PCI

NI PCI-1588 User Manual

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Worldwide Technical Support and Product Information

ni.com

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Determining FCC Class

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Depending on where it is operated, this Class A product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.) Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products.

All Class A products display a simple warning statement of one paragraph in length regarding interference and undesired operation. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

Consult the FCC Web site at `www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE marking Declaration of Conformity*, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by NI could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user is required to correct the interference at their own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Compliance with EU Directives

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* The CE marking Declaration of Conformity contains important supplementary information and instructions for the user or installer.

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About This Manual

Thank you for purchasing the National Instruments NI PCI-1588 Timing and Synchronization Module. The NI PCI-1588 enables you to use IEEE 1588 to perform synchronized events over Ethernet. The NI PCI-1588 can generate events and clock signals at specified 1588 future times and timestamp input events with the 1588 system time. This provides a method for performing synchronous activity and analysis over low-cost Ethernet cabling.

This manual describes the electrical and mechanical aspects of the NI PCI-1588 and contains information concerning its operation and programming.

Conventions

The following conventions appear in this manual:

<> — Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.

» — The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on a product, refer to the *Safety Information* section of Chapter 1, *Introduction*, for information about precautions to take.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

National Instruments Documentation

The *NI PCI-1588 User Manual* is one piece of the documentation set for your measurement system. You could have any of several other documents describing your hardware and software. Use the documentation you have as follows:

- Measurement hardware documentation—This documentation contains detailed information about the measurement hardware that plugs into or is connected to the computer. Use this documentation for hardware installation and configuration instructions, specifications about the measurement hardware, and application hints.
- Software documentation—Refer to the *NI-Sync User Manual*, available on the *NI-Sync* CD and at `ni.com/manuals`.

You can download NI documentation from `ni.com/manuals`.

Related Documentation

The following document contains information that you might find helpful as you read this manual:

- *NI-Sync User Manual*, available on the *NI-Sync* CD and at `ni.com/manuals`

1 Introduction

The NI PCI-1588 enables you to use IEEE 1588 to perform synchronized events over Ethernet. The NI PCI-1588 can generate events and clock signals at specified 1588 future times and timestamp input events with the 1588 system time. This provides a method for performing synchronous activity and analysis over low-cost Ethernet cabling.

What You Need to Get Started

To set up and use the NI PCI-1588, you need the following items:

- ❑ NI PCI-1588 Timing and Triggering Module
- ❑ *NI PCI-1588 User Manual*
- ❑ *NI-Sync* CD
- ❑ One of the following software packages and documentation:
  - – LabVIEW
  - – LabWindows™/CVI™
  - – Microsoft Visual C++ (MSVC)
- ❑ Desktop computer with available PCI slot
- ❑ Twisted Pair Ethernet (RJ-45) cabling
- ❑ SMB and/or RTSI cabling depending on application

Unpacking

The NI PCI-1588 is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge (ESD) can damage several components on the module.

Caution *Never* touch the exposed pins of connectors.

To avoid such damage in handling the module, take the following precautions:

- Ground yourself using a grounding strap or by touching a grounded object.
- Touch the antistatic package to a metal part of the computer chassis before removing the module from the package.

Remove the module from the package and inspect the module for loose components or any sign of damage. Notify NI if the module appears damaged in any way. Do *not* install a damaged module into the computer.

Store the NI PCI-1588 in the antistatic envelope when not in use.

Software Programming Choices

When programming the NI PCI-1588, you can use NI application development environment (ADE) software such as LabVIEW or LabWindows/CVI, or you can use other ADEs such as Visual C/C++.

LabVIEW features interactive graphics, a state-of-the-art interface, and a powerful graphical programming language.

LabWindows/CVI is a complete ANSI C ADE that features an interactive user interface and code generation tools.

Safety Information

The following section contains important safety information that you *must* follow when installing and using the product.

Do *not* operate the product in a manner not specified in this document. Misuse of the product can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to National Instruments for repair.

Do *not* substitute parts or modify the product except as described in this document. You *must* have all covers and filler panels installed during operation of the product.

Do *not* operate the product in an explosive atmosphere or where there may be flammable gases or fumes. If you must operate the product in such an environment, it must be in a suitably rated enclosure.

