Computer-Based Instruments

NI 5112 User Manual

NATIONAL INSTRUMENTS™

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Worldwide Technical Support and Product Information

`ni.com`

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Compliance

FCC/Canada Radio Frequency Interference Compliance*

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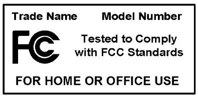
The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this 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. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

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

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.



Consult the FCC web site `http://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 Mark 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 National Instruments 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 will be required to correct the interference at his 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.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

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

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

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This website lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

The following conventions are used 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, DBIO<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.
bold	Bold text denotes items that you must select or click on 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. This font also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	This font is used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, filenames and extensions, and code excerpts.

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Taking Measurements with the NI 5112

Thank you for buying a National Instruments (NI) 5112 high-speed digitizer. This chapter provides information on installing, connecting signals to, and acquiring data from the NI 5112.

Installing the Software and Hardware

There are two main steps involved in installation:

1. Install the NI-SCOPE driver software. You use this driver to write programs to control your NI 5112 in different application development environments (ADEs). NI-SCOPE also allows you to interactively control your NI 5112 with the Scope Soft Front Panel.
2. Install your NI 5112. For step-by-step instructions for installing NI-SCOPE and the NI 5112, see the *Where to Start with Your NI Digitizer*.

Connecting Signals

Figure 1-1 shows the front panel for the NI 5112, which contains five connectors—three BNC connectors, an SMB connector, and a 9-pin miniature circular DIN connector.

Two of the BNC connectors, CH0 and CH1, are for attaching the analog input signals you wish to measure. The third BNC connector, TRIG, is for the analog trigger channel. The SMB connector, PFI1, is for external digital triggers and for generating a probe compensation signal. The DIN connector, AUX, gives you access to an additional external digital trigger line, PFI2.

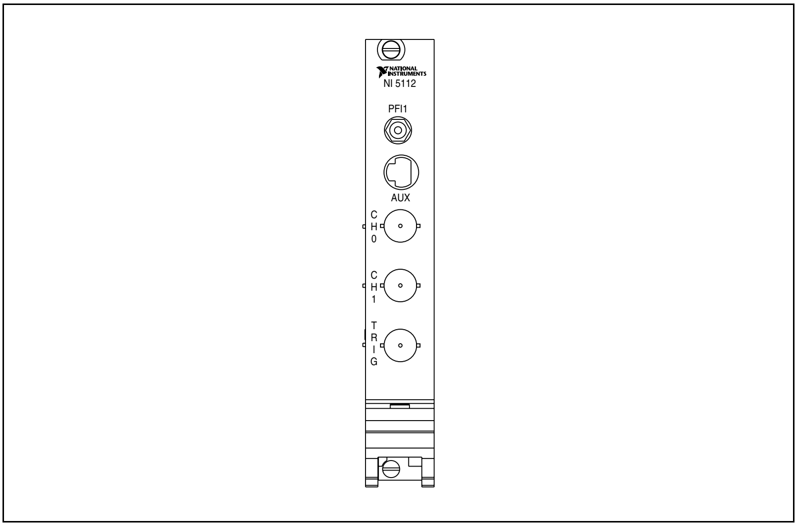
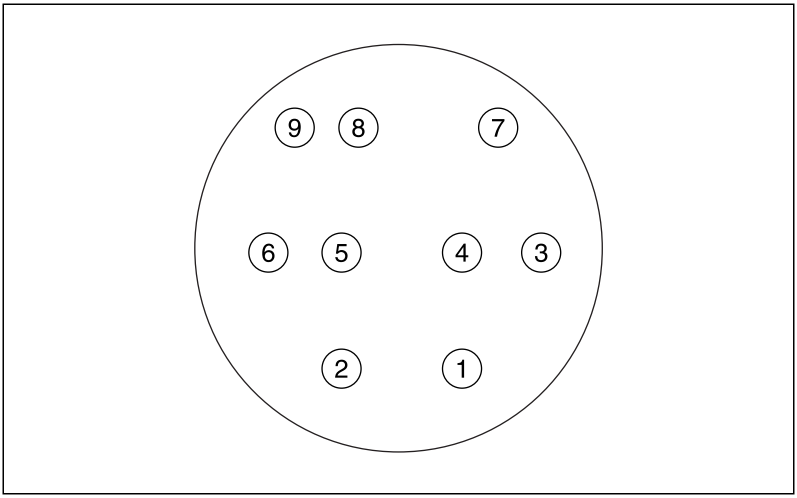


Figure 1-1. NI 5112 Connectors



1	+5 Volts (Fused)	4	Reserved	7	Reserved
2	GND	5	Reserved	8	Reserved
3	Reserved	6	PFI 2	9	Reserved

Figure 1-2. 9-Pin Mini Circular DIN Connector

Acquiring Data with Your NI 5112

You can acquire data either programmatically—by writing an application for your NI 5112—or interactively with the Scope Soft Front Panel.

Programmatically Controlling Your NI 5112

To help you get started programming your NI 5112, NI-SCOPE comes with examples that you can use or modify.

