



DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller

Data Sheet

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Contents

1	21140A Overview	1
1.1	General Description	1
1.2	Features	2
1.3	Microarchitecture	3
2	Pinout	6
2.1	Signal Reference Tables	8
2.2	Pin Tables	18
2.3	Signal Grouping by Function	20
3	Electrical and Environmental Specifications	22
3.1	Voltage Limit Ratings	22
3.2	Temperature Limit Ratings	22
3.3	Supply Current and Power Dissipation	23
3.4	PCI Electrical Parameters	23
3.4.1	PCI I/O Voltage Specifications	23
3.4.2	PCI Reset	24
3.4.3	PCI Clock Specifications	25
3.4.4	Other PCI Signals	26
3.5	Serial, MII/SYM, Boot ROM, Serial ROM, and General-Purpose Port Interface Specifications	27
3.6	Serial Network Port Timing	28
3.6.1	Serial 10-Mb/s Timing—Transmit	28
3.6.2	Serial 10-Mb/s Timing—Collision	29
3.6.3	Serial 10 Mb/s Timing—Receive, Start of Packet	30
3.6.4	Serial 10-Mb/s Timing—Receive, Start, and End of Packet	31
3.7	MI I/SYM Port Timing	32
3.7.1	MI I/SYM 10/100-Mb/s and 10-Mb/s Timing—Transmit	32
3.7.2	MI I/SYM 10/100-Mb/s Timing—Receive	34
3.7.3	MI I/SYM 10/100-Mb/s Timing—Signal Detect	35
3.7.4	MI I/SYM 10/100-Mb/s Timing—Receive Error	36
3.7.5	MI I/SYM 10/100-Mb/s Timing—Carrier Sense and Collision	36
3.8	Boot ROM Port Timing	37
3.8.1	Boot ROM Read Timing	37
3.8.2	Boot ROM Write Timing	38
3.9	Serial ROM Port Timing	39
3.10	External Register Timing	40
3.11	Joint Test Action Group—Test Access Port	41
3.11.1	JTAG DC Specifications	41
3.11.2	JTAG Boundary-Scan Timing	41

4	Mechanical Specifications	43
A	Support, Products, and Documentation	45

Figures

1	21140A Block Diagram	5
2	21140A Pinout Diagram (Top View)	7
3	PCI Reset Timing Diagram	24
4	PCI Clock Specification Timing Diagram	25
5	Timing Diagram for Other PCI Signals	26
6	Serial Network Port Timing Diagram—Transmit	28
7	Serial Network Port Timing Diagram—Collision	29
8	Serial Network Port Timing Diagram—Receive, Start of Packet	30
9	Serial Network Port Timing Diagram—Receive, End of Packet	31
10	MII/SYM Port Timing Diagram—Transmit	32
11	MII/SYM Port Timing Diagram—Receive	34
12	MII/SYM Port Timing Diagram—Signal Detect	35
13	MII/SYM Port Timing Diagram—Receive Error	36
14	MII/SYM Port Timing Diagram—Carrier Sense and Collision	36
15	Boot ROM Read Timing Diagram	37
16	Boot ROM Write Timing Diagram	38
17	Serial ROM Port Timing Diagram	39
18	External Register Read Timing Diagram	40
19	External Register Write Timing Diagram	40
20	JTAG Boundary-Scan Timing Diagram	42
21	144-PIN PQFP Package	44

Tables

1	Index to Pinout Tables	6
2	Logic Signals	8
3	Power Pins	9
4	Functional Description of 21140A Signals	10
5	Input Pins	19
6	Output Pins	19
7	Input/Output Pins	19
8	Open Drain Pins	20
9	Signal Functions	20
10	Voltage Limit Ratings	22
11	Temperature Limit Ratings	22
12	Supply Current and Power Dissipation	23
13	I/O Voltage Specifications for 5.0-V Levels	23
14	I/O Voltage Specification for 3.3-V Levels	24
15	PCI Reset Timing	24
16	PCI Clock Specifications	25
17	Other PCI Signals	27
18	Serial, MII/SYM, Boot ROM, Serial ROM, and General-Purpose Port	27
19	Serial Network Port Timing—Transmit	29
20	Serial Network Port Timing—Collision	29
21	Serial Network Port Timing—Receive, Start, and End of Packet	31
22	MI/SYM Port Timing—Transmit	33
23	MI/SYM Port Timing—Receive	34
24	MI/SYM Port Timing—Signal Detect	35
25	MI/SYM Port Timing—Receive Error	36
26	MI/SYM Port Timing—Carrier Sense and Collision	36
27	Boot ROM Read Timing Specifications	37
28	Boot ROM Write Timing Specifications	38
29	Serial ROM Port Timing Characteristics	39
30	External Register Timing Specifications	40
31	JTAG DC Specifications	41
32	JTAG Interface Signal Timing Relationships	42
33	144-Pin PQFP Dimensional Attributes	43

1 21140A Overview

The DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller (21140A) supports the peripheral component interconnect (PCI) bus. It provides a direct interface connection to the PCI and adapts easily to most other standard buses. The 21140A software interface and data structures are optimized to minimize the host CPU load and to allow for maximum flexibility in the buffer descriptor management. The 21140A contains large onchip FIFOs, so no additional onboard memory is required. The 21140A provides an upgradable boot ROM interface.

The 21140A has several additional features that are not available on the 21140, yet it remains pin and software compatible with the 21140.

1.1 General Description

The 21140A interfaces with the PCI bus by using onchip control and status registers (CSRs), and a shared CPU memory area that is set up mainly during initialization. This minimizes the processor involvement in the 21140A operation during normal reception and transmission. Traffic on the PCI bus is also minimized by filtering out received runt frames and by automatically retransmitting collided frames without needing to repeat a fetch from shared memory. The 21140A is compliant with revisions 2.0 and 2.1 of the *PCI Local Bus Specification*.

On the network side, the 21140A provides two ports: a serial standard 7-wire (SRL) 10-Mb/s port and a media-independent interface/symbol (MII/SYM) 10/100-Mb/s port. The 10-Mb/s port provides a direct interface to the external 10-Mb/s front-end decoder (ENDEC). The 10/100-Mb/s port supports two operational modes:

- A direct interface to the external 10/100-Mb/s ENDEC. The 21140A includes the onchip physical coding sublayer (PCS) and the scrambler for efficient 100BASE-T (CAT5 cable) implementation.
- A full implementation of the MII standard.

The 21140A is also capable of functioning in a full-duplex environment for both the 10-Mb/s and 10/100-Mb/s ports.

Features

1.2 Features

The 21140A has the following features:

- Offers a single-chip Fast Ethernet controller for PCI local bus:
 - Provides a glueless connection to the PCI bus
 - Supports two network ports: 10 Mb/s and 10/100 Mb/s
- Provides a standard 10/100-Mb/s MII supporting CAT3 unshielded twisted-pair (UTP), CAT5 UTP, shielded twisted-pair (STP) and fiber cables
- Contains onchip scrambler and PCS for CAT5 to significantly reduce cost of 100BASE-T solutions
- Supports full-duplex operation on both 10-Mb/s and 10/100-Mb/s ports
- Provides external and internal loopback capability on both ports
- Contains a variety of flexible address filtering modes (including perfect, hash tables, inverse perfect, and promiscuous):
 - 16 perfect addresses (normal or inverse filtering)
 - 512 hash-filtered addresses
 - 512 hash-filtered multicast addresses and one perfect address
 - Pass all multicast
 - Promiscuous
 - Pass all incoming packets with a status report
- Offers a unique, patented solution to Ethernet capture-effect problem
- Contains large independent receive and transmit FIFOs; no additional onboard memory required
- Includes a powerful onchip direct memory access (DMA) with programmable burst size providing for low CPU utilization
- Implements unique, patent-pending intelligent arbitration between DMA channels preventing underflow or overflow
- Supports PCI clock frequency from dc to 33 MHz; network operational with PCI clock from 20 MHz to 33 MHz
- Supports an unlimited PCI burst

- Supports PCI read multiple command
- Supports early interrupts on transmit and receive for improved performance
- Implements low-power management with two power-saving modes (sleep or snooze)
- Supports both PCI 5.0-V and 3.3-V signaling environments
- Supports either big or little endian byte ordering for buffers and descriptors
- Contains 8-bit, general-purpose, programmable register and corresponding I/O pins
- Provides LED support for various network activity indications
- Provides MicroWire interface for serial ROM (1K and 4K EEPROM)
- Provides an upgradable boot ROM interface of up to 256KB
- Supports automatic loading of subsystem vendor ID and subsystem ID from serial ROM to configuration register
- Implements JTAG-compatible test-access port with boundary-scan pins
- Supports IEEE 802.3, ANSI 8802-3, and Ethernet standards
- Implements low-power, 3.3-V complementary metal-oxide semiconductor (CMOS) process technology
- Supports PCI write and invalidate, and read line commands

1.3 Microarchitecture

The following list describes the 21140A hardware components, and Figure 1 shows a block diagram of the 21140A:

