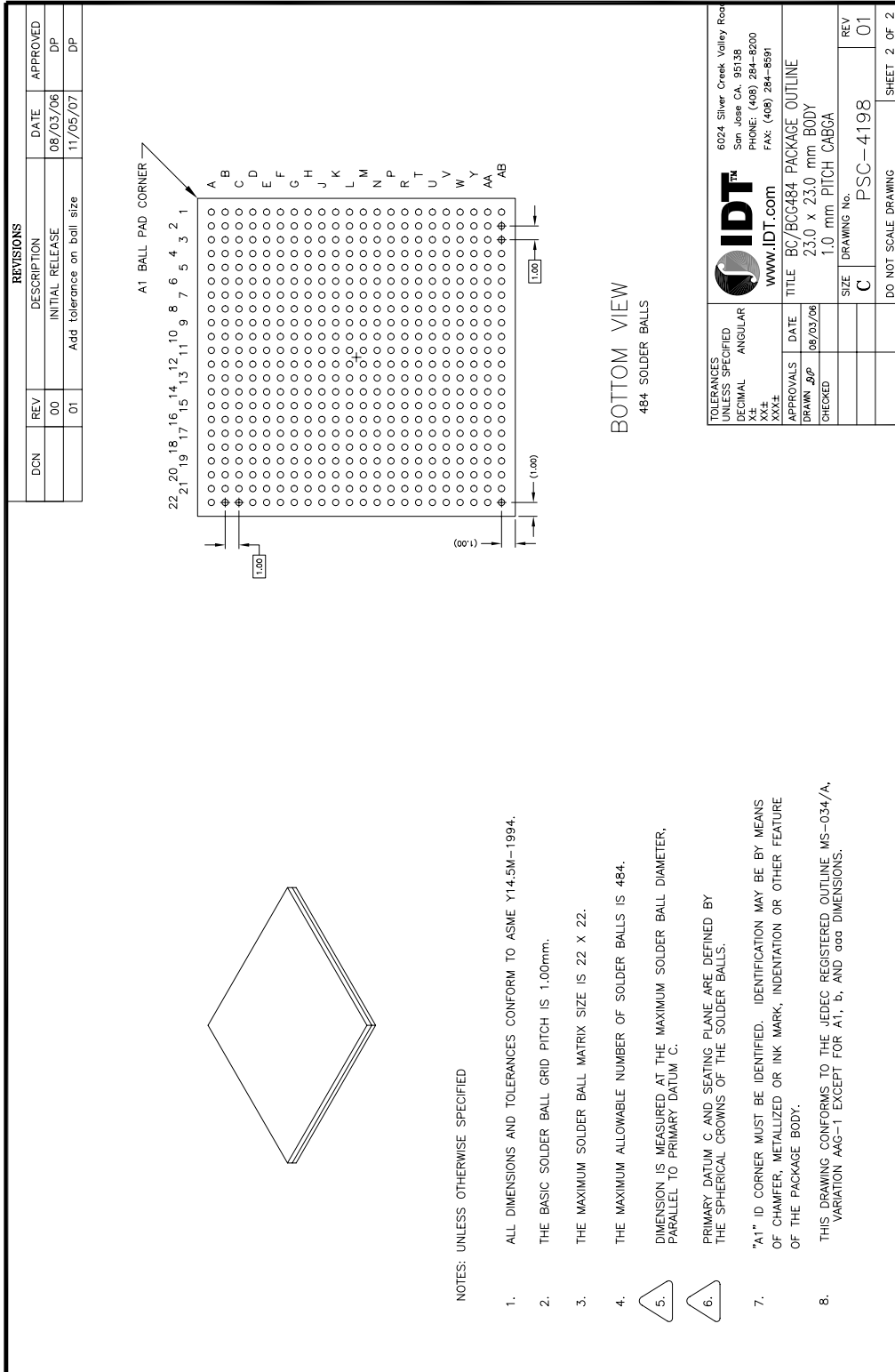
# PES16T4 Pinout — Top View



# PES16T4 Package Drawing — 484-Pin BC484/BCG484



PES16T4 Package Drawing — Page Two



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS AND TOLERANCES CONFORM TO ASME Y14.5M-1994.
2. THE BASIC SOLDER BALL GRID PITCH IS 1.00mm.
3. THE MAXIMUM SOLDER BALL MATRIX SIZE IS 22 X 22.
4. THE MAXIMUM ALLOWABLE NUMBER OF SOLDER BALLS IS 484.
5. DIMENSION IS MEASURED AT THE MAXIMUM SOLDER BALL DIAMETER, PARALLEL TO PRIMARY DATUM C.
6. PRIMARY DATUM C AND SEATING PLANE ARE DEFINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
7. "A1" ID CORNER MUST BE IDENTIFIED. IDENTIFICATION MAY BE BY MEANS OF CHAMFER, METALLIZED OR INK MARK, INDENTATION OR OTHER FEATURE OF THE PACKAGE BODY.
8. THIS DRAWING CONFORMS TO THE JEDEC REGISTERED OUTLINE MS-034/A, VARIATION AAG-1 EXCEPT FOR A1, B, AND GGG DIMENSIONS.