You can find examples for these different ADEs:

- In LabVIEW, navigate to **Functions Palette»Instrument I/O» Instrument Drivers»NI SCOPE»Scopes»Examples**
- LabWindows/CVI, C, and Visual Basic with Windows 98/95—Go to `vxipnp\win95\Niscope\Examples\c\`
- LabWindows/CVI, C, and Visual Basic with Windows 2000/NT—Go to `vxipnp\winnt\Niscope\Examples\`

For more information about using NI-SCOPE to programmatically control your NI 5112, see your *NI-SCOPE Software User Manual*. Other resources include the *NI-SCOPE Instrument Driver Quick Reference Guide*, which contains abbreviated information on the most commonly used functions and LabVIEW VIs. For more detailed function reference help, see the *NI-SCOPE Function Reference Help* file, located at **Start»Programs» National Instruments»NI-SCOPE**. For more detailed VI help, use LabVIEW context-sensitive help (**Help»Show Context Help**) or the *NI-SCOPE VI Reference Help.*

Interactively Controlling Your NI 5112 with the Scope Soft Front Panel

The Scope Soft Front Panel allows you to interactively control your NI 5112 as you would a desktop oscilloscope. To launch the Scope Soft Front Panel, select **Start»Programs»National Instruments» NI-SCOPE»NI-SCOPE Soft Front Panel**. Refer to the *Scope Soft Front Panel Help* file for instructions on configuring the Scope Soft Front Panel for your specific application.

Note Press F1 while running the Scope Soft Front Panel to access the *Scope Soft Front Panel Help*.

Safety Information

The following paragraphs contain important safety information concerning hazardous voltages and hazardous operating conditions. Please adhere to these safety instructions while configuring or connecting signals to the NI 5112.

Cautions Only qualified personnel aware of the dangers involved should install this unit. Disconnect all power before installing or removing the device. If signal wires are connected to the device, dangerous voltages may exist even when the equipment is turned off. Before you remove the device, disconnect the AC power line or any high-voltage sources, ≥ 30 V_{rms} and 42.4 V_{peak}, or 60 VDC, that may be connected to the device.

Do *not* operate the device in an explosive atmosphere or where there may be flammable gases or fumes.

To ensure adequate grounding, the device must be properly installed in the chassis or host computer. NI is *not* liable for any damages or injuries resulting from inadequate safety earth ground connections.

You *must* insulate all of your signal connections to the highest voltage with which the NI 5112 may come in contact.

Equipment described in this document must be used in an Installation Category II or lower environment per IEC 60664-1.

Do *not* operate damaged equipment. The safety-protection features built into this device can be impaired if the device becomes damaged in any way. If it is damaged, power the device off, and do *not* use it until service-trained personnel can check its safety. If necessary, return the device to NI for service and repair to ensure that its safety is not compromised.

Clean the device and accessories by brushing off light dust with a soft non-metallic brush. Remove other contaminants with a stiff non-metallic brush. The unit must be completely dry and free from contaminants before returning it to service.

The device must be used in a NRTL-listed chassis or host computer. You *must* ensure all covers and filler panels are installed before operating the device.

Do *not* substitute parts or modify equipment. Because of the danger posed by introducing additional hazards, do *not* install unauthorized parts or modify the device. Return the device to NI for service and repair to ensure that its safety features are not compromised.

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the NI 5112 can damage any or all of the devices in the same chassis. NI is *not liable for any damages or injuries* resulting from incorrect signal connections.

Use only NI oscilloscope probes or probes bearing the CE mark.

2 Hardware Overview

This chapter includes an overview of the NI 5112, explains the operation of each functional unit making up your NI 5112, and describes the signal connections. Figure 2-1 shows a block diagram of the NI 5112.