If you need to clean the product, use a soft, nonmetallic brush. The product *must* be completely dry and free from contaminants before you return it to service.

Operate the product only at or below Pollution Degree 2. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

- Pollution Degree 1 means no pollution or only dry, nonconductive pollution occurs. The pollution has no influence.
- Pollution Degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.
- Pollution Degree 3 means that conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

You *must* insulate signal connections for the maximum voltage for which the product is rated. Do *not* exceed the maximum ratings for the product. Do not install wiring while the product is live with electrical signals. Remove power from signal lines before connecting them to or disconnecting them from the product.

Operate the product at or below the *installation category*[1] marked on the hardware label. Measurement circuits are subjected to *working voltages*[2] and transient stresses (overvoltage) from the circuit to which they are connected during measurement or test. Installation categories establish standard impulse withstand voltage levels that commonly occur in electrical distribution systems. The following is a description of installation categories:

- Installation Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS[3] voltage. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

[1] Installation categories, also referred to as *measurement categories*, are defined in electrical safety standard IEC 61010-1.

[2] Working voltage is the highest rms value of an AC or DC voltage that can occur across any particular insulation.

[3] MAINS is defined as a hazardous live electrical supply system that powers equipment. Suitably rated measuring circuits may be connected to the MAINS for measuring purposes.

- Installation Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet (for example, 115 V for U.S. or 230 V for Europe). Examples of Installation Category II are measurements performed on household appliances, portable tools, and similar products.
- Installation Category III is for measurements performed in the building installation at the distribution level. This category refers to measurements on hard-wired equipment such as equipment in fixed installations, distribution boards, and circuit breakers. Other examples are wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and stationary motors with permanent connections to fixed installations.
- Installation Category IV is for measurements performed at the primary electrical supply installation (<1,000 V). Examples include electricity meters and measurements on primary overcurrent protection devices and on ripple control units.

2 Installing and Configuring

This chapter describes how to install the NI PCI-1588 hardware and software and how to configure the device.

Installing the Software

Refer to the `readme.htm` file on the *NI-Sync* CD for software installation directions.

The NI PCI-1588 uses an AMD PCNET Family PCI Ethernet Adaptor for its Ethernet communication. The drivers for this adaptor are prepackaged with the OS.

Note Be sure to install the NI-Sync driver software *before* installing the NI PCI-1588 hardware.

Installing the Hardware

The following are general installation instructions. Consult your computer user manual or technical reference manual for specific instructions and warnings about installing new PCI boards.

1. Power off and unplug the computer.
2. Remove the computer cover.
3. Choose an available PCI slot in the computer.
4. Remove the filler panel for the PCI slot you chose in step 3.
5. Ground yourself using a grounding strap or by touching a grounded object. Follow the ESD protection precautions described in the *Unpacking* section of Chapter 1, *Introduction*.
6. Insert the NI PCI-1588 into the PCI slot. Ensure the board is seated properly in the slot.
7. Screw the front panel of the NI PCI-1588 to the front panel mounting rail of the computer.
8. Visually verify the installation. Make sure the module is not touching other modules or components and is fully inserted into the slot.

9. Replace the computer cover.
10. Plug in and power on the computer.

The NI PCI-1588 is now installed.

Configuring the Module

The NI PCI-1588 is completely software configurable. The system software automatically allocates all module resources.

To configure the NI PCI-1588 Ethernet network settings, find the AMD PCNET Family PCI Ethernet Adaptor in your list of network adaptors and adjust the network settings as needed.

The two LEDs on the front panel provide information about Ethernet status. The front panel description sections of Chapter 3, *Hardware Overview*, describe the LEDs in greater detail.

3 Hardware Overview

This chapter presents an overview of the hardware functions of the NI PCI-1588, shown in Figure 3-1.

