# Computer-Based Instruments

## NI PXI-562*x* User Manual

***High-Speed Frequency-Domain Digitizer***

NATIONAL INSTRUMENTS™

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**Worldwide Technical Support and Product Information**

`ni.com`

**National Instruments Corporate Headquarters**

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 683 0100

**Worldwide Offices**

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 3262 3599, Canada (Calgary) 403 274 9391, Canada (Montreal) 514 288 5722, Canada (Ottawa) 613 233 5949, Canada (Québec) 514 694 8521, Canada (Toronto) 905 785 0085, China 86 21 6555 7838, Czech Republic 02 2423 5774, Denmark 45 76 26 00, Finland 09 725 725 11, France 01 48 14 24 24, Germany 089 741 31 30, Greece 01 42 96 427, Hong Kong 2645 3186, India 91 80 4190000, Israel 03 6393737, Italy 02 413091, Japan 03 5472 2970, Korea 02 3451 3400, Malaysia 603 9596711, Mexico 001 800 010 0793, Netherlands 0348 433466, New Zealand 09 914 0488, Norway 32 27 73 00, Poland 22 3390 150, Portugal 210 311 210, Russia 095 238 7139, Singapore 65 6 226 5886, Slovenia 3 425 4200, South Africa 11 805 8197, Spain 91 640 0085, Sweden 08 587 895 00, Switzerland 056 200 51 51, Taiwan 02 2528 7227, United Kingdom 01635 523545

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# Compliance

## FCC/Canada Radio Frequency Interference Compliance*

### Determining FCC Class

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.

Trade Name Model Number
Tested to Comply with FCC Standards
FOR HOME OR OFFICE USE

Consult the FCC Web site at `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 Web site 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.

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# About This Manual

The NI PXI-562*x* is a single-channel high-speed digitizer module whose dynamic range and resolution are optimized for frequency-domain analysis applications in research, product design and validation, and manufacturing test. This manual provides information on installing, connecting signals to, and acquiring data from the NI PXI-562*x*. This manual also provides an overview of the features, functionality, and use of the NI PXI-562*x* high-speed digitizer module.

## 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 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` — 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, and code excerpts.

# Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *NI PXI-5620 Specifications*
- *NI PXI-5621 Specifications*
- *NI-SCOPE User Manual*
- *Spectral Measurements Toolset User Guide*

# 1

# Taking Measurements with the NI PXI-562*x*

The NI PXI-5620 is a 64 Ms/s, 14-bit frequency-domain digitizer module optimized for the best possible noise and distortion performance in a 5–25 MHz passband. It has a –3 dB front-end bandwidth from 10 kHz to 36 MHz, and is always AC-coupled, meaning it does not admit DC components of a signal.

The NI PXI-5621 is a DC-coupled version of the NI PXI-5620, optimized for a passband of 0–25 MHz. Except for its permanent DC coupling and wider front-end bandwidth, the NI PXI-5621 is functionally identical to the NI PXI-5620.

Refer to the *NI PXI-5620 Specifications* and the *NI PXI-5621 Specifications* documents for NI PXI-562*x* performance specifications. This chapter provides information on installing, connecting signals to, and acquiring data from the NI 562*x* modules.

The NI 562*x* family of high-speed digitizers has the following features:

- A 14-bit, 64 MS/s analog-to-digital converter (ADC)
- 32 or 64 MB deep onboard sample memory

## Installing the Software and Hardware

Perform the following steps to set up your digitizer:

1. If you are using an application development environment (ADE) or third-party tool, install it now if you have not already done so. The supported ADEs include LabVIEW, LabWindows/CVI, and other C or C++ environments.

**Note** You *must* install all of the included software before installing your hardware.

2. Install NI-SCOPE. The included NI-SCOPE CD contains the software you need to configure, test, and program operation of the NI 562*x*.

a. Insert your NI-SCOPE CD into your CD drive. If installation does not start automatically, navigate to your CD drive and click `setup.exe`.

b. To install both the instrument driver and ADE examples, select the **Programmatic and Interactive Support** option when prompted.

3. Install the Spectral Measurements Toolset (SMT) CD, if included. The SMT provides frequency-domain functionality and examples. If installation does not start automatically, navigate to your CD drive and click `setup.exe`.

**Caution** You *must* turn off and unplug your chassis before installing your device. To prevent damage due to electrostatic discharge or contamination, handle the device using the edges or the metal bracket.

4. Install your digitizer as shown in Figure 1-1.

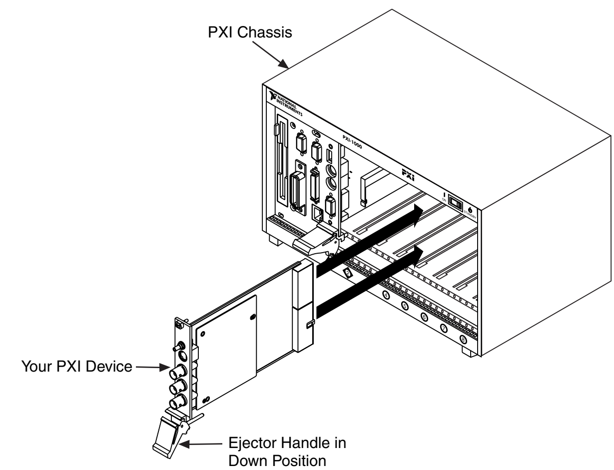



**Figure 1-1.** PXI Installation

# Configuring and Testing the Digitizer

To configure and test your NI 562*x*, complete the following steps:

1. Launch Measurement & Automation Explorer.
2. Double-click **Devices and Interfaces** to open a list of recognized devices.