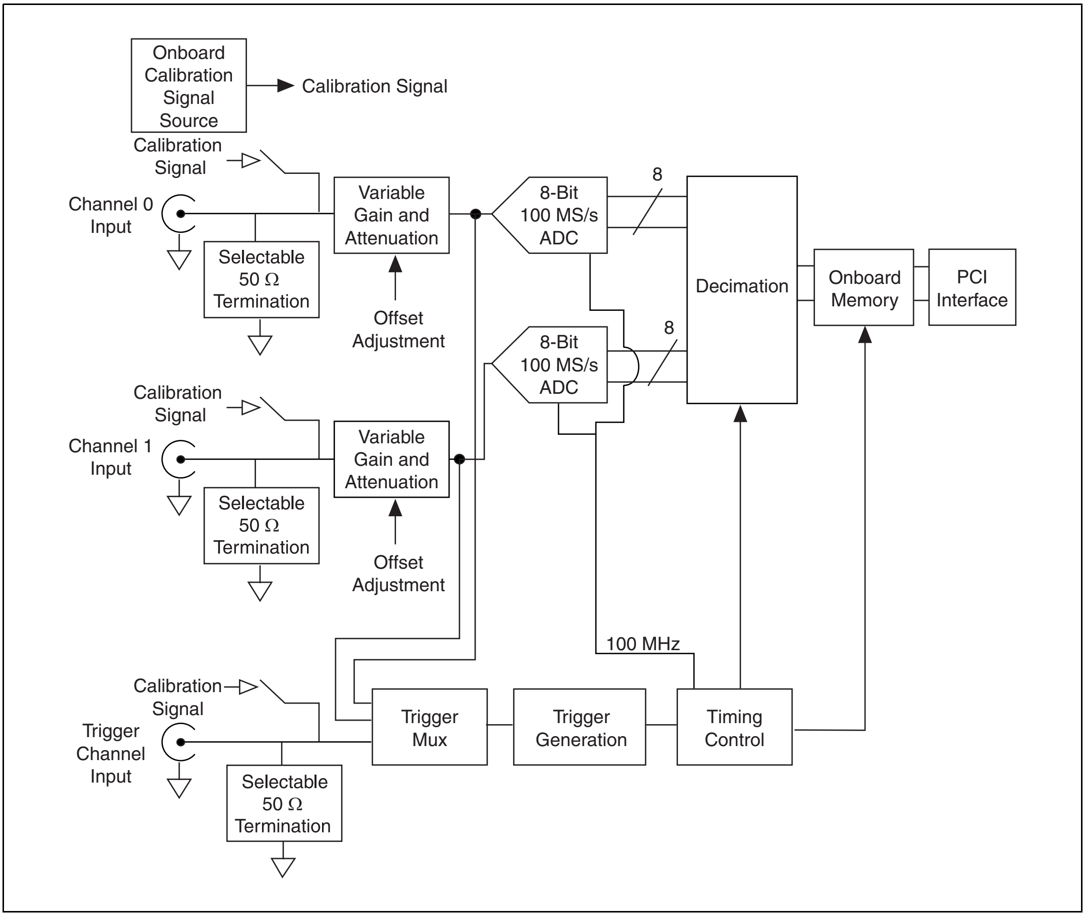


Figure 2-1. NI 5112 Block Diagram

Measurement Fundamentals

The NI 5112 has a programmable gain amplifier (PGA) at the analog input. The PGA accurately interfaces to and scales the signal presented at the connector for the analog-to-digital converter (ADC) regardless of source impedance, source amplitude, or DC biasing.

Input Ranges

To optimize the ADC resolution, you can select different gains for the PGA. In this way, you can scale your input signal to match the full input range of the converter. The NI 5112 PGA offers a variable input range, from ±0.025 V to ±25 V.

These input ranges are available in 10% steps. For example, some typical ranges are 48.5 mV, 53.3 mV, 58.7 mV, 64.6 mV, 71.0 mV, 78.1 mV, 86.1 mV, and so on. Notice that each range is 10% higher than the one before it. Since the ranges are calibrated on a per device basis, the ranges of your device may be slightly different than the ones listed here.When you request a range, the NI-SCOPE software automatically coerces the requested range up to the first available range.

Input Impedance

The input impedance of the NI 5112 is software selectable between 50 Ω and 1 MΩ. The output impedance of the device connected to the NI 5112 and the input impedance of the NI 5112 form an impedance divider, which attenuates the input signal according to the following formula:

$$V_m = V_s \times \left(\frac{R_{in}}{R_{in} + R_s}\right)$$

where V_m is the measured voltage, V_s is the source voltage, R_s is the output impedance of the source, and R_{in} is the input impedance of the NI 5112.

If you are measuring a waveform with significant frequency content above 1 MHz, use cables with a characteristic impedence of 50 Ω and set the NI 5112 input impedance to 50 Ω. In this situation, assuming that the source has an output impedance of 50 Ω, the connection will be properly terminated and effects of transmission-line reflections minimized.

When performing measurements on systems that are expected to be terminated with a 50 Ω load, select the 50 Ω input impedance of the NI 5112. With 50 Ω input impedance selected, the input signal should be limited to 5 V_{rms}. Signals larger than this will not damage the NI 5112, but your measurements may be inaccurate. When the input reaches about 7 V_{rms}, an overload-protection relay will open, and the device will revert to 1 MΩ impedance.

AC Coupling

You can configure the NI 5112 input channels to be either AC or DC coupled. When you need to measure a small AC signal on top of a large DC component, you can use AC coupling. AC coupling rejects any DC component in your signal before it enters the PGA. Activating AC coupling inserts a capacitor in series with the input. You can select input coupling via software.

The boundary between DC and AC signals is called the *AC coupling cutoff frequency*. Frequencies above this cutoff pass through to the PGA, while frequencies below it are blocked. As shown in the following figure, adding an attenuator probe lowers this cutoff point.

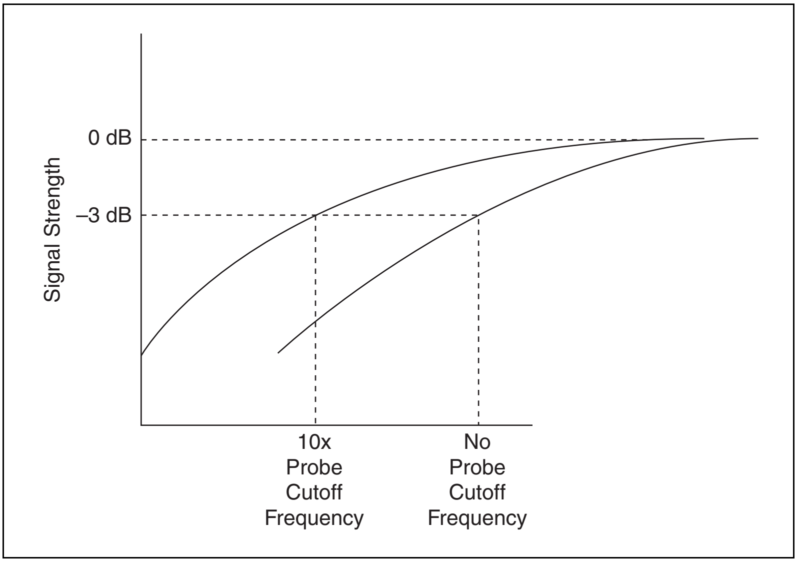


Figure 2-2. Impact of Cutoff Frequencies with Attenuator Probes

DC Coupling

DC coupling allows DC and low-frequency components of a signal to pass through without attenuation. This feature can be exploited to zoom in on AC signals with large DC offsets, such as switching noise on a 12 V power supply. Refer to Appendix A, *Specifications,* for input limits that must be observed regardless of coupling.