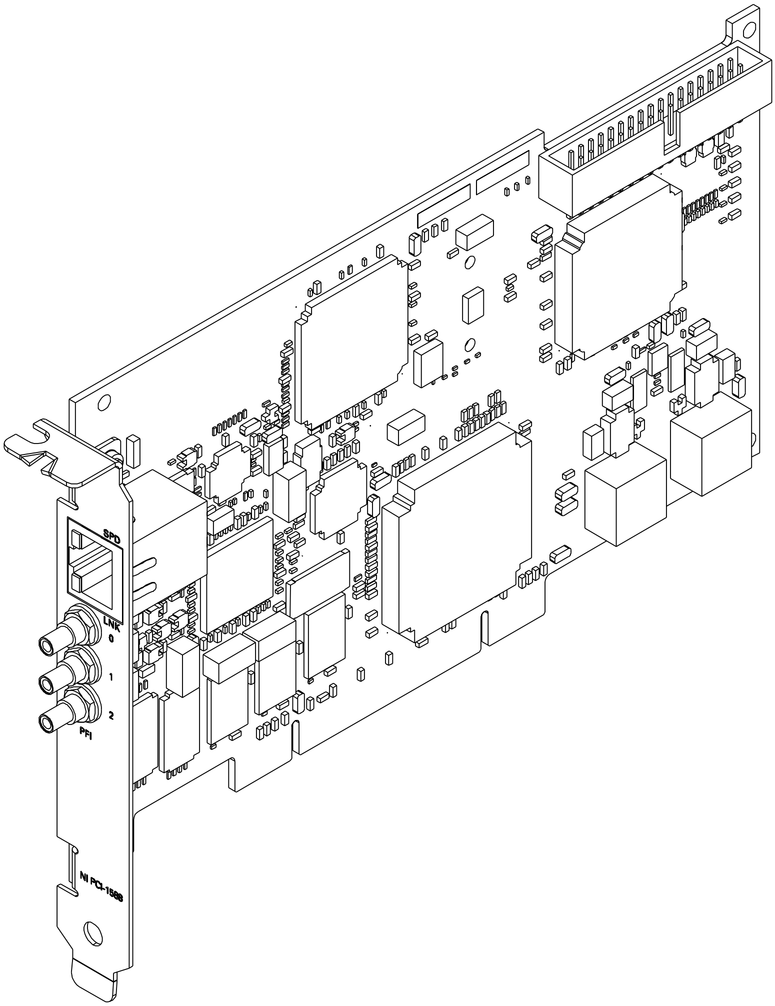


Figure 3-1. Isometric View of the NI PCI-1588

Figure 3-2 provides a functional overview of the NI PCI-1588 hardware.

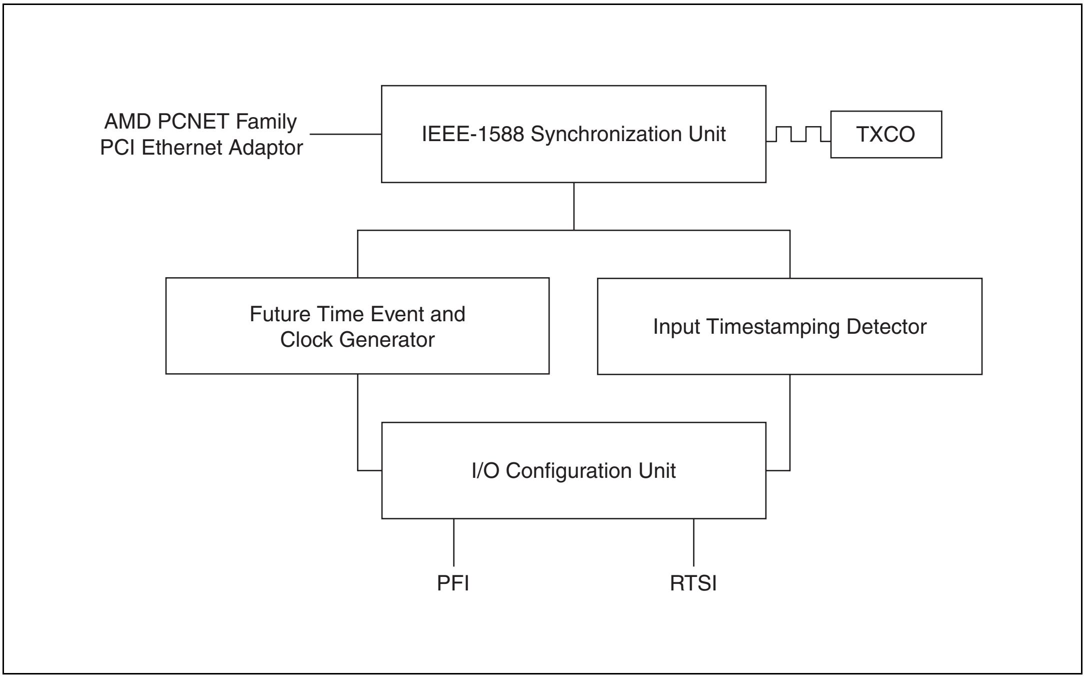
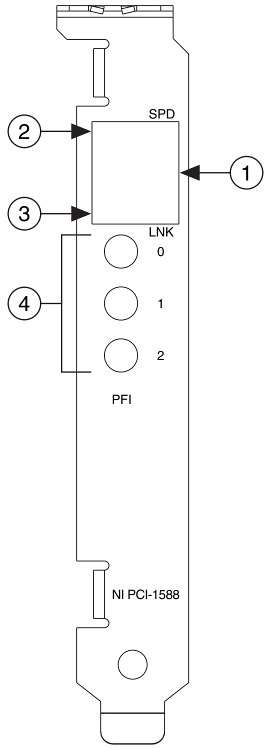