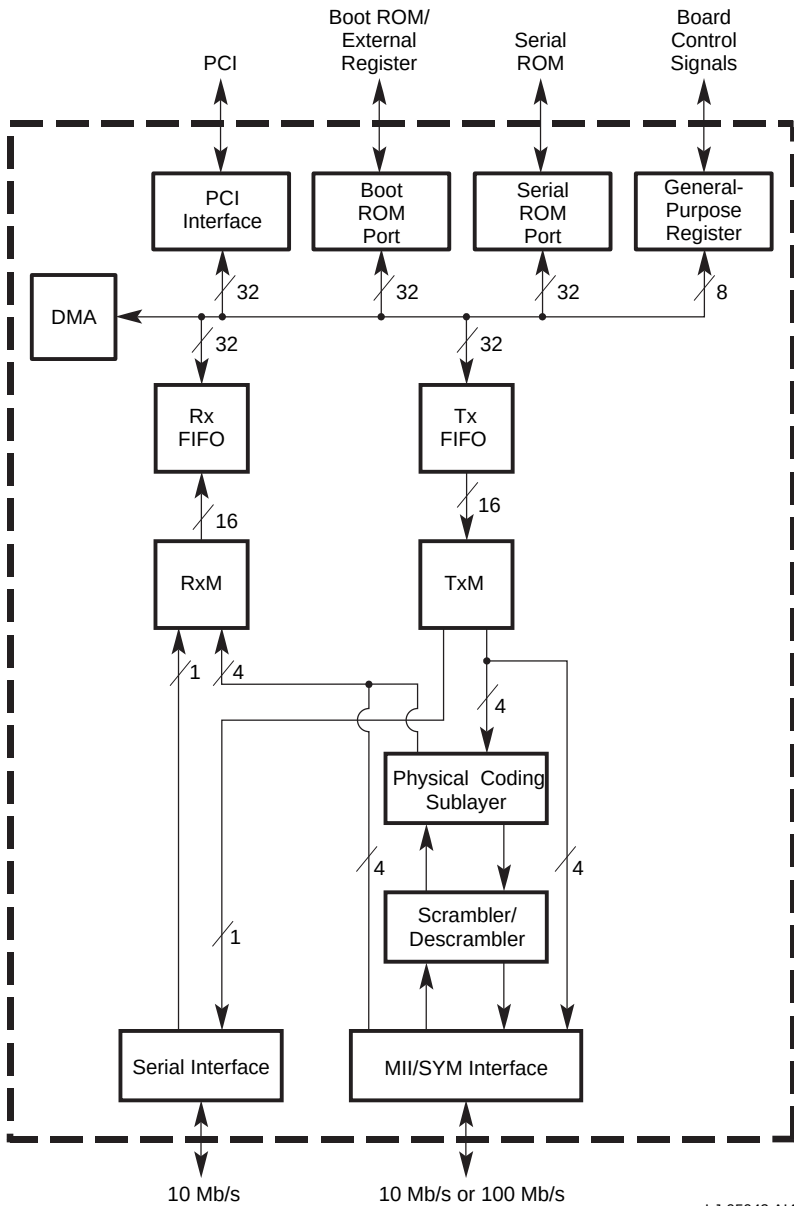
- PCI interface—Includes all interface functions to the PCI bus; handles all interconnect control signals; and executes PCI DMA and I/O transactions.
- DMA—Contains dual receive and transmit controller; handles data transfers between CPU memory and onchip memory.
- FIFOs—Contains two FIFOs for receive and transmit; supports automatic packet deletion on receive (runt packets or after a collision) and packet retransmission after a collision on transmit.
- TxM—Handles all CSMA/CD MAC¹ transmit operations, and transfers data from transmit FIFO to the ENDEC for transmission.

Microarchitecture

- RxM—Handles all CSMA/CD receive operations, and transfers the data from the ENDEC to the receive FIFO.
- Physical coding sublayer—Implements the encoding and decoding sublayer of the 100BASE-TX (CAT5) specification, including the squelch.
- Scrambler/descrambler—Implements the twisted-pair physical layer medium dependent (TP-PMD) scrambler/descrambler scheme.
- General-purpose register—Enables software to use for input or output functions.
- Serial interface—Provides a 7-wire conventional interface to the Ethernet ENDEC components.
- MII/SYM interface—Provides a full MII signal interface and a direct interface to the 10/100-Mb/s ENDEC for CAT5.
- Serial ROM port—Provides a direct interface to the MicroWire ROM for storage of the Ethernet address and system parameters.
- Boot ROM port—Provides an interface to perform read and write operations to the boot ROM; supports accesses to bytes or longword (32-bit). Also provides the ability to connect an external 8-bit register to the boot ROM port.

¹Media access control

Figure 1 21140A Block Diagram



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2 Pinout

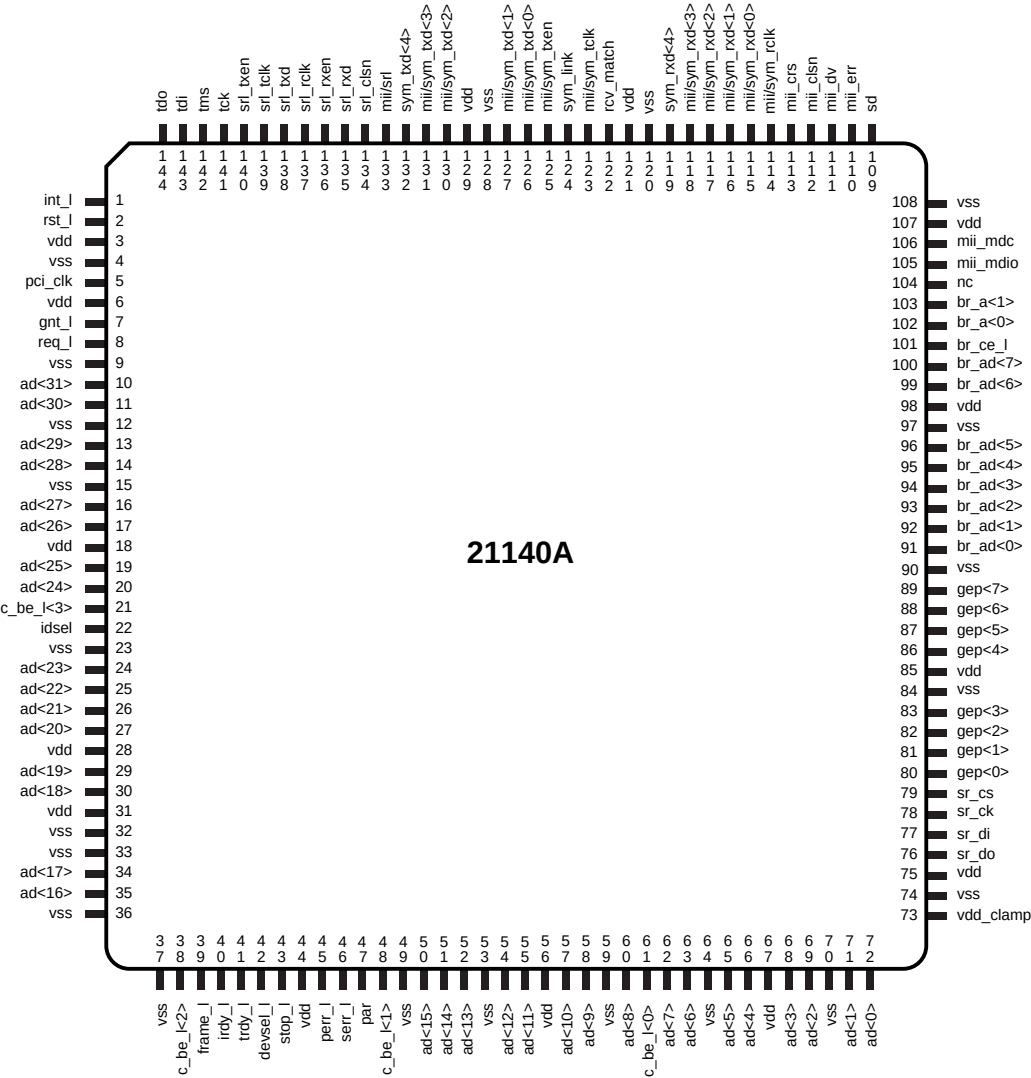
The 21140A is packaged in a 144-pin plastic quad flat pack (PQFP). The tables in this section provide a description of the pins and their respective signal definitions.

Table 1 lists the tables in this section. Figure 2 shows the 21140A pinout.

Table 1 Index to Pinout Tables

For this information...	Refer to...
Logic signals	Table 2
Power pins	Table 3
Functional signals description	Table 4
Input pins	Table 5
Output pins	Table 6
Input/output pins	Table 7
Open drain pins	Table 8
Signal functions	Table 9

Figure 2 21140A Pinout Diagram (Top View)



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Signal Reference Tables

2.1 Signal Reference Tables

Table 2 provides an alphabetical list of the 21140A logic names and their pin numbers. Table 3 provides a list of the 21140A power pin numbers.

Table 2 Logic Signals

(Sheet 1 of 2)

Signal	Pin Number	Signal	Pin Number	Signal	Pin Number
ad<0>	72	ad<24>	20	frame_l	39
ad<1>	71	ad<25>	19	gep<0>	80
ad<2>	69	ad<26>	17	gep<1>	81
ad<3>	68	ad<27>	16	gep<2>	82
ad<4>	66	ad<28>	14	gep<3>	83
ad<5>	65	ad<29>	13	gep<4>	86
ad<6>	63	ad<30>	11	gep<5>	87
ad<7>	62	ad<31>	10	gep<6>	88
ad<8>	60	br_a<0>	102	gep<7>	89
ad<9>	58	br_a<1>	103	gnt_l	7
ad<10>	57	br_ad<0>	91	idsel	22
ad<11>	55	br_ad<1>	92	int_l	1
ad<12>	54	br_ad<2>	93	irdy_l	40
ad<13>	52	br_ad<3>	94	mii_clsn	112
ad<14>	51	br_ad<4>	95	mii_crs	113
ad<15>	50	br_ad<5>	96	mii_dv	111
ad<16>	35	br_ad<6>	99	mii_err	110
ad<17>	34	br_ad<7>	100	mii_mdc	106
ad<18>	30	br_ce_l	101	mii_mdio	105
ad<19>	29	c_be_l<0>	61	mii/srl	133
ad<20>	27	c_be_l<1>	48	mii/sym_rclk	114
ad<21>	26	c_be_l<2>	38	mii/sym_rxd<0>	115
ad<22>	25	c_be_l<3>	21	mii/sym_rxd<1>	116

Table 2 Logic Signals

(Sheet 2 of 2)

Signal	Pin Number	Signal	Pin Number	Signal	Pin Number
ad<23>	24	devsel_l	42	mii/sym_rxd<2>	117
mii/sym_rxd<3>	118	req_l	8	srl_tclk	139
mii/sym_tclk	123	rst_l	2	srl_txd	138
mii/sym_txd<0>	126	sd	109	srl_txen	140
mii/sym_txd<1>	127	serr_l	46	stop_l	43
mii/sym_txd<2>	130	sr_ck	78	sym_link	124
mii/sym_txd<3>	131	sr_cs	79	sym_rxd<4>	119
mii/sym_txen	125	sr_di	77	sym_txd<4>	132
nc	104	sr_do	76	tck	141
par	47	srl_clsn	134	tdi	143
pci_clk	5	srl_rclk	137	tdo	144
perr_l	45	srl_rxd	135	tms	142
rcv_match	122	srl_rxen	136	trdy_l	41

Table 3 Power Pins

Signal	Pin Numbers	Signal	Pin Numbers
vdd (3.3 V)	3, 6, 18, 28, 31, 44, 56, 67, 75, 85, 98, 107, 121, 129	vss (Gnd)	4, 9, 12, 15, 23, 32, 33, 36, 37, 49, 53, 59, 64, 70, 74, 84, 90, 97, 108, 120, 128
vdd_clamp (5.0 V or 3.3 V)	73		

Signal Reference Tables

Table 4 provides a functional description of each of the 21140A signals. These signals are listed alphabetically. The functional grouping of each pin is listed in Section 2.3.