DC Offset

DC offset positions a waveform around an arbitrary DC value. Using DC offset allows you to examine small changes in the input signal, which can improve the accuracy of your measurement. For instance, imagine that you are acquiring the waveform shown in Figure 2-3 that outputs 0.75–1.25 V. Without using DC offset, you would need to specify a range of 2.5 V (±1.25 V) to capture the waveform. Since the input range is adjustable in 10% steps, points would be acquired in 10 mV (2.5 V/256) intervals. However, if you specified a DC offset of 1 V to center the input range around 1 V instead of 0 V, you could limit the range to 0.5 V (±0.25 V). This would reduce each step from 10 mV to 2 mV and improve the accuracy of the measurement. You can apply up to 50 V of DC offset to the NI 5112 input stage.

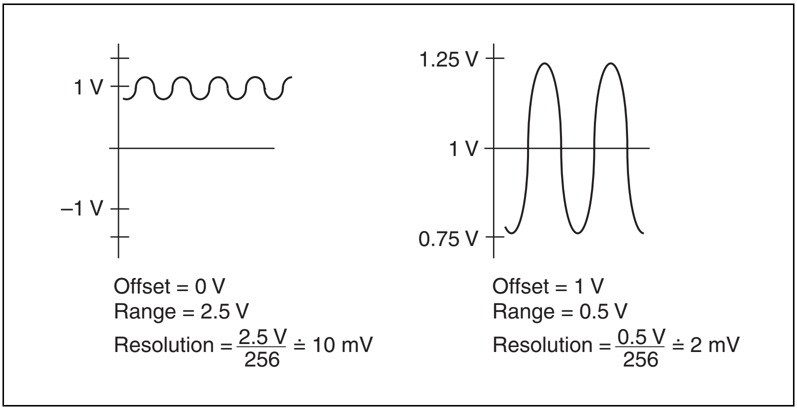


Figure 2-3. DC Offset

Table 2-1 lists the maximum DC offset for a given input voltage range.

Table 2-1. Maximum DC Offset

Vertical Range	Maximum Selectable Offset
50 mV–500 mV	±500 mV
500 mV–5 V	±5 V
5 V–50 V	±50 V

Note Absolute value of the DC offset should not exceed 42 V – input range/2. For example, using a vertical range of ±10 V the maximum DC offset allowed is ±32 V.

20 MHz Bandwidth Limit

The NI 5112 has a selectable 20 MHz bandwidth limit on the analog input channels. This limit enables a lowpass filter that can remove unwanted noise above 20 MHz from your measurement.

External Trigger

The NI 5112 external trigger is a front panel BNC input to which you may attach an analog trigger. This allows you to acquire data from the input channels while triggering on the external channel. This external trigger allows you to use the input channels and external trigger concurrently. The input range for the external trigger input is ±10 V. You can select either AC or DC coupling.

Acquisition System

The acquisition system chosen determines the way samples are acquired and stored. The NI 5112 supports two sampling methods: *real-time sampling* and *random interleaved sampling* (RIS). Using real-time sampling, you can acquire data at a rate of 100/n MS/s, where n is a number from 1 to 100e+6.

RIS mode samples different points along a recurrent waveform for each trigger. Over many cycles this data is used to reconstruct the waveform at an apparent sampling rate higher than 100 MS/s. RIS can effectively sample at rates of 100 MS/s × n, where n is a number from 2 to 25. Consult your *NI-SCOPE Software User Manual* for more information regarding RIS.

During an acquisition, samples are stored in a circular buffer that is continually rewritten until a trigger is received. After the trigger is received, the NI 5112 continues to acquire posttrigger samples if you have specified a posttrigger sample count. The acquired samples are placed into onboard memory. The number of posttrigger or pretrigger samples is limited only by the amount of onboard memory.

Acquisition Mode

Regardless of the user-requested sample rate, the NI 5112 ADC is always running at 100 MS/s. The NI 5112 stores a stream of 8-bit samples into the onboard memory at the requested sample rate. If you request a rate less than 100 MS/s, the timing engine of the NI 5112 only stores 1 sample in a group of *n* samples, effectively reducing the sample rate to 100/*n* MS/s.

Calibration

The NI 5112 can be calibrated for very high accuracy and resolution due to an advanced calibration scheme. There are two different types of calibration: internal calibration (or self-calibration), and external calibration.

Internal calibration is performed via a software command that compensates for drifts caused by environmental temperature changes. You can internally calibrate your digitizer without external equipment. *External calibration*, which is performed much less frequently, recalibrates the NI 5112 internal reference when its specified calibration interval has expired. External calibration requires you to connect an external precision voltage reference to your device. Refer to your *NI-SCOPE Software User Manual* for information on calibration.

Internally Calibrating the NI 5112

There are a couple of simple ways to internally calibrate the NI 5112. You may select the self-calibration option in the Scope Soft Front Panel, or you can use the provided calibration example for your ADE to calibrate the device. See the *Programmatically Controlling Your NI 5112* section for information on where to find these examples.

When Internal Calibration Is Needed

To provide the maximum accuracy independent of temperature changes, your NI 5112 needs to be recalibrated when environmental conditions change in your PC beyond a specified temperature range. Since the environment inside your system is most likely different from the environment in which the device was initially calibrated, you should recalibrate your device after installation. Be sure to first wait at least 15 minutes for your system to warm up to its operating temperature.