Figure 3-2. Functional Overview of the NI PCI-1588

NI PCI-1588 Front Panel

Figure 3-3 shows the connectors and LEDs on the NI PCI-1588 front panel.



1	RJ-45 Ethernet Connector	3	Link LED
2	Speed LED	4	PFI <0..2> Connectors

Figure 3-3. NI PCI-1588 Front Panel

Speed LED

The Speed LED indicates the NI PCI-1588 Ethernet link speed. Refer to Figure 3-3 for the Speed LED location.

Table 3-1 summarizes what the Speed LED represents.

Table 3-1. Speed LED Description

Color	Status
Off	10 Mbps
Green	100 Mbps

Link LED

The Link LED indicates the NI PCI-1588 Ethernet link condition. Refer to Figure 3-3 for the Link LED location.

Table 3-2 summarizes what the Link LED represents.

Table 3-2. Link LED Color Description

Color	Status
Off	No Ethernet link
Green	Ethernet link established

Connectors

This section describes the connectors on the NI PCI-1588 front panel.

- **RJ-45 Ethernet**—Ethernet connection. This connector allows the module to communicate via standard Ethernet cabling.
- **PFI <0..2>**—Programmable Function Interface <0..2>. These connectors can be used for either input or output. You can program the behavior of these PFI connections individually.

Refer to Figure 3-3 for the connector locations.

Caution Connections that exceed any of the maximum ratings of input or output signals on the NI PCI-1588 can damage the module and the computer. NI is *not* liable for any damage resulting from such signal connections.

Hardware Features

The NI PCI-1588 performs three broad functions:

- Synchronization over Ethernet using IEEE 1588.
- Generation of event and clock signals.
- Timestamping incoming signals with the 1588 time.

Table 3-3 outlines the function and direction of the signals discussed in detail in the remainder of this chapter.

Table 3-3. Signal Descriptions

Signal Name	Direction	Description
PFI <0..2>	In/Out	The Programmable Function Interface terminals on the NI PCI-1588 can function as timestamped inputs or future time event or clock signal outputs.
RTSI <0..7>	In/Out	The RTSI trigger bus consists of eight digital lines shared among a variety of NI PCI products. The RTSI terminals on the NI PCI-1588 can function as timestamped inputs or future time events or clock signal outputs.

The remainder of this chapter describes how these signals are used, acquired, and generated by the NI PCI-1588 hardware, and explains how you can use the signals between various locations to synchronize events in your system.

Synchronization Best Practices

The NI PCI-1588 can achieve sub-microsecond synchronization using the IEEE 1588 protocol. If you are not getting the performance you need, the following section describes some guidelines for achieving the best possible performance from your NI PCI-1588. While the NI PCI-1588 will function properly if you follow the specifications, the following guidelines may increase the synchronization performance.