The following terms describe the 21140A pinout:

- **Address phase**
Address and appropriate bus commands are driven during this cycle.
- **Data phase**
Data and the appropriate byte enable codes are driven during this cycle.
- **_l**
All pin names with the _l suffix are asserted low.

The following abbreviations are used in Table 4:

I = Input

O = Output

I/O = Input/output

O/D = Open drain

P = Power

Table 4 Functional Description of 21140A Signals

(Sheet 1 of 9)

Signal	Type	Pin Number	Description
ad<31:0>	I/O	See Table 2.	32-bit PCI address and data lines. Address and data bits are multiplexed on the same pins. During the first clock cycle of a transaction, the address bits contain a physical address (32 bits). During subsequent clock cycles, these same lines contain 32 bits of data. A 21140A bus transaction consists of an address phase followed by one or more data phases. The 21140A supports both read and write bursts (in master operation only). Little and big endian byte ordering can be used.
br_a<0>	O	102	Boot ROM address line bit 0. In a 256KB configuration, this pin also carries in two consecutive address cycles, boot ROM address bits 16 and 17.

Table 4 Functional Description of 21140A Signals

(Sheet 2 of 9)

Signal	Type	Pin Number	Description
br_a<1>	O	103	Boot ROM address line bit 1. This pin also latches the boot ROM address and control lines by the two external latches.
br_ad<7:0>	I/O	See Table 2.	Boot ROM address and data multiplexed lines bits 7 through 0. In the first of two consecutive address cycles, these lines contain the boot ROM address bits 7 through 2, oe_l and we_l; followed by boot ROM address bits 15 through 8 in the second cycle. During the data cycle, bits 7 through 0 contain data. During operation with the external register, these lines are used to carry data bits 7 through 0 to and from the external register.
br_ce_l	O	101	Boot ROM or external register chip enable. This pin has an internal 5 k Ω pull-up resistor.
c_be_l<3:0>	I/O	See Table 2.	Bits 0 through 3 of the bus command and byte enable lines. Bus command and byte enable are multiplexed on the same PCI pins. During the address phase of the transaction, these 4 bits provide the bus command. During the data phase, these 4 bits provide the byte enable. The byte enable determines which byte lines carry valid data. For example, bit 0 applies to byte 0, and bit 3 applies to byte 3.
devsel_l	I/O	42	Device select is asserted by the target of the current bus access. When the 21140A is the initiator of the current bus access, it expects the target to assert devsel_l within five bus cycles, confirming the access. If the target does not assert devsel_l within the required bus cycles, the 21140A aborts the cycle. To meet the timing requirements, the 21140A asserts this signal in a medium speed (within two bus cycles).

Signal Reference Tables

Table 4 Functional Description of 21140A Signals

(Sheet 3 of 9)

Signal	Type	Pin Number	Description
frame_l	I/O	39	The frame_l signal is driven by the 21140A (bus master) to indicate the beginning and duration of an access. The frame_l signal asserts to indicate the beginning of a bus transaction. While frame_l is asserted, data transfers continue. The frame_l signal deasserts to indicate that the next data phase is the final data phase transaction.
gep<7:0>	I/O	See Table 2.	General-purpose pins can be used by software as either status pins or control pins. These pins can be configured by software to perform either input or output functions.
gnt_l	I	7	Bus grant asserts to indicate to the 21140A that access to the bus is granted.
idsel	I	22	Initialization device select asserts to indicate that the host is issuing a configuration cycle to the 21140A.
int_l	O/D	1	Interrupt request asserts when one of the appropriate bits of CSR5 sets and causes an interrupt, provided that the corresponding mask bit in CSR7 is not asserted. Interrupt request deasserts by writing a 1 into the appropriate CSR5 bit. If more than one interrupt bit is asserted in CSR5 and the host does not clear all input bits, the 21140A deasserts int_l for one cycle to support edge-triggered systems. This pin must be pulled up by an external resistor.

Table 4 Functional Description of 21140A Signals

(Sheet 4 of 9)

Signal	Type	Pin Number	Description
irdy_l	I/O	40	Initiator ready indicates the bus master's ability to complete the current data phase of the transaction. A data phase is completed on any rising edge of the clock when both irdy_l and target ready trdy_l are asserted. Wait cycles are inserted until both irdy_l and trdy_l are asserted together. When the 21140A is the bus master, irdy_l is asserted during write operations to indicate that valid data is present on the 32-bit ad lines. During read operations, the 21140A asserts irdy_l to indicate that it is ready to accept data.
mii_clsn	I	112	Collision detected is asserted when detected by an external physical layer protocol (PHY) device.
mii_crs	I	113	Carrier sense is asserted by the PHY when the media is active.
mii_dv	I	111	Data valid is asserted by an external PHY when receive data is present on the mii/sym_rxd lines and is deasserted at the end of the packet. This signal should be synchronized with the mii/sym_rclk signal.
mii_err	I	110	Receive error asserts when a data decoding error is detected by an external PHY device. This signal is synchronized to mii/sym_rclk and can be asserted for a minimum of one receive clock. When asserted during a packet reception, it sets the cyclic redundancy check (CRC) error bit in the receive descriptor (RDES0).
mii_mdc	O	106	MII management data clock is sourced by the 21140A to the PHY devices as a timing reference for the transfer of information on the mii_mdio signal.

Signal Reference Tables

Table 4 Functional Description of 21140A Signals

(Sheet 5 of 9)

Signal	Type	Pin Number	Description
mii_mdio	I/O	105	MII management data input/output transfers control information and status between the PHY and the 21140A.
mii/srl	O	133	Indicates the selected port: SRL or MII/SYM. When asserted, the MII/SYM port is active. When deasserted, the SRL port is active.
mii/sym_rclk	I	114	Supports either the 25-MHz or 2.5-MHz receive clock. This clock is recovered by the PHY.
mii/sym_rxd<3:0>	I	See Table 2.	Four parallel receive data lines when MII mode is selected. This data is driven by an external PHY that attached the media and should be synchronized with the mii/sym_rclk signal.
mii/sym_tclk	I	123	Supports the 25-MHz or 2.5-MHz transmit clock supplied by the external physical layer medium dependent (PMD) device. This clock should always be active.
mii/sym_txd<3:0>	O	See Table 2.	Four parallel transmit data lines. This data is synchronized to the assertion of the mii/sym_tclk signal and is latched by the external PHY on the rising edge of the mii/sym_tclk signal.
mii_txen	O	125	Transmit enable signals that the transmit is active to an external PHY device. In PCS mode (CSR6<23>), this signal reflects the transmit activity of the MAC sublayer.
nc	O	104	No connection.
par	I/O	47	Parity is calculated by the 21140A as an even parity bit for the 32-bit ad and 4-bit c_be_l lines. During address and data phases, parity is calculated on all the ad and c_be_l lines whether or not any of these lines carry meaningful information.

Table 4 Functional Description of 21140A Signals

(Sheet 6 of 9)

Signal	Type	Pin Number	Description
pci_clk	I	5	The clock provides the timing for the 21140A related PCI bus transactions. All the bus signals are sampled on the rising edge of pci_clk . The clock frequency range is between 25 MHz and 33 MHz.
perr_l	I/O	45	Parity error asserts when a data parity error is detected. When the 21140A is the bus master and a parity error is detected, the 21140A asserts both CSR5 bit 13 (system error) and CFCS bit 24 (data parity report). Next, it completes the current data burst transaction, then stops operation. After the host clears the system error, the 21140A continues its operation. The 21140A asserts perr_l when a data parity error is detected in either master-read or slave-write operations. This pin must be pulled up by an external resistor.
rcv_match	O	122	Receive match indication is asserted when a received packet has passed address recognition.
req_l	O	8	Bus request is asserted by the 21140A to indicate to the bus arbiter that it wants to use the bus.
rst_l	I	2	Resets the 21140A to its initial state. This signal must be asserted for at least 10 active PCI clock cycles. When in the reset state, all PCI output pins are put into tristate and all PCI O/D signals are floated.
sd	I	109	Signal detect indication supplied by an external physical layer medium dependent (PMD) device.

Signal Reference Tables

Table 4 Functional Description of 21140A Signals

(Sheet 7 of 9)

Signal	Type	Pin Number	Description
serr_l	O/D	46	If an address parity error is detected and CFCS bit 8 (serr_l enable) is enabled, the 21140A asserts both serr_l (system error) and CFCS bit 30 (signal system error). When an address parity error is detected, system error asserts two clocks after the failing address. This pin must be pulled up by an external resistor.
sr_ck	O	78	Serial ROM clock signal.
sr_cs	O	79	Serial ROM chip-select signal. This pin has an internal 2 k Ω pull-down resistor.
sr_di	O	77	Serial ROM data-in signal.
sr_do	I	76	Serial ROM data-out signal. This pin has an internal 5 k Ω pull-up resistor.
srl_clsn	I	134	Collision detect signals a collision occurrence on the Ethernet cable to the 21140A. It may be asserted and deasserted asynchronously by the external ENDEC to the receive clock.
srl_rclk	I	137	Receive clock carries the recovered receive clock supplied by an external ENDEC. During idle periods, srl_rclk may be inactive.
srl_rxd	I	135	Receive data carries the input receive data from the external ENDEC. The incoming data should be synchronous with the srl_rclk signal.
srl_rxen	I	136	Receive enable signals activity on the Ethernet cable to the 21140A. It is asserted when receive data is present on the Ethernet cable and is deasserted at the end of a frame. It may be asserted and deasserted asynchronously to the receive clock (srl_rclk) by the external ENDEC.