What Internal Calibration Does

Internal calibration uses a precision-traceable onboard reference for the calibration. It requires no external equipment and is executed by a software command.

Internal calibration performs the following operations:

- Gain and offset are calibrated for each individual input range.
- AC flatness is calibrated over the entire bandwidth to be within specified tolerances.
- Analog trigger levels are calibrated.
- The time-to-digital converter used for RIS measurements is calibrated.

External Calibration

External calibration checks the internal reference on the NI 5112. Although the NI 5112 is factory calibrated, it needs periodic external calibration to verify that it is still within the specified accuracy. For more information on calibration, contact NI or visit the NI Web site at `ni.com/calibration`. For actual intervals and accuracy, see Appendix A, *Specifications*.

Triggering and Arming

There are several triggering methods for the NI 5112. The trigger can be an analog level that is compared to the input or any of several digital inputs. You can also call a software function to trigger the device. Figure 2-4 shows the different trigger sources. The digital triggers are TTL-level signals with a minimum pulse-width requirement of 10 ns.

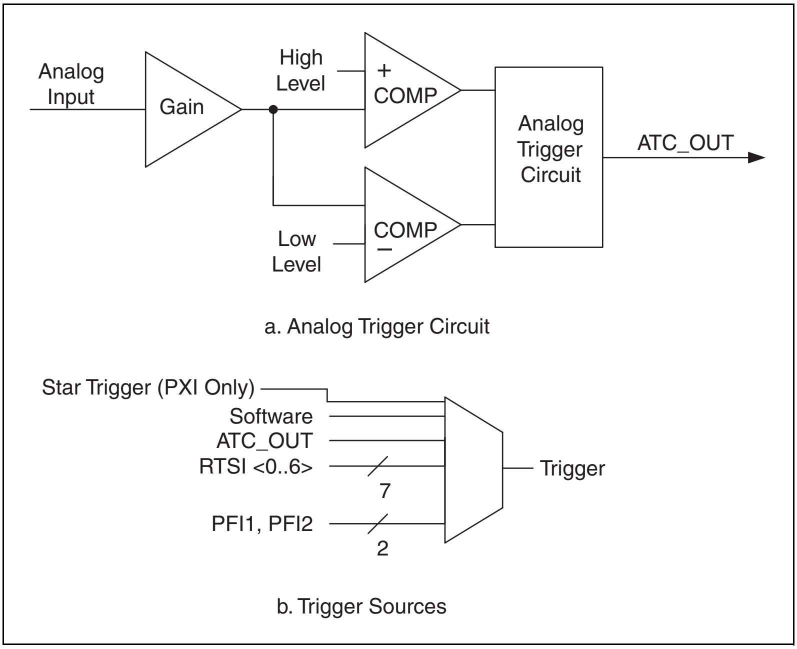


Figure 2-4. Trigger Sources

Analog Trigger Circuit

The analog trigger on the NI 5112 operates by comparing the current analog input to an onboard threshold voltage. This threshold voltage is the trigger value and can be set to any voltage within the current input range.The NI 5112 supports edge triggers, hysteresis triggers, and window triggers. Edge triggers occur when the signal crosses a threshold you specify. A hysteresis value associated with the trigger helps reduce false triggers due to noisy signals. Window triggers occur when a signal enters of leaves a window you specify. You may generate triggers on a rising- or falling-slope condition. For additional information on triggering, see your *NI-SCOPE Software User Manual*.

Trigger Hold-Off

Trigger hold-off is the minimum length of time (in seconds) from an accepted trigger to the start of the next record. In other words, when a trigger is accepted, the trigger counter is loaded with the desired hold-off time. After completing its current record, the digitizer records no data and accepts no triggers until the hold-off counter runs out. When the counter runs out, the next record begins and a trigger may be accepted. Setting a hold-off time shorter than posttrigger acquisition time has no effect, as triggers are always rejected during an acquisition.

The NI 5112 trigger hold-off is provided in hardware using a 32-bit counter clocked by a 25 MHz internal timebase. With this configuration, you can select a hardware hold-off value from 100 µs to 171.79 s in increments of 40 ns. 100 µs is the minimum value that can be specified for hold-off; setting a smaller value has no effect. For more information regarding trigger hold-off, see your *NI-SCOPE Software User Manual.*

Memory

The NI 5112 acquires samples into onboard memory before transferring them to the host computer. The minimum size for a buffer is 128 bytes, although you can specify smaller buffers in software. When specifying a smaller buffer size in software, 128 points are still acquired into onboard memory, but only the specified number of points are transferred into the host computer memory.

Multiple-Record Acquisitions

The NI 5112 supports multiple-record acquisitions, which allow the capture of multiple triggered waveforms without software intervention. In this mode, the digitizer will automatically begin a new acquisition in a new memory record immediately after finishing the previous one.

Multiple-record acquisitions can quickly acquire numerous triggered waveforms because they allow hardware rearming of the digitizer. Between each record, however, there is a *dead time* of approximately 500 ns during which no triggers are accepted. During this time, the memory controller sets up for the next record. There is also a hold-off of 100 µs from the last trigger in a record to the start of a new record. This means that the actual dead time will be the greater of the between-record dead time (500 ns + post-trigger storage time) and the 100 µs hold-off time.