Network Topology

To obtain the best NI PCI-1588 performance, follow these guidelines to set up the Ethernet network topology:

- Use short cabling when possible. Ethernet cabling is inherently asymmetric; the longer the cabling, the higher the asymmetry. This impacts synchronization performance, because the IEEE 1588 protocol assumes a symmetric network path.
- Use hubs when connecting to multiple IEEE 1588-capable devices. Hubs offer low latency and close to deterministic performance for transporting Ethernet traffic. This latency is on the order of hundreds of nanoseconds. Using switches degrades performance due to increased latency and indeterminate performance from the onboard buffers. Synchronization performance across switches can be in the tens of microseconds. If a switch must be used, obtain a 1588 boundary clock or transparent switch to achieve the best performance. These devices allow traffic to cross Ethernet collision domains without the inherent loss in performance from a switch or router.
- Ensure that the network is running at 100 Mbps by noting the Speed LED status. Synchronization performance is degraded when running at 10 Mbps.

Operating Environment

For best synchronization performance, the NI PCI-1588 operating environment is as important as network topology. Follow these operating environment guidelines, while taking care to remain within the specified operating temperature limits:

- Install the NI PCI-1588 in your PC as far as possible from other boards and in a slot with the least direct airflow, while taking care not to alter the cooling properties of your PC. In addition, be sure the computer case is properly installed. Airflow can degrade the NI PCI-1588 performance, because it tends to cause rapid changes in temperature. The NI PCI-1588 has precision thermally compensated components, but limiting direct airflow helps achieve the best performance. Consider placing the computer containing the NI PCI-1588 in an environment free of rapid temperature transitions.
- Perform the same steps as above to ensure that all other IEEE 1588-capable devices also have a thermally stable environment.

Timing System Performance

The NI PCI-1588 can generate or input a 1 Hz pulse per second signal on any PFI or RTSI terminal. You can set up this signal to transition on the seconds boundary of the 1588 system time. You can then use this signal to analyze system performance by connecting two or more pulse per second signals to an oscilloscope and measuring the latency between them. Adjustments can be made to account for deterministic latency. Refer to the *NI-Sync API Reference Help* for more information. The NI PCI-1588 can also timestamp an incoming pulse per second signal. The NI PCI-1588 will timestamp the externally generated pulse per second with its internal 1588 system time. By comparing this timestamp with the nearest seconds boundary, you can quickly determine the synchronization performance.

I/O Considerations

Using the Ethernet Port

The NI PCI-1588 provides one standard RJ-45 connection for Ethernet communication. This port auto negotiates to the best possible speed—10 Mbps or 100 Mbps. The Ethernet port is auto-MDI capable, which means crossover cabling is not necessary when connecting the NI PCI-1588 to another network card. The NI PCI-1588 senses whether a crossed connection is needed and performs the action internally. The Ethernet port also allows for full duplex operation, so traffic can be sent and received at the same time.

Using Front Panel PFIs as Outputs

The front panel PFI output signals use +3.3 V signaling for high-impedance loads. You can use the PFI terminals to generate events and low speed ($\leq$ 1 Mhz) clock signals. PFI output signals are suitable for driving most LEDs. To ensure proper signaling for fast edge rate signals, ensure that the system terminates to 50 Ω on the receiving end. Cabling should also be 50 Ω impedance. In a 50 Ω environment, the PFI terminals will output less than +3.3 V in the high state. See the *Specifications* appendix for more information. Refer to the *NI-Sync User Manual* for information on how to set up the PFI lines for output.

Caution Do not attempt to drive signals into PFI terminals set up as outputs. Doing so can damage the NI PCI-1588.

Using Front Panel PFI Lines as Inputs

The front panel PFI terminals can be configured by software to accept input signals. Refer to the *NI-Sync User Manual* for information on how to set up the PFI terminals to accept input signals. You can use these terminals to timestamp triggers with the 1588 system time. The input terminals accept native +3.3 V signaling, but are +5 V tolerant. You should use 50 Ω source termination when driving signals into PFI terminals.

The voltage thresholds for the front-panel PFI input signals are fixed. Refer to the specifications for the actual voltage thresholds. The front-panel PFI input signals can be timestamped on rising, falling, or both edges of an input signal.