Table 4 Functional Description of 21140A Signals

(Sheet 8 of 9)

Signal	Type	Pin Number	Description
srl_tclk	I	139	Transmit clock carries the transmit clock supplied by an external ENDEC. This clock must always be active (even during reset).
srl_txd	O	138	Transmit data carries the serial output data from the 21140A. This data is synchronized to the srl_tclk signal.
srl_txen	O	140	Transmit enable signals an external ENDEC that the 21140A transmit is in progress.
stop_l	I/O	43	Stop indicator indicates that the current target is requesting the bus master to stop the current transaction. The 21140A responds to the assertion of stop_l when it is the bus master, either to disconnect, retry, or abort.
sym_link	O	124	Indicates that the descrambler is locked to the input data signal.
sym_rxd<4>	I	119	Receive data, together with the four receive lines mii/sym_rxd<3:0> , provide five parallel lines of data in symbol form for use in PCS mode (100BASE-T, CSR6<23>). This data is driven by an external PMD device and should be synchronized to the mii/sym_rclk signal.
sym_txd<4>	O	132	Transmit data, together with the four transmit lines mii/sym_txd<3:0> , provide five parallel lines of data in symbol form for use in PCS mode (100BASE-T, CSR6<23>). This data is synchronized on the rising edge of the mii/sym_tclk signal.
tck	I	141	JTAG clock shifts state information and test data into and out of the 21140A during JTAG test operations. This pin should not be left unconnected.
tdi	I	143	JTAG data in is used to serially shift test data and instructions into the 21140A during JTAG test operations. This pin has an internal pull-up resistor and can be left unconnected.

Pin Tables

Table 4 Functional Description of 21140A Signals

(Sheet 9 of 9)

Signal	Type	Pin Number	Description
tdo	O	144	JTAG data out is used to serially shift test data and instructions out of the 21140A during JTAG test operations.
tms	I	142	JTAG test mode select controls the state operation of JTAG testing in the 21140A. This pin has an internal pull-up resistor and can be left unconnected.
trdy_l	I/O	41	Target ready indicates the target agent's ability to complete the current data phase of the transaction. A data phase is completed on any clock when both trdy_l and irdy_l are asserted. Wait cycles are inserted until both irdy_l and trdy_l are asserted together. When the 21140A is the bus master, target ready is asserted by the bus slave on the read operation, indicating that valid data is present on the ad lines. During a write cycle, it indicates that the target is prepared to accept data.
vdd	P	See Table 3.	3.3-V supply input voltage.
vdd_clamp	P	73	5.0-V reference for 5.0-V signaling environments and 3.3 V for 3.3-V signaling environments.
vss	P	See Table 3.	Ground pins.

2.2 Pin Tables

This section contains four types of pin tables:

- Table 5 lists the input pins.
- Table 6 lists the output pins.
- Table 7 lists the input/output pins.
- Table 8 lists the open drain pins.

Table 5 Input Pins

Signal	Active Level	Signal	Active Level
gnt_l	Low	sd	High
idsel	High	sr_do	—
mii_clsn	High	srl_clsn	High
mii_crs	High	srl_rclk	—
mii_dv	High	srl_rxd	—
mii_err	High	srl_rxen	High
mii/sym_rclk	—	srl_tclk	—
mii/sym_rxd<3:0>	—	sym_rxd<4>	—
mii/sym_tclk	—	tck	—
pci_clk	—	tdi	—
rst_l	Low	tms	—

Table 6 Output Pins

Signal	Active Level	Signal	Active Level
br_a<0>	High	req_l	Low
br_a<1>	High	sr_ck	—
br_ce_l	Low	sr_cs	High
mii_mdc	—	sr_di	—
mii/srl	—	srl_txd	—
mii/sym_txd<3:0>	—	srl_txen	High
mii_txen	High	sym_link	High
nc	—	sym_txd<4>	—
rcv_match	High	tdo	High

Table 7 Input/Output Pins

(Sheet 1 of 2)

Signal	Active Level	Signal	Active Level
ad<31:0>	—	irdy_l	Low
br_ad<7:0>	—	mii_mdio	—
c_be_l<3:0>	Low	par	—

Signal Grouping by Function

Table 7 Input/Output Pins

(Sheet 2 of 2)

Signal	Active Level	Signal	Active Level
devsel_l	Low	perr_l	Low
frame_l	Low	stop_l	Low
gep<7:0>	—	trdy_l	Low

Table 8 Open Drain Pins

Signal	Active Level	Signal	Active Level
int_l	Low	serr_l	Low

2.3 Signal Grouping by Function

Table 9 lists the signals according to their interface function.

Table 9 Signal Functions

(Sheet 1 of 2)

Interface	Function	Signal
PCI	Address and data	ad<31:0>, par
	Arbitration	gnt_l, req_l
	Bus command and byte enable	c_be_l<3:0>
	Device select	devsel_l, idsel
	Error reporting	perr_l, serr_l
	Interrupt	int_l
	System	pci_clk, rst_l
	Control signals	frame_l, stop_l, irdy_l, trdy_l
MII/symbol	Transmit data lines	mii/sym_txd<3:0>
Network port	Receive data lines	mii/sym_rxd<3:0>
	Transmit, receive clocks	mii/sym_tclk, mii/sym_rclk
	SYM mode	sym_rxd<4>, sym_txd<4>
	Signal detection	sd

Table 9 Signal Functions

(Sheet 2 of 2)

Interface	Function	Signal
	Transmit enable	mii_txen
	Collision detect	mii_clsn
	Error reporting	mii_err
	Data control	mii_dv, mii_crs
	MII management data clock	mii_mdc
	MII management data input/output	mii_mdio
Serial network port	Transmit and receive data	srl_txd, srl_rxd
	Transmit control	srl_txen, srl_tclk
	Receive control	srl_rxen, srl_rclk
	Collision detect	srl_clsn
Miscellaneous	LED indicators	rcv_match, sym_link
	General-purpose pins	gep<7:0>
	MII/SYM and serial port select	mii/srl
Test access port	JTAG test operations	tck, tdi, tdo, tms
Serial ROM port	Serial ROM	sr_ck, sr_cs, sr_di, sr_do
Boot ROM	ROM interface	br_a<1:0>, br_ad<7:0>, br_ce_l
Power	3.3-V and 5.0-V supply input	vdd, vdd_clamp
	Ground	vss

3 Electrical and Environmental Specifications

This section contains the electrical and environmental specifications for the 21140A.

Caution: Stresses greater than the maximum or less than the minimum ratings can cause permanent damage to the 21140A. Exposure to the maximum or minimum ratings for extended periods of time lessen the reliability of the 21140A.

3.1 Voltage Limit Ratings

Table 10 lists the voltage limit ratings.

Table 10 Voltage Limit Ratings

Parameter	Minimum	Maximum
Power supply voltage	+3.0 V	+3.6 V
vdd_clamp (3.3 V) ¹	+3.0 V	+3.6 V
vdd_clamp (5.0 V)	+4.75 V	+5.25 V
ESD protection voltage	—	2000 V

¹In the 3.3-V signalling environment, **vdd_clamp** must not be more than +0.3 V above **vdd**.

3.2 Temperature Limit Ratings

Table 11 lists the temperature limit ratings.

Table 11 Temperature Limit Ratings

Parameter	Minimum	Maximum
Storage temperature	–55°C	+125°C
Operating temperature	0°C	70°C

3.3 Supply Current and Power Dissipation

The values in Table 12 are estimates based on a PCI clock frequency of 33 MHz and a network data rate of 10 Mb/s for SRL and 10/100 Mb/s for MII.

Table 12 Supply Current and Power Dissipation

Symbol	Typical ¹		Maximum ²	
	I _{dd} (mA)	Power (mW)	I _{dd} (mA)	Power (mW)
Normal power mode	125	413	180	648
Snooze power mode	75	248	150	540
Sleep power mode	60	198	125	450

¹Typical: **vdd** = 3.3 V, Ta = 25°C.

²Maximum: **vdd** = 3.6 V, Ta = 0°C.

3.4 PCI Electrical Parameters

This section describes the PCI characteristics for the 21140A.

3.4.1 PCI I/O Voltage Specifications

The 21140A meets the I/O voltage specifications listed in Table 13 and Table 14.

Table 13 I/O Voltage Specifications for 5.0-V Levels

Symbol	Parameter	Condition	Minimum	Maximum
V _{ih}	Input high voltage	—	2.0 V	vdd_clamp + 0.5 V
V _{il}	Input low voltage	—	−0.5 V	0.8 V
I _i ¹	Input leakage current	0.5 V < V _{in} < 2.7 V	—	±70 μA
V _{oh}	Output high voltage	I _{out} = −2 mA	2.4 V	—
V _{ol} ²	Output low voltage	I _{out} = 3 mA, 6 mA	—	0.55 V
Cap ³	Pin capacitance	—	5 pF	8 pF

¹Input leakage currents include high-impedance output leakage for all bidirectional buffers with tristate outputs.

²Signals without pull-up resistors have a low output current of 3 mA. Signals requiring pull-up resistors (including **frame_l**, **trdy_l**, **irdy_l**, **devsel_l**, **stop_l**, **serr_l**, and **perr_l**) have a low output current of 6 mA.

³Parameter design guarantee.

PCI Electrical Parameters

Table 14 I/O Voltage Specification for 3.3-V Levels

Symbol	Parameter	Condition	Minimum	Maximum
V_{ih}	Input high voltage	—	$0.475 * \mathbf{vdd_clamp}$	$\mathbf{vdd_clamp} + 0.5 \text{ V}$
V_{il}	Input low voltage	—	-0.5 V	$0.325 * \mathbf{vdd_clamp}$
I_i^1	Input leakage current	$0.0 \text{ V} < V_{in} < \mathbf{vdd_clamp}$	—	$\pm 10 \text{ }\mu\text{A}$
V_{oh}	Output high voltage	$I_{out} = -500 \text{ }\mu\text{A}$	$0.9 * \mathbf{vdd_clamp}$	—
V_{ol}	Output low voltage	$I_{out} = 1500 \text{ }\mu\text{A}$	—	$0.1 * \mathbf{vdd_clamp}$
Cap^2	Pin capacitance	—	5 pF	8 pF

¹Input leakage currents include high-impedance output leakage for all bidirectional buffers with tristate outputs.