There may also be additional dead time while the minimum number of pretrigger samples are being acquired. To increase the dead time between records, use the trigger hold-off feature. For more information on multiple-record acquisitions and dead time, see your *NI-SCOPE Software User Manual*.

RTSI Trigger and PFI Lines

The RTSI bus allows NI digitizers to synchronize timing and triggering on multiple devices. The RTSI bus has seven bidirectional trigger lines and one bidirectional clock signal.

You can program any of the seven trigger lines to provide or accept an asynchronous trigger signal. You can also use any of the RTSI trigger lines to provide a synchronization pulse from a master device if you are synchronizing multiple NI 5112s.

You can use the RTSI bus clock line to provide or accept a 10 MHz reference clock to synchronize multiple NI 5112 devices.

PFI Lines

The NI 5112 has two front-panel digital lines that can accept a trigger, accept or generate a reference clock, or output a square wave of programmable frequency. With PFI lines, you can synchronize to third-party equipment that may not use the RTSI or the PXI timing and triggering buses. The function of each PFI line is independent; however, only one trigger source can be accepted during acquisition.

PFI Lines as Inputs

You can select PFI1 or PFI2 as an input for a trigger or a reference clock. For instance, you can accept a 10 MHz reference clock from an external source rather than using the PXI backplane 10 MHz system reference clock or the clock of another NI 5112 through the RTSI clock line.

PFI Lines as Outputs

You can select PFI1 or PFI2 to output several digital signals:

- Reference Clock is a 10 MHz TTL-level clock signal. You can use the reference clock to synchronize another NI 5112 configured as a slave device residing in another PCI or PXI chassis, or other equipment that can accept a 10 MHz reference clock.
- Frequency Output is a 1 kHz digital pulse-train signal with a 50% duty cycle, which means that the signal is high and low for the same length of time. Commonly, the Frequency Output signal provides a signal for compensating a passive probe.
- Trigger Output is a TTL signal that pulses to a high level for at least 40 ns after the board triggers.
- Synchronization pulse for synchronizing multiple devices

Synchronizing Multiple Devices

The NI 5112 uses a phase-locked loop to synchronize the 100 MHz sample clock to a 10 MHz reference clock. This reference frequency can be supplied by a crystal oscillator on the NI 5112 or through an external clock input. The NI 5112 can also output its 10 MHz reference clock to synchronize other NI 5112 devices and other equipment to its reference clock.

Synchronizing Multiple PXI Devices

The PXI bus can synchronize multiple NI 5112s with the following timing and triggering features:

- System Reference Clock—This is a 10 MHz clock with 25 ppm accuracy. It is independently distributed to each PXI peripheral slot through equal-length traces with a skew of less than 1 ns between slots. Multiple devices can use this common timebase for synchronization. This allows each NI 5112 to phase lock to the system clock.
- Trigger Bus—This bus features eight bidirectional lines that link all PXI slots, providing interdevice synchronization and communication. The skew from slot to slot is less than 10 ns.
- Star Trigger—This special trigger slot provides an independent dedicated bidirectional line for each of up to 13 peripheral slots on a single backplane. All lines are matched in length, which provides a low slot-to-slot skew of less than 1 ns. A star trigger controller plugged into this slot can route triggers and clocks among peripheral slots.

To synchronize multiple NI 5112s, follow this procedure:

1. Distribute the PXI 10 MHz system reference clock to all devices.
2. Distribute a clock synchronization pulse signal from the master to slaves. This pulse synchronizes the clock dividers on each NI 5112.
3. Distribute the master trigger signal across the STAR bus lines to all devices.

Note To make use of the STAR bus triggering, the master has to reside in the STAR controller slot, which is slot 2 in the PXI chassis.

Synchronizing Multiple PCI Devices

To synchronize the NI 5112s for PCI, you must connect the boards with an RTSI bus cable. The physical bus interface is an internal 34-pin connector, and signals are shared via a ribbon cable inside the PC enclosure. The RTSI bus has seven bidirectional trigger lines and one bidirectional clock signal. RTSI cables are available for chaining two, three, four, or five devices together.

To synchronize multiple NI 5112s for PCI, follow this procedure:

1. Use the RTSI bus clock line to distribute the 10 MHz reference clock from the master to all slaves.
2. Distribute a clock synchronization pulse through one of the RTSI trigger lines from master to slaves. This pulse synchronizes the clock dividers on each NI 5112.
3. Distribute the master trigger signal through one of the designated RTSI trigger lines to all slaves.

Note When synchronizing multiple NI 5112 devices, the asynchonous trigger and the synchronization pulse must be routed on different bus lines.

A Specifications

This appendix lists the specifications of the NI 5112. These specifications are typical at 25 °C unless otherwise stated.

Acquisition System

Resolution .... 8 bits

Bandwidth (–3 dB) .... 100 MHz maximum
20 MHz typical with bandwidth limit enabled

Number of channels .... 2 simultaneously sampled, single ended

Maximum sample rate............................ 2.5 GS/s repetitive,
100 MS/s single-shot

Onboard sample memory....................... 16 or 32 MB per channel, depending on memory option purchased

Calibrated vertical ranges....................... ±25 mV to ±25 V in 10% steps

Calibrated offset ranges .... ±500 mV for vertical ranges smaller than 500mV
±5V for vertical ranges between 500mV and 5V
Up to ±37V for vertical ranges greater than 5V
Note: Absolute value of the DC offset should not exceed
42 V – input range/2. Example: For vertical range of ±10 V the maximum DC offset allowed is ±32 V.