Using the RTSI Triggers

You can use the RTSI lines to communicate with other NI PCI modules. All modules, connected with a RTSI cable, receive the same RTSI signals, so RTSI line 0 is the same for every PCI module. This feature makes the RTSI lines convenient in situations where you want, for example, to start an acquisition on several devices at the same time, because all modules will receive the same signal. To use RTSI signals to communicate with other NI PCI modules, you need RTSI cabling to connect the signals between the boards.

RTSI signals do not reach each module at precisely the same time. A difference of several nanoseconds between modules can occur in a PC. However, this delay is not a problem for many applications. You can perform the same input/output functions on RTSI terminals as you can with PFI terminals. For example, you can trigger a DAQ acquisition at a specific time by generating a future time event on a RTSI line and configuring an NI-DAQ module to start an acquisition based on the same RTSI line. For more information on configuring RTSI terminals, refer to the *NI-Sync User Manual*.

A

Specifications

Clock Signal Characteristics

Output frequency .... DC to 1 Mhz[1]

Duty cycle .... Programmable

PFI <0..2>

Input Characteristics

Input impedance .... 1 kΩ, nominal

Input coupling .... DC

Voltage level .... 0 to +3.3 V, +5 V tolerant

Absolute maximum input voltage[2] .... –0.5 V to 6.0 V

Minimum pulse width .... 36 ns

Input threshold

- Voltage threshold high .... +2.3 V
- Voltage threshold low .... +0.8 V

Asynchronous delay, t_{pd}

- PFI <0..2> to timestamp .... 1 to 4 ns, typical

Output Characteristics

Output impedance .... 50 Ω, nominal

Output coupling .... DC

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[1] Both upper and lower limits must be multiples of the nominal update period of the 1588 system time. Refer to the *NI-Sync User Manual* for details.

[2] Stresses beyond those listed can cause permanent damage to the device. Exposure to absolute maximum rated conditions for extended periods of time can affect device reliability. Functional operation of the device outside the conditions indicated in the operational parts of the specifications is not implied.

Output threshold

- Output high .... 1.1 V min, 1.6 V typical for 50 Ω load; 2.4 V min, 3.3 V typical for 1 MΩ load
- Output low .... 0.3 V max, 0 V typical for 50 Ω load; 0.7 V max, 0 V typical for 1 MΩ load

Absolute maximum applied voltage[1] ...... ±5.0 V, max

Future time to out time, t_{CtoQ} .... 1 to 4 ns, typical

Output-to-output skew, synchronous ...... <1 ns, typical

Output current .... ±48 mA, max

Square wave rise/fall time (10 to 90%) for 50 Ω load .... 0.5 ns min, 2.5 ns max

RTSI Characteristics

RTSI <0..7> connector to timestamp ...... 5 ns, typical

Future time event to RTSI <0..7> connector output .... 5 ns, typical

TCXO Characteristics

Frequency .... 10 MHz

Initial accuracy .... ±1.5 ppm

Aging per year .... ±1 ppm

Temperature stability (0 to 55 °C)[2] .... ±2 ppm

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[1] Stresses beyond those listed can cause permanent damage to the device. Exposure to absolute maximum rated conditions for extended periods of time can affect device reliability. Functional operation of the device outside the conditions indicated in the operational parts of the specifications is not implied.

[2] Includes temperature stability of TCXO and supporting circuitry.

Physical

PC requirement	One PCI slot (will not fit in low-profile slot)
Dimensions	17.45 × 10.65 cm (6.87 × 4.19 in.)
Front panel connectors	SMB male, 50 Ω RJ45 Ethernet
Front panel indicators	Two green LEDs on RJ45 connector
Recommended maximum cable length for SMB connectors	
PFI, DC to 10 MHz	200 m

Power Requirements

+5 V	715 mA max, 430 mA typical
PCI signaling level	Universal

1588 Synchronization Accuracy[1]

3 m Ethernet direct connection	±230 ns peak, 33 ns standard deviation
Via hub[2]	±268 ns peak, 48 ns standard deviation
Via switch[3]	±10 µs peak, 75 ns standard deviation

[1] All measurements were taken in ambient room temperature conditions between two NI PCI-1588 boards inside closed PCs. Synchronization was performed for 15 minutes before testing began. Sync interval of 1 second was used for all tests, and all Ethernet connections were 100 Mbps. For the switch test, a moderate amount of non-1588 Ethernet traffic was present on the switch. All test durations were 8 hours.