²Parameter design guarantee.

3.4.2 PCI Reset

PCI reset (**pci_rst**) is an asynchronous signal that must be active for at least 10 active PCI clock (**pci_clk**) cycles. Figure 3 shows the PCI reset timing characteristics, and Table 15 lists the PCI reset signal limits.

Figure 3 PCI Reset Timing Diagram

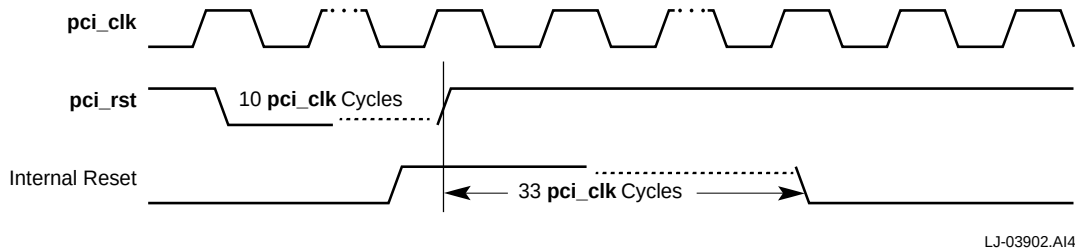


Table 15 PCI Reset Timing

Symbol	Parameter	Minimum	Maximum	Conditions
Trst	pci_rst pulse width	$10 * T_{cycle}$	Not applicable	pci_clk active

3.4.3 PCI Clock Specifications

The clock frequency range for the PCI is between 20 MHz and 33 MHz.¹ Figure 4 shows the PCI clock specification timing characteristics and required measurement points for both 5-V and 3.3-V signaling environments. Table 16 lists the frequency-derived clock specifications.

Figure 4 PCI Clock Specification Timing Diagram

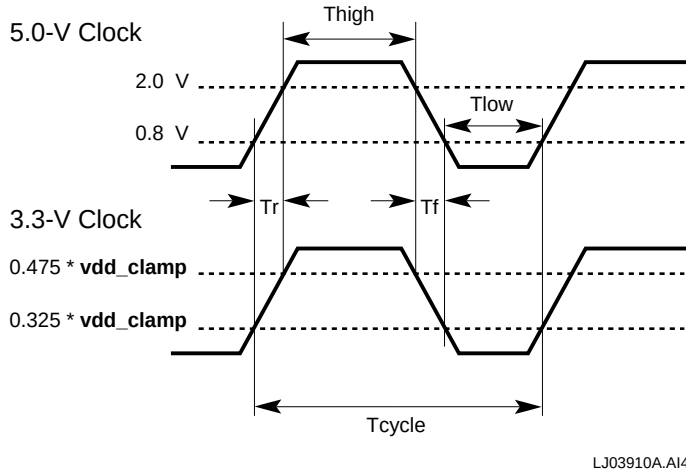


Table 16 PCI Clock Specifications

Symbol	Parameter	Minimum	Maximum
Tcycle	Cycle time	30 ns	50 ns
Thigh	pci_clk high time	11 ns	—
Tlow	pci_clk low time	11 ns	—
Tr/Tf ¹	pci_clk slew rate	1 V/ns	4 V/ns

¹Rise and fall times are specified in terms of the edge rate measured in V/ns. Parameter design guarantee.

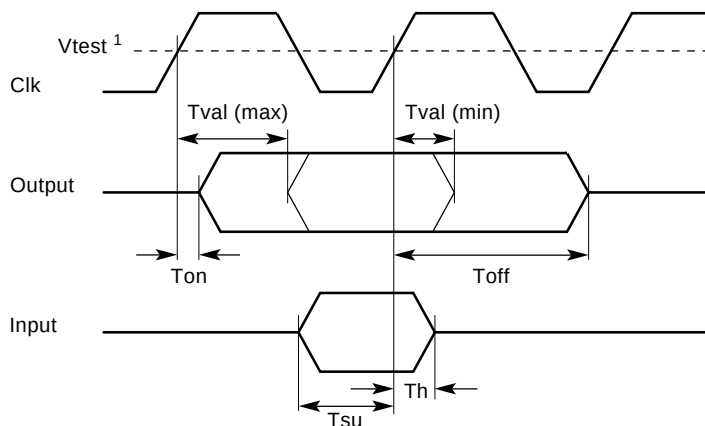
¹The PCI clock frequency is from dc to 33 MHz; network operational with the PCI clock from 20 MHz to 33 MHz.

PCI Electrical Parameters

3.4.4 Other PCI Signals

Figure 5 shows the timing diagram characteristics, and Table 17 lists the other PCI signals. This timing is identical to the timing for the general-purpose register signals.

Figure 5 Timing Diagram for Other PCI Signals



¹ V_{test} is 1.5 V in a 5.0-V signaling environment and is $0.4 * v_{dd_clamp}$ in a 3.3-V signaling environment.

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Table 17 Other PCI Signals

Symbol	Parameter	Minimum	Maximum
Tval ¹	clk-to-signal valid delay	2 ns	11 ns
Ton ²	Float-to-active delay from clk	2 ns	—
Toff	Active-to-float delay from clk	—	28 ns
Tsu	Input signal valid setup time before clk	7 ns	—
Th	Input signal hold time from clk	0 ns	—

¹Load for this measurement is as specified in revisions 2.0 and 2.1 of the *PCI Local Bus Specification*.

²Parameter design guarantee.

3.5 Serial, MII/SYM, Boot ROM, Serial ROM, and General-Purpose Port Interface Specifications

Table 18 lists the specifications for the serial, MII /SYM, boot ROM, serial ROM, and general-purpose port interfaces.

Table 18 Serial, MII/SYM, Boot ROM, Serial ROM, and General-Purpose Port

Symbol	Definition	Condition	Minimum	Maximum	Units
V _{oh}	Output high voltage	I _{oh} = −4 mA	2.4	—	V
V _{ol}	Output low voltage	I _{ol} = 4 mA	—	0.4	V
V _{ih}	Input high voltage	—	2.0	—	V
V _{il}	Input low voltage	—	—	0.8	V
I _{in}	Input current	V _{in} = V _{cc} or V _{ss}	−10.0	10.0	μA
I _{ip}	Input leakage current on pin with internal pull-up resistor (sr_do)	0.0 < V _{in} < vdd	—	+20/−1000 ¹	μA
I _{oz} ²	Maximum tristate output leakage current	V _{in} = V _{dd} or V _{ss}	−10.0	10.0	μA

¹For pin **sr_do**, which has an internal pull-up resistor, the maximum leakage current of 1 mA can occur when V_{in} = 0 V.

²For **br_ce_l**, the maximum value is 1000.0 μA.

3.6 Serial Network Port Timing

This section describes the serial network port timing limits.

3.6.1 Serial 10-Mb/s Timing—Transmit

Figure 6 shows the serial network port transmit timing characteristics, and Table 19 lists the serial network port transmit timing limits.

Figure 6 Serial Network Port Timing Diagram—Transmit

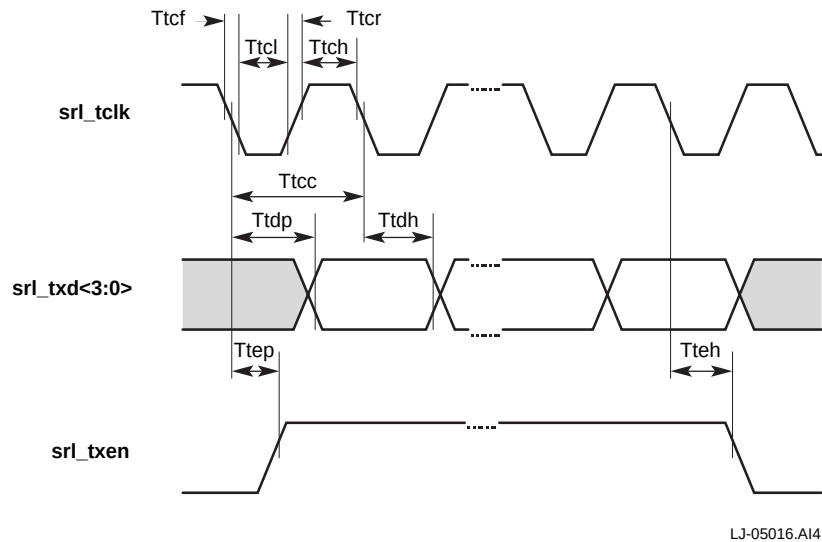


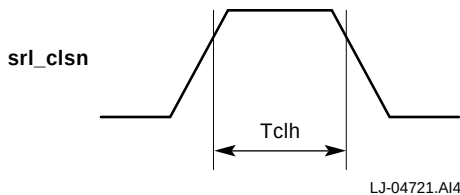
Table 19 Serial Network Port Timing—Transmit

Symbol	Definition	Minimum	Maximum	Units
Ttcl	srl_tclk low time	45	55	ns
Ttch	srl_tclk high time	45	55	ns
Ttcr ¹	srl_tclk rise time	—	8	ns
Ttcf ¹	srl_tclk fall time	—	8	ns
Ttdp	srl_tclk fall time to srl_txd valid	—	26	ns
Ttdh	srl_txd hold after srl_tclk fall time	5	—	ns
Ttep	srl_tclk fall time to srl_txen valid	—	26	ns
Tteh	srl_txen hold after srl_tclk fall time	5	—	ns

¹Parameter design guarantee.

3.6.2 Serial 10-Mb/s Timing—Collision

Figure 7 shows the serial network port collision timing characteristics, and Table 20 lists the serial network port collision timing limit.