## Revision History

**February 8, 2007:** Initial publication.

**April 4, 2007:** In Table 3, revised description for MSMBCLK signal.

**May 30, 2007:** Changed device revision in Ordering Information from ZD to ZH.

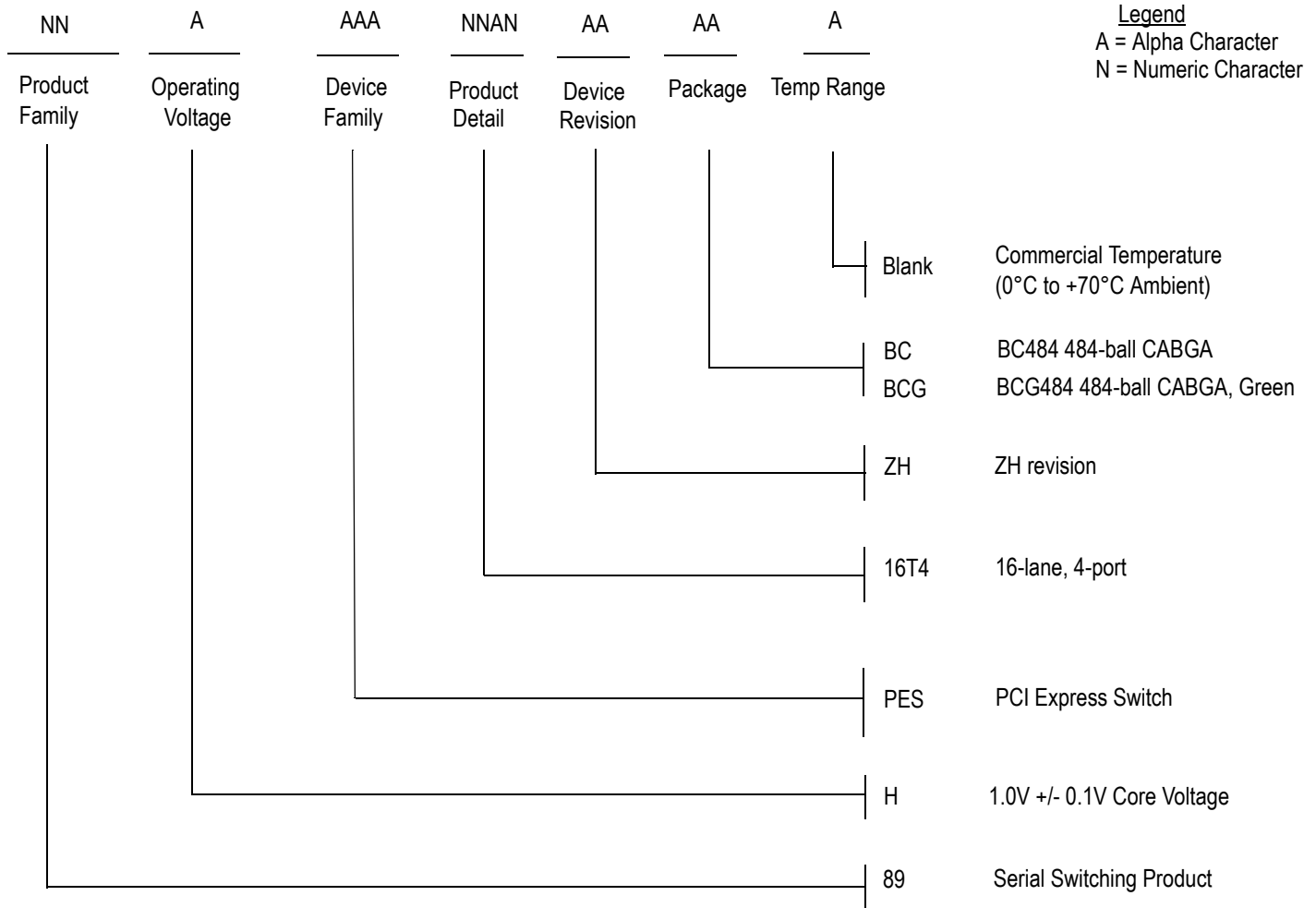
**November 1, 2007:** Changed package drawing to reflect correct ball/package dimensions.

**November 6, 2007:** Updated package drawing with solder ball tolerance added.

**November 8, 2007:** Added new parameter, Termination Resistor, to Table 9, Input Clock Requirements.

**March 25, 2008:** Added  $\theta_{JB}$  and  $\theta_{JC}$  parameters to Table 16, Thermal Specifications.

## Ordering Information



**Legend**

A = Alpha Character  
N = Numeric Character

### Valid Combinations

- 89HPES16T4ZHBC 484-ball CABGA package, Commercial Temperature
- 89HPES16T4ZHBCG 484-ball Green CABGA package, Commercial Temperature



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