[2] Netgear DS104 Hub used.

[3] Airlink 101 Gigabit over copper switch used.

Environmental

Operating Environment

Ambient temperature range ....0 to 55 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)

Relative humidity range..........................10% to 90%, noncondensing (Tested in accordance with IEC-60068-2-56.)

Maximum altitude..................................2,000 m (at 25 °C ambient temperature)

Pollution Degree 2

Indoor use only

Storage Environment

Ambient temperature range ....–20 to 70 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)

Relative humidity range..........................5% to 95% noncondensing (Tested in accordance with IEC-60068-2-56.)

Safety

This product is designed to meet the requirements of the following standards of safety for information technology equipment:

- IEC 60950-1, EN 60950-1
- UL 60950-1
- CAN/CSA-C22.2 No. 60950-1

Note For UL and other safety certifications, refer to the product label, or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

Emissions .... EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity .... EN 61326-1:1997 + A2:2001, Table 1

EMC/EMI .... CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE Marking, as follows:

Low-Voltage Directive (safety) 73/23/EEC

Electromagnetic Compatibility Directive (EMC) 89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

B Technical Support and Professional Services

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Glossary

Symbol	Prefix	Value
p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}

Symbols

%	percent
±	plus or minus
+	positive of, or plus
–	negative of, or minus
/	per
°	degree
Ω	ohm

B

bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. An example of a PC bus is the PCI bus.

C

C	Celsius

clock	hardware component that controls timing for reading from or writing to groups

D

DAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO devices plugged into a computer, and possibly generating control signals with D/A and/or DIO devices in the same computer
DC	direct current

E

ESD	electrostatic discharge

F

frequency	the reciprocal of the period of a signal
front panel	the physical front panel of an instrument or other hardware

H

Hz	hertz—the basic unit of rate, measured in events or oscillations per second using a frequency counter or spectrum analyzer

I

in.	inch or inches

J

jitter	the rapid variation of a clock or sampling frequency from an ideal constant frequency

L

LabVIEW	a graphical programming language
LED	light-emitting diode—a semiconductor light source

M

master	the requesting or controlling device in a master/slave configuration

O

oscillator	a device that generates a fixed frequency signal. An oscillator most often generates signals by using oscillating crystals, but also may use tuned networks, lasers, or atomic clock sources. The most important specifications on oscillators are frequency accuracy, frequency stability, and phase noise.
output impedance	the measured resistance and capacitance between the output terminals of a circuit

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. It is achieving widespread acceptance as a standard for PCs and work-stations; it offers a theoretical maximum transfer rate of 132 Mbytes/s.
PFI	Programmable Function Interface
precision	the measure of the stability of an instrument and its capability to give the same measurement over and over again for the same input signal
propagation delay	the amount of time required for a signal to pass through a circuit

R

RTSI bus	Real-Time System Integration bus—the NI timing bus that connects DAQ devices directly, by means of connectors on top of the devices, for precise synchronization of functions

S

s	seconds
skew	the actual time difference between two events that would ideally occur simultaneously. Inter-channel skew is an example of the time differences introduced by different characteristics of multiple channels. Skew can occur between channels on one module, or between channels on separate modules (intermodule skew).
slave	the controlled device in a master/slave configuration
slot	the place in the computer or chassis in which a card or module can be installed
SMB	sub miniature type B—a small coaxial signal connector that features a snap coupling for fast connection
synchronous	a property of an event that is synchronized to a reference clock

T

t_{CtoQ}	clock to output time
t_{hold}	hold time
t_{pd}	propagation delay time
timestamp	a save snapshot of the time at which an event occurred
trigger	a digital signal that starts or times a hardware event (for example, starting a data acquisition operation)
t_{setup}	setup time

V

V	volts
VI	virtual instrument

Index

T

U

W