Figure 7 Serial Network Port Timing Diagram—Collision**Table 20 Serial Network Port Timing—Collision**

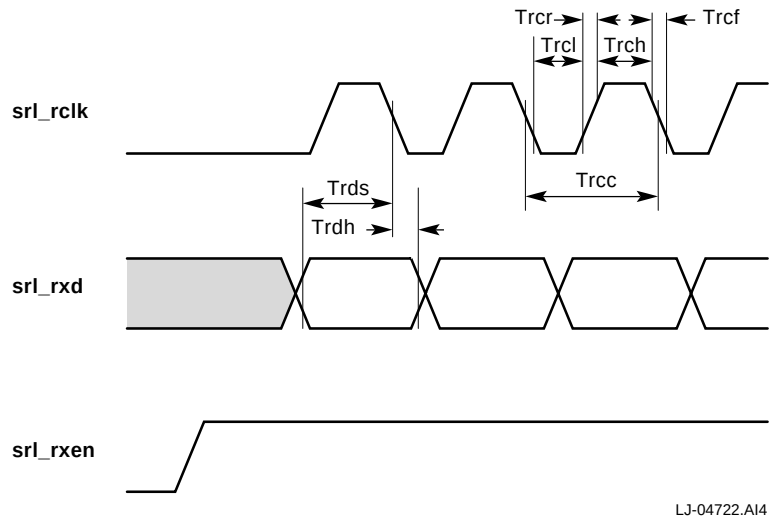
Symbol	Definition	Minimum	Maximum	Units
Tchl ¹	srl_clsn high time	20	—	ns

¹Parameter design guarantee.

3.6.3 Serial 10 Mb/s Timing—Receive, Start of Packet

Figure 8 shows the serial network port timing characteristics in receive mode, start of packet; and Table 21 lists the serial network port timing limits in receive mode, start of packet.

Figure 8 Serial Network Port Timing Diagram—Receive, Start of Packet



3.6.4 Serial 10-Mb/s Timing—Receive, Start, and End of Packet

Figure 9 shows the serial network port timing characteristics in receive mode, end of packet; and Table 21 lists the serial network port timing limits in receive mode, end of packet.

Figure 9 Serial Network Port Timing Diagram—Receive, End of Packet

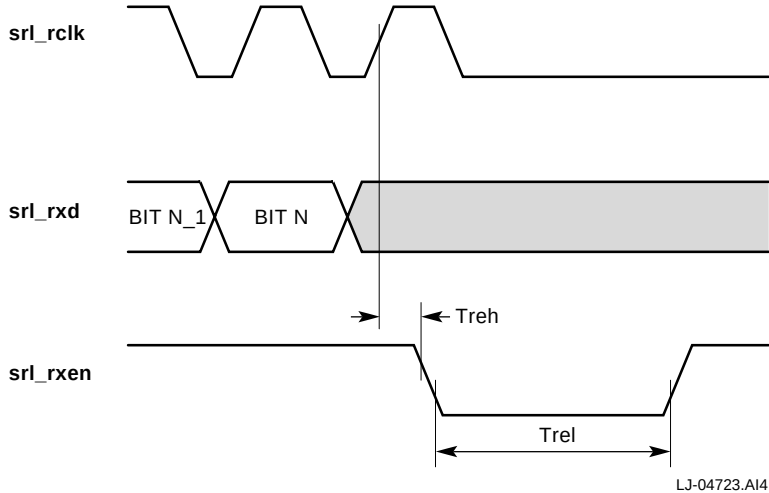


Table 21 Serial Network Port Timing—Receive, Start, and End of Packet

Symbol	Definition	Minimum	Maximum	Units
Trcc	srl_rclk cycle time	85	118	ns
Trcl	srl_rclk low time	38	80	ns
Trch	srl_rclk high time	38	80	ns
Trcr ¹	srl_rclk rise time	—	8	ns
Trcf ¹	srl_rclk fall time	—	8	ns
Trds	srl_rxd setup to srl_rclk fall time	10	—	ns
Trdh	srl_rxd hold after srl_rclk fall time	5	—	ns
Trel	srl_rxen low time	120	—	ns
Treh	srl_rxen hold after srl_rclk rise time	10	100	ns

¹Parameter design guarantee.

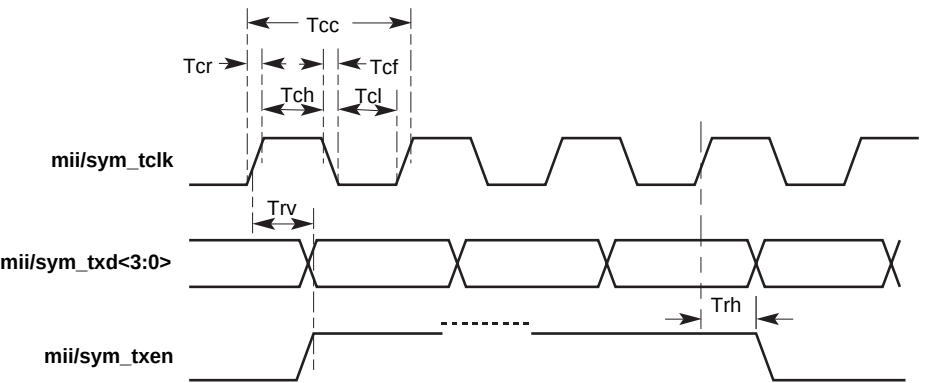
3.7 MII/SYM Port Timing

This section describes the MII/SYM port timing limits.

3.7.1 MII/SYM 10/100-Mb/s and 10-Mb/s Timing—Transmit

Figure 10 shows the MII/SYM port transmit timing characteristics, and Table 22 lists the MII/SYM port transmit timing limits.

Figure 10 MII/SYM Port Timing Diagram—Transmit



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Table 22 MII/SYM Port Timing—Transmit

Symbol	Definition	Minimum	Typical	Maximum	Units
Tcc ^{1,2}	mii/sym_tclk cycle time	—	40t	—	ns
Tch ²	mii/sym_tclk high time	14t	—	26t	ns
Tcl ²	mii/sym_tclk low time	14t	—	26t	ns
Tcr	mii/sym_tclk rise time	—	8	—	ns
Tcf	mii/sym_tclk fall time	—	8	—	ns
Trv ³	mii_tclk rise to mii_txen valid time or mii/sym_tclk rise to mii/sym_txd valid time	—	—	20	ns
Trh	mii_txen hold after mii_tclk rise time	5	—	—	ns

¹±50 parts per million.

²t = 1 for 100-Mb/s operation and t = 10 for 10-Mb/s operation.

³Outputs transmit data (**mii/sym_txd**) and transmit enable (**mii_txen**) are driven internally from the rising edge of **mii/sym_tclk**.

MII/SYM Port Timing

3.7.2 MII/SYM 10/100-Mb/s Timing—Receive

Figure 11 shows the MII/SYM port receive timing characteristics, and Table 23 lists the MII/SYM port receive timing limits.

Figure 11 MII/SYM Port Timing Diagram—Receive

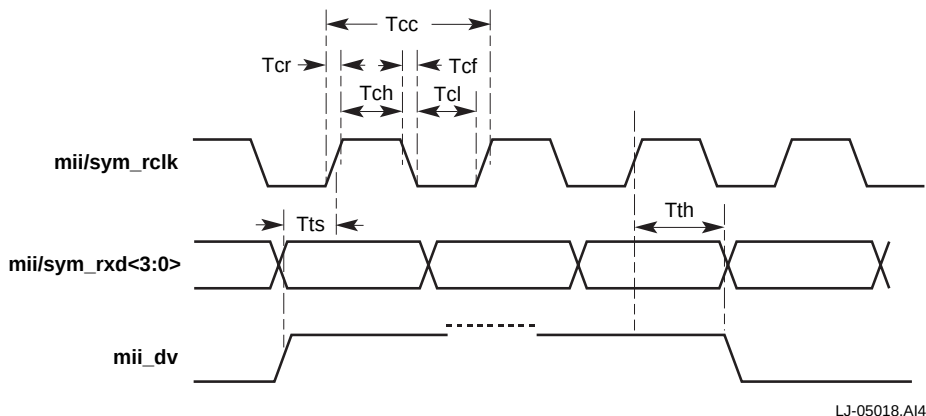


Table 23 MII/SYM Port Timing—Receive

(Sheet 1 of 2)

Symbol	Definition	Minimum	Typical	Maximum	Units
$T_{cc}^{1,2}$	mii/sym_rclk cycle time	—	40t	—	ns
T_{ch}^2	mii/sym_rclk high time	14t	—	26t	ns
T_{cl}^2	mii/sym_rclk low time	14t	—	26t	ns
T_{cr}	mii/sym_rclk rise time	—	8	—	ns
T_{cf}	mii/sym_rclk fall time	—	8	—	ns

Table 23 MII/SYM Port Timing—Receive

(Sheet 2 of 2)

Symbol	Definition	Minimum	Typical	Maximum	Units
T_{ts}^3	mii/sym_rxd setup (both rise and fall transactions) to mii/sym_rclk rise time or mii_dv setup (both rise and fall transactions) to mii_rclk rise time	8	—	—	ns
T_{th}^4	mii/sym_rxd hold (both rise and fall transactions) after mii/sym_rclk rise time or mii_dv hold (both rise and fall transactions) after mii_rclk rise time	10	—	—	ns

¹±50 parts per million.² $t = 1$ for 100-Mb/s operation and $t = 10$ for 10-Mb/s operation.³Inputs receive data (**mii/sym_rxd**) and data valid (**mii_dv**) are latched internally on the rising edge of **mii/sym_rclk**.⁴Parameter design guarantee.

3.7.3 MII/SYM 10/100-Mb/s Timing—Signal Detect

Figure 12 shows the MII/SYM port signal detect timing characteristics, and Table 24 lists the MII/SYM port signal detect timing limits.