DC accuracy	±2.5% of range setting ±0.5% of offset setting
Input coupling	DC or AC, software selectable
AC coupling cutoff frequency (–3 dB)	11 Hz with 1× probe 1.1 Hz with 10× probe
Input impedance	1 MΩ ǁ 30 pF or 50 Ω software selectable. With 50 Ω input impedance, input signal should be below 5 V_{rms} to maintain measurement accuracy.
Input protection	±42 V (DC + peak AC)

Timebase System

Reference clock	10 MHz square wave
Clock accuracy (as master)	50 ppm
Clock input tolerance (as slave)	1% minimum
Clock input levels	TTL
Sampling clock frequency	100 MHz fixed, data can be decimated by *n* where 1<*n*<100e6
Reference clock sources	Backplane 10 MHz reference clock (NI 5112 for PXI), RTSI clock line, PFI lines, and onboard 10 MHz clock.

Triggering System

Modes	Edge, hysteresis, window, digital
Source	Ch0, Ch1, TRIG, PFI<1..2>, RTSI <0..6>, PXI-Star (NI 5112 for PXI
Slope	Rising/falling
Coupling	DC or AC on CH0, CH1, TRIG

Pretrigger depth	Up to 16 or 32 MB per channel, depending on memory option purchased
Noncontinuous posttrigger depth	Up to 16 or 32 MB per channel, depending on memory option purchased
Holdoff time	100 µs to 171.79 s
Trigger sensitivity	>1000 steps in full-scale voltage range
DC accuracy (Ch 0, Ch 1)	±2.5% of range setting ±0.5% of offset setting
DC accuracy (TRIG)	±500 mV
Bandwidth	100 MHz
TRIG input range	±10 V
TRIG input impedance	1 MΩ || 30 pF or 50 Ω, software selectable
TRIG input protection	±42 V (DC + peak AC)

Acquisition Methods

Random interleaved sampling (RIS)	200 MS/s to 2.5 GS/s effective sample rate for repetitive signals only
Real-time sampling	1 S/s to 100 MS/s sample rate for transient and repetitive signals

Calibration

Internal	Internal calibration is done on software command. The calibration involves gain, offset, frequency response, triggering, and timing adjustment for all input ranges.
Interval	24 hours, or any time temperature changes beyond ±2 °C from

temperature at which last internal calibration was performed

External...Internal reference requires external recalibration

Interval..5 years

Warm-up time.................................15 minutes

Power Requirements

+3.3 VDC...0.5 A

+5 VDC..1.5 A

+12 VDC..80 mA

–12 VDC..120 mA

Physical

Dimensions ....10 by 16 cm (4.2 by 6.87 in.)

I/O Connectors

Analog inputs CH0, CH1........................BNC female

Analog trigger TRIG ....BNC female

Digital trigger PFI1................................SMB female

Digital trigger PFI2................................9-pin DIN

Maximum working voltage (signal voltage plus common-mode voltage)

Channel to earth..............................42 V, Installation Category I

Channel to channel ....42 V, Installation Category I

Environmental

Operating temperature ....0 to 50 °C

Storage temperature ....–20 to 70 °C

Humidity ....10 to 90% RH noncondensing

Maximum altitude .... 2000 m

Pollution degree 2

Indoor use only

Safety

Meets the requirements of the following standards for safety for electrical equipment for measurement, control, and laboratory use:

EN 61010-1:1993/A2:1995, IEC 61010-01:1990/A2:1995,
UL 3101-1:1993, UL 3111-1:1994, UL 3121:1998 and
CAN/CSA C22.2 no.1010.1:1992/A2:1997

Electromagnetic Compatibility

CE, C-Tick and FCC Part 15 (Class A) Compliant

Electrical emissions................................ EN 55011 Class A at 10 m, FCC Part 15A above 1 GHz

Electrical immunity................................ Evaluated to EN 61326:1997/A1:1998, Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels *must* be installed. See the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `http://www.ni.com/hardref.nsf/`. This website lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC (in Adobe Acrobat format) appears. Click the Acrobat icon to download or read the DoC.

B

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meanings	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}
G-	giga-	10^{9}

Symbols

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

A

A	amperes
A/D	analog-to-digital
AC	alternating current

AC coupled	the passing of a signal through a filter network that removes the DC component of the signal
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
ADC resolution	the resolution of the ADC, which is measured in bits. An ADC with16 bits has a higher resolution, and thus a higher degree of accuracy, than a 12-bit ADC.
alias	a false lower frequency component that appears in sampled data acquired at too low a sampling rate
amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise
amplitude flatness	a measure of how close to constant the gain of a circuit remains over a range of frequencies
attenuate	to reduce in magnitude

B

b	bit—one binary digit, either 0 or 1
B	byte—eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data.
bandwidth	the range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond
buffer	temporary storage for acquired or generated data (software)
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. Examples of PC buses are the PCI and ISA bus.