Figure 12 MII/SYM Port Timing Diagram—Signal Detect

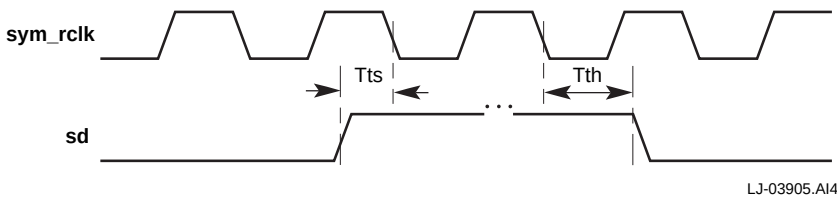


Table 24 MII/SYM Port Timing—Signal Detect

Symbol	Definition	Minimum	Maximum	Units
T_{ts}	sd ¹ setup (both rise and fall transactions) to sym_rclk fall time	10	—	ns
T_{th}^2	sd ¹ hold (both rise and fall transactions) after sym_rclk fall time	12	—	ns

¹Input signal detect (**sd**) is latched internally on the falling edge of **sym_rclk**.²Parameter design guarantee.

MII/SYM Port Timing

3.7.4 MII/SYM 10/100-Mb/s Timing—Receive Error

Figure 13 shows the MII/SYM port receive error timing characteristics, and Table 25 lists the MII/SYM port receive error timing limits.

Figure 13 MII/SYM Port Timing Diagram—Receive Error

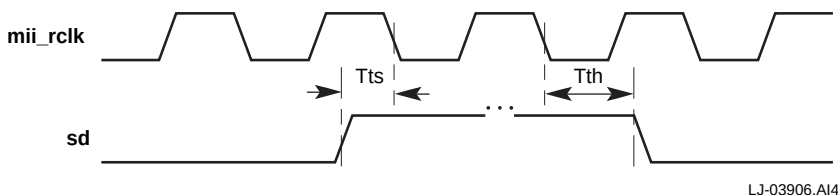


Table 25 MII/SYM Port Timing—Receive Error

Symbol	Definition	Minimum	Maximum	Units
Tts	mii_err ¹ setup (both rise and fall transactions) to mii_rclk rise time	10	—	ns
Tth ²	mii_err ¹ hold (both rise and fall transactions) after mii_rclk rise time	10	—	ns

¹Input receive error (**mii_err**) is latched internally on the rising edge of **mii_rclk**.

²Parameter design guarantee.

3.7.5 MII/SYM 10/100-Mb/s Timing—Carrier Sense and Collision

Figure 14 shows the MII/SYM port carrier sense and collision timing characteristics, and Table 26 lists the MII/SYM port carrier sense and collision timing limits.

Figure 14 MII/SYM Port Timing Diagram—Carrier Sense and Collision

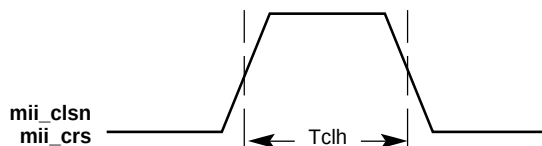


Table 26 MII/SYM Port Timing—Carrier Sense and Collision

Symbol	Definition	Minimum	Maximum	Units
Tclh	mii_crs , mii_clsn high time	20	—	ns

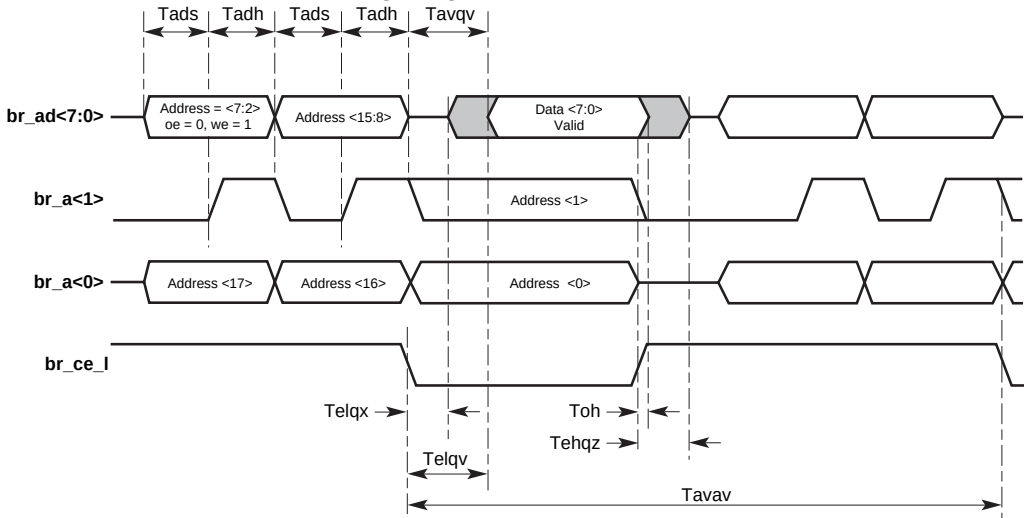
3.8 Boot ROM Port Timing

This section describes the boot ROM port timing.

3.8.1 Boot ROM Read Timing

Figure 15 shows the boot ROM read timing characteristics, and Table 27 lists the boot ROM read timing limits.

Figure 15 Boot ROM Read Timing Diagram



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Table 27 Boot ROM Read Timing Specifications

Symbol	Parameter	Minimum	Maximum	Units
Tavav	Read cycle time	120	—	ns
Telqv	br_ce_l to output delay	—	120	ns
Telqx ¹	br_ce_l to output enable	0	—	ns
Tehqz ¹	br_ce_l rising edge to output high impedance	—	55	ns
Toh ¹	Output hold from br_ce_l change	0	—	ns
Tads	Address setup to latch enable high	30	—	ns
Tadh	Address hold from latch enable high	30	—	ns

¹Parameter design guarantee.

3.9 Serial ROM Port Timing

Figure 17 shows the serial ROM port timing, and Table 29 lists the characteristics. This timing is identical to the timing for the MII management signals (**mii_mdio** and **mii_mdc**).

Figure 17 Serial ROM Port Timing Diagram

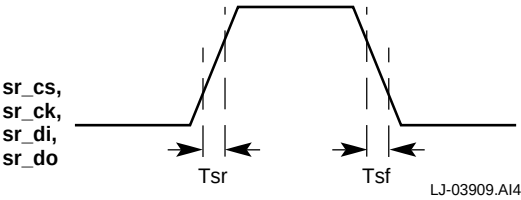


Table 29 Serial ROM Port Timing Characteristics

Symbol	Definition	Minimum	Maximum	Units
Tsr ¹	Rise time	—	10	ns
Tsf ¹	Fall time	—	10	ns

¹Parameter design guarantee.

3.10 External Register Timing

Figure 18 shows the external register read timing characteristics, and Figure 19 shows its write timing characteristics. Table 30 lists the external register timing specifications for both read and write operations.

Figure 18 External Register Read Timing Diagram

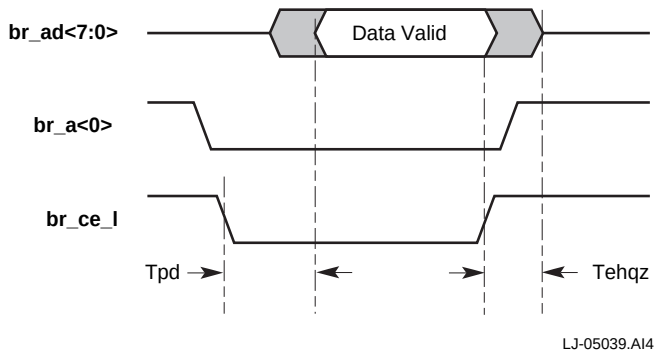


Figure 19 External Register Write Timing Diagram

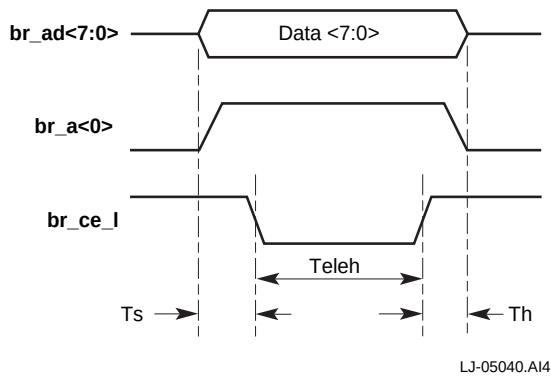


Table 30 External Register Timing Specifications (Sheet 1 of 2)

Symbol	Parameter	Minimum	Maximum	Units
Teleh	br_ce_l pulse width	120	—	ns
Read Timing				
Tpd	br_ce_l low to br_ad<7:0> valid	—	20	ns

Table 30 External Register Timing Specifications
(Sheet 2 of 2)

Symbol	Parameter	Minimum	Maximum	Units
T_{ehqz}^1	br_ce_l high to br_ad <7:0> high impedance	—	20	ns
Write Timing				
T_s	Data setup time prior to br_ce_l	30	—	ns
T_h	Data hold after br_ce_l high	30	—	ns

¹Parameter design guarantee.

3.11 Joint Test Action Group—Test Access Port

This section provides the joint test action group (JTAG) test access port specifications.

3.11.1 JTAG DC Specifications

Table 31 lists the dc specifications for the JTAG pins.

Table 31 JTAG DC Specifications

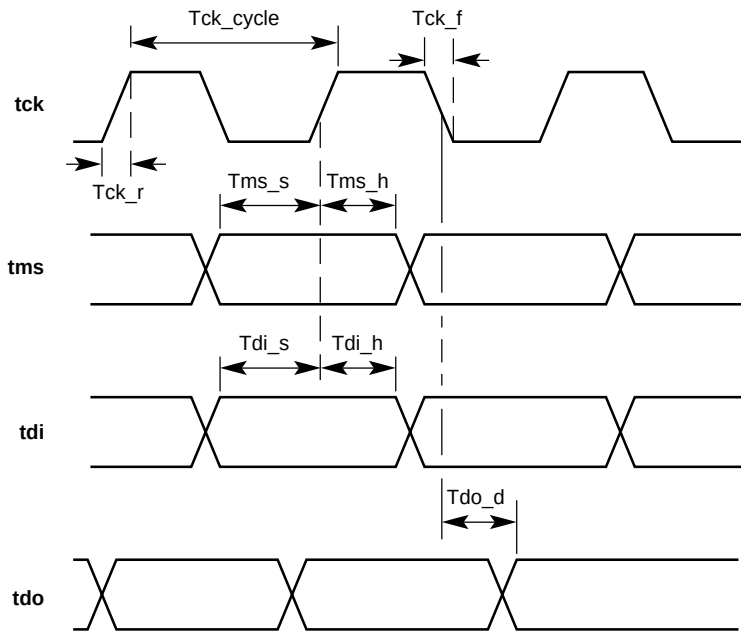
Symbol	Definition	Conditions	Minimum	Maximum	Units
V_{oh}	Output high voltage	$I_{oh} = -4 \text{ mA}$	2.4	—	V
V_{ol}	Output low voltage	$I_{ol} = 4 \text{ mA}$	—	0.4	V
V_{ih}	Input high voltage	—	2.0	—	V
V_{il}	Input low voltage	—	—	0.8	V
I_{ip}	Input leakage current on pins with internal pull-up resistors (tdi , tms)	$0.0 < V_{in} < \mathbf{vdd}$	—	$\pm 20/-1000^1$	μA
I_{oz}	Tristate output leakage current (tdo)	$0.0 < V_{out} < \mathbf{vdd}$	—	± 20	μA

¹For **tdi** and **tms** pins, which have internal pull-up resistors, the maximum leakage current of 1 mA can occur when $V_{in} = 0 \text{ V}$.

3.11.2 JTAG Boundary-Scan Timing

Figure 20 shows the JTAG boundary-scan timing, and Table 32 lists the interface signal timing relationships.

Figure 20 JTAG Boundary-Scan Timing Diagram



LJ-03908.A14

Table 32 JTAG Interface Signal Timing Relationships

Symbol	Parameter	Minimum	Maximum	Units
Tms_s	tms setup time	20	—	ns
Tms_h	tms hold time	5	—	ns
Tdi_s	tdi setup time	20	—	ns
Tdi_h	tdi hold time	5	—	ns
Tdo_d	tdo delay time	—	20	ns
Tck_r ¹	tck rise time	—	3	ns
Tck_f ¹	tck fall time	—	3	ns
Tck_cycle	tck cycle time	90	—	ns

¹Parameter design guarantee.

4 Mechanical Specifications

The 21140A is contained in an industry standard 144-pin PQFP. Table 33 lists the mechanical specifications, and Figure 21 shows the mechanical layout of the 21140A.

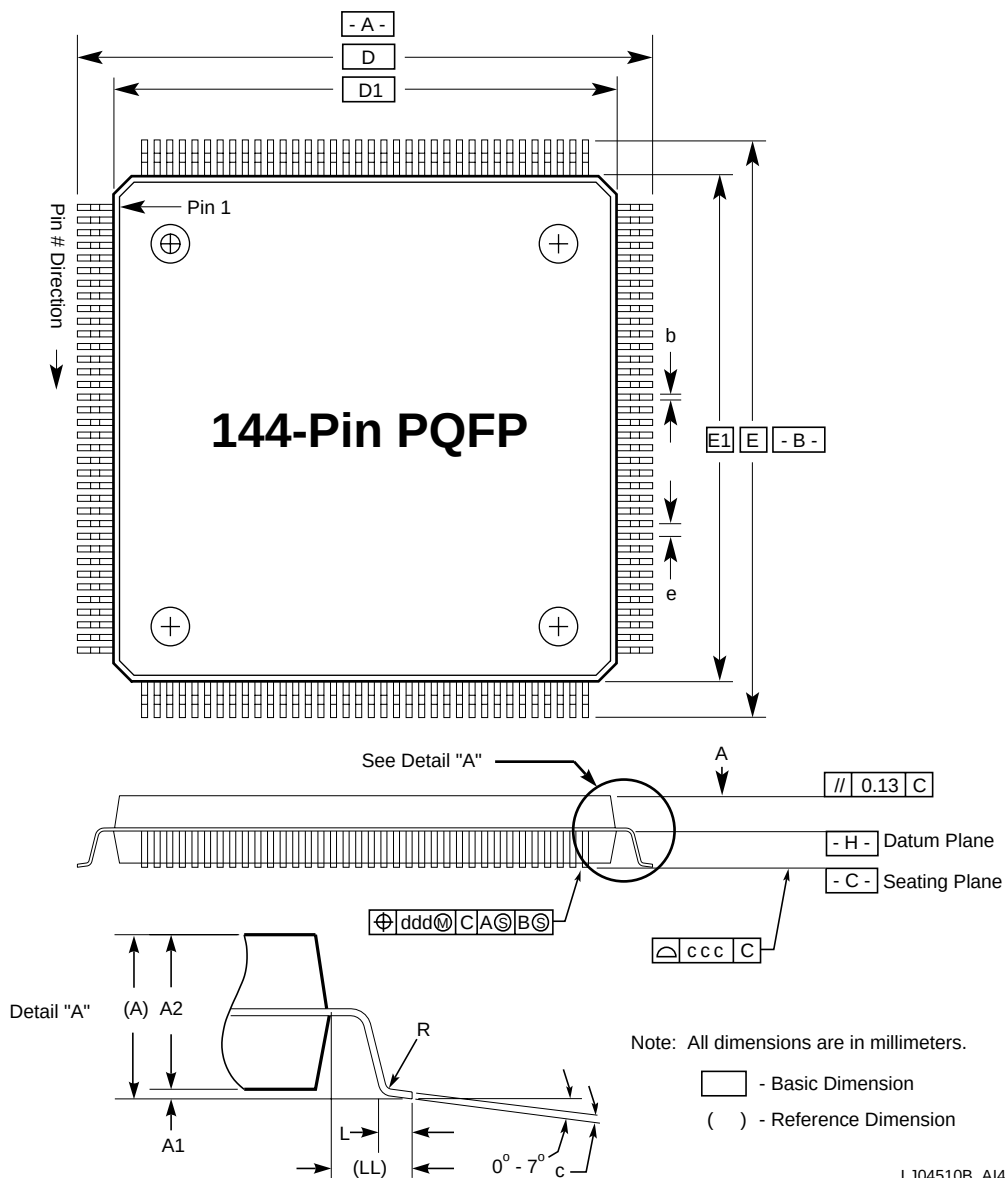
Table 33 144-Pin PQFP Dimensional Attributes

Symbol	Dimension	Limit	Value (mm)
A	Package overall height	Maximum	4.10
A1	Package standoff height	Minimum	0.25
A2	Package thickness	Minimum Maximum	3.17 3.67
b	Lead width	Minimum Maximum	0.22 0.38
c	Lead thickness	Minimum Maximum	0.12 0.23
ccc	Coplanarity		0.1
D	Package overall width	BSC ¹	31.20
D1	Package width	BSC	28.00
ddd	Lead skew		0.13
E	Package overall length	BSC	31.20
E1	Package length	BSC	28.00
e	Lead pitch	BSC	0.65
L	Foot length	Minimum Maximum	0.65 1.03
LL	Lead length	Reference ²	1.60
R	Ankle radius	Minimum Maximum	0.13 0.3

¹ANSI Y14.5M-1982 American National Standard Dimensioning and Tolerancing, Section 1.3.2, defines basic (BSC) dimension 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.

²The value for this measurement is for reference only.

Figure 21 144-PIN PQFP Package



A Support, Products, and Documentation

To view current product update and errata revision information, please visit the DIGITAL Semiconductor World Wide Web Internet site. You may also visit this web site for technical support, a *DIGITAL Semiconductor Product Catalog*, or help deciding which documentation best meets your needs:

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Phone (U.S. and international): 1-978-568-7474

Fax: 1-978-568-6698

Electronic mail address: ctc@hlo.mts.dec.com

DIGITAL Semiconductor Products

To order the DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller and Evaluation Boards, contact your local distributor. The following tables list some of the semiconductor products available from DIGITAL Semiconductor.

Note: The following products and order numbers might have been revised. For the latest versions, contact your local distributor.

Product	Order Number
DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller	21140–AF
DIGITAL Semiconductor 21143 PCI/CardBus 10/100-Mb/s Ethernet LAN Controller (MQFP package)	21143–PD
DIGITAL Semiconductor 21143 PCI/CardBus 10/100-Mb/s Ethernet LAN Controller (LQFP package)	21143–TD

Evaluation board kits include an evaluation board, and can include a complete design kit, an installation kit, or an accessories kit.

Evaluation Board Kits	Order Number
DIGITAL Semiconductor 21140A 10/100BASE–TX Evaluation Board Kit	21A40–TX
DIGITAL Semiconductor 21143 PCI 10/100BASE–TX Evaluation Board Kit	21A43–04

DIGITAL Semiconductor Documentation

The following table lists some of the available DIGITAL Semiconductor documentation.

To determine which documents apply to a particular device part number, visit the DIGITAL Semiconductor Documentation Library on DIGITAL Semiconductor's World Wide Web Internet site at:

<http://ftp.digital.com/pub/digital/info/semiconductor/literature/dsc-library.html>

Title	Order Number)
DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller Hardware Reference Manual	EC-QN7NF-TE
DIGITAL Semiconductor 21140A PCI Fast Ethernet LAN Controller Product Brief	EC-QN7MB-TE
DIGITAL Semiconductor 21143 PCI/CardBus 10/100-Mb/s Ethernet LAN Controller Data Sheet	EC-QWC3F-TE
DIGITAL Semiconductor 21143 PCI/CardBus 10/100-Mb/s Ethernet LAN Controller Hardware Reference Manual	EC-QWC4F-TE
DIGITAL Semiconductor 21143 PCI/CardBus 10/100-Mb/s Ethernet LAN Controller Product Brief	EC-QWC2B-TE
DIGITAL Semiconductor 21143 Connection to the Network Using Physical Layer Devices: An Application Note	EC-QXY7A-TE

Third-Party Documentation

You can order the following third-party documentation directly from the vendor.

Title	Vendor
PCI Local Bus Specification, Revision 2.1	PCI Special Interest Group
PCI Multimedia Design Guide, Revision 1.0	U.S. 1-800-433-5177
PCI System Design Guide	International 1-503-797-4207
PCI-to-PCI Bridge Architecture Specification, Revision 1.0	Fax 1-503-234-6762
PCI BIOS Specification, Revision 2.1	
IEEE 802.3	The Institute of Electrical and Electronics Engineers, Inc.
	U.S. 1-800-701-4333
	International 1-908-981-0060
	Fax 1-908-981-9667