C

C	Celsius
clock	hardware component that controls timing for reading from or writing to groups
CMRR	common-mode rejection ratio—a measure of an instrument's ability to reject interference from a common-mode signal, usually expressed in decibels (dB)
counter/timer	a circuit that counts external pulses or clock pulses (timing)
coupling	the manner in which a signal is connected from one location to another

D

dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB = 20log10 V1/V2, for signals in volts
DC	direct current
default setting	a default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*.
device	a plug-in data acquisition board, card, or pad. The NI 5112 is an example of a device.
differential input	an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured
double insulated	a device that contains the necessary insulating structures to provide electric shock protection without the requirement of a safety ground connection
drivers	software that controls a specific hardware instrument

E

EEPROM	electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed
equivalent time sampling	any method used to sample signals in such a way that the apparent sampling rate is higher than the real sampling rate
event	the condition or state of an analog or digital signal

F

filtering	a type of signal conditioning that allows you to remove unwanted signals from the signal you are trying to measure

G

gain	the factor by which a signal is amplified, sometimes expressed in decibels

H

hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
harmonics	multiples of the fundamental frequency of a signal
Hz	hertz—per second, as in cycles per second or samples per second

I

in.	inches
input bias current	the current that flows into the inputs of a circuit
input impedance	the measured resistance and capacitance between the input terminals of a circuit

installation category	classification of parts of installation systems or circuits with standardized limits for transient overvoltages, dependent on the nominal line voltage to earth Installation category IV is for measurements performed at the source of the low-voltage installation. Examples are electricity meters and measurements on primary over current protection devices and ripple control units. Installation category III is for measurements performed in the building installation. Examples are measurements on distribution boards, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment, for example, stationary motors with a permanent connection to the fixed installation. Installation category II is for measurements performed on circuits directly connected to the low voltage installation. Examples are measurements on household appliances, portable tools and similar equipment. Installation category I is for measurements performed on circuits not directly connected to MAINS. Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS-derived circuits.
instrument driver	a set of high-level software functions that controls a specific plug-in DAQ board. Instrument drivers are available in several forms, ranging from a function callable language to a virtual instrument (VI) in LabVIEW.
interrupt	a computer signal indicating that the CPU should suspend its current task to service a designated activity
interrupt level	the relative priority at which a device can interrupt
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
ISA	industry standard architecture

K

k	kilo—the standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters
kS	1,000 samples

L

LabVIEW	laboratory virtual instrument engineering workbench—a graphical programming ADE developed by National Instruments
LSB	least significant bit

M

m	meters
MAINS	the low-voltage (<1000V) electricity supply system to which the equipment concerned is designed to be connected for the purpose of powering the equipment. Measuring circuits may also be connected to the MAINS for measuring purposes.
MB	megabytes of memory
memory buffer	*See* buffer
MS	million samples
MSB	most significant bit

N

noise	an undesirable electrical signal—noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
Nyquist frequency	a frequency that is one-half the sampling rate. *See* Nyquist Sampling Theorem

Nyquist Sampling Theorem	the theorem states that if a continuous bandwidth-limited analog signal contains no frequency components higher than half the frequency at which it is sampled, then the original signal can be recovered without distortion.

O

Ohm's Law	(R=V/I)—the relationship of voltage to current in a resistance
overrange	a segment of the input range of an instrument outside of the normal measuring range. Measurements can still be made, usually with a degradation in specifications.
oversampling	sampling at a rate greater than the Nyquist frequency

P

passband	the frequency range that a filter passes without attenuation
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 workstations and offers a theoretical maximum transfer rate of 132 Mbytes/s
peak value	the absolute maximum or minimum amplitude of a signal (AC + DC)
PFI	Programmable Function Input
pollution	foreign matter, solid, liquid, or gas that may produce a reduction of dielectric strength or surface resistivity Pollution degree 1: No pollution or only dry, nonconductive pollution occurs. The pollution has no influence. Pollution degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected. Pollution degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs, which becomes conductive due to condensation.
posttriggering	the technique to acquire a programmed number of samples after trigger conditions are met

pretriggering	the technique used on a device to keep a buffer filled with data, so that when the trigger conditions are met, the sample includes the data leading up to the trigger condition
PXI	PCI eXtensions for Instrumentation. PXI is an open specification that builds off the CompactPCI specification by adding instrumentation-specific features.

R

R	resistor
RAM	random-access memory
random interleaved sampling	method of increasing sample rate by repetitively sampling a repeated waveform
real-time sampling	sampling that occurs immediately
resolution	the smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits or in digits. The number of bits in a system is roughly equal to 3.3 times the number of digits.
rms	root mean square—a measure of signal amplitude; the square root of the average value of the square of the instantaneous signal amplitude
ROM	read-only memory
RTSI bus	real-time system integration bus—the NI timing bus that connects devices directly, by means of connectors on top of the boards, for precise synchronization of functions

S

s	seconds
S	samples
sense	in four-wire resistance the sense measures the voltage across the resistor being excited by the excitation current
settling time	the amount of time required for a voltage to reach its final value within specified limits

S/s	samples per second—used to express the rate at which an instrument samples an analog signal
system noise	a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

T

temperature coefficient	the percentage that a measurement will vary according to temperature. *See also* thermal drift.
thermal drift	measurements that change as the temperature varies
thermal EMFs	thermal electromotive forces—voltages generated at the junctions of dissimilar metals that are functions of temperature. Also called thermoelectric potentials.
thermoelectric potentials	*See* thermal EMFs
transfer rate	the rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations; the maximum rate at which the hardware can operate

U

undersampling	sampling at a rate lower than the Nyquist frequency—can cause aliasing
update rate	the number of output updates per second

V

V	volts
VAC	volts alternating current
VDC	volts direct current
V_{error}	voltage error

VI	virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
V_{rms}	volts, root mean square value

W

waveform shape	the shape the magnitude of a signal creates over time
working voltage	the highest voltage that should be applied to a product in normal use, normally well under the breakdown voltage for safety margin

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