3. Find the NI 562*x* in the list. Notice the device number assigned to your NI 562*x*. You need this device number to program your NI 562*x*.
4. Right-click the device name, and select **Properties** from the menu.
5. From the Properties window, click **Test Resources** to test the device resources. A dialog box appears and indicates if the resource test has passed.
6. Click **Run Test Panels** to run the functional test panels and begin using your NI 562*x*. Connect a signal to your digitizer, and select appropriate parameters.
7. Click **Advanced** to enable triggering options.
8. Click **Close** when you finish testing your NI 562*x*.
9. Click **OK** in the Properties window.

You have successfully installed and configured the necessary software and hardware to use your NI 562*x*.

# Acquiring Data Programmatically

You can acquire data programmatically either by writing an application for your NI 562*x* or by using one of the examples that ships with NI-SCOPE.

For time-domain examples, go to the following default locations:

- LabVIEW examples are located in the Functions palette at **Instrument I/O»Instrument Drivers»NI SCOPE»IF Digitizers**.
- Examples for C and Visual Basic programmers using Windows Me/98/95 are located in `vxipnp\win95\niScope\Examples`.
- Examples for C programmers using Windows 2000/NT are located at `vxipnp\winnt\niScope\Examples\c`.
- Examples for Visual Basic programmers using Windows 2000/NT are located at `vxipnp\winnt\niScope\Examples\VisualBasic`.
- LabWindows/CVI examples are located at `cvi\NI-SCOPE Support\samples\niScope\cvi`.

**Note** If you installed the examples in a different location, your file paths differ from the default locations above.

For more detailed VI and function help, refer to the *NI-SCOPE VI Reference Help* and the *NI-SCOPE Function Reference Help*, located at **Start»Programs»National Instruments»NI-SCOPE**.

# 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. Use the product only with the chassis, modules, accessories, and cables specified in the installation instructions. 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. Operate the product only at or below the pollution degree stated in the *NI PXI-5620 Specifications* and the *NI PXI-5620 Specifications* documents. 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.

Clean the product with a soft nonmetallic brush. Make sure that the product is completely dry and free from contaminants before returning it to service.

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

Operate this product only at or below the installation category stated in the *NI PXI-5620 Specifications* and the *NI PXI-5620 Specifications* documents.

The following is a description of installation categories:

- Installation Category I is for measurements performed on circuits not directly connected to MAINS[1]. This category is a signal level such as voltages on a printed wire board (PWB) on the secondary of an isolation transformer.

  Examples of Installation Category I are measurements on circuits not derived from MAINS and specially protected (internal) MAINS-derived circuits.
- Installation Category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution such as that provided by a standard wall outlet.

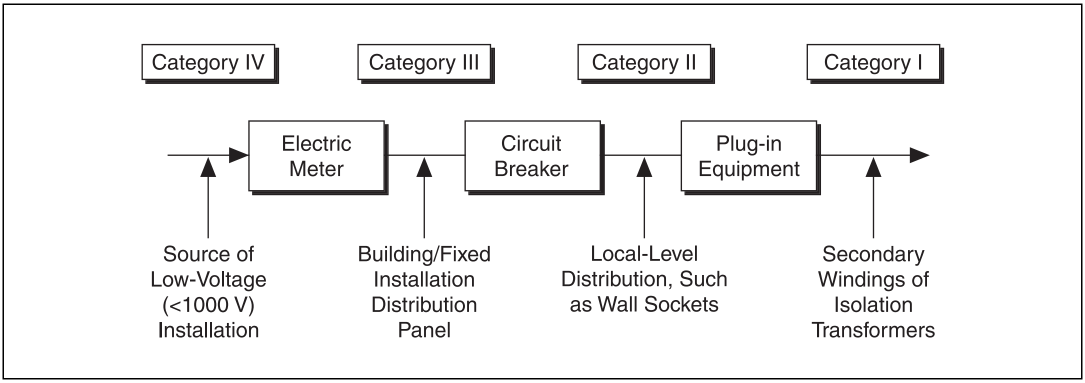
  Examples of Installation Category II are measurements on household appliances, portable tools, and similar equipment.
- Installation Category III is for measurements performed in the building installation. This category is a distribution level referring to hardwired equipment that does not rely on standard building insulation.

  Examples of Installation Category III include measurements on distribution circuits and circuit breakers. Other examples of Installation Category III are wiring including cables, bus-bars, junction boxes, switches, socket outlets in the building/fixed installation, and equipment for industrial use, such as stationary motors with a permanent connection to the building/fixed installation.
- Installation Category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

  Examples of Installation Category IV are electric meters, and measurements on primary overcurrent protection devices and ripple-control units.

[1] MAINS is defined as the electricity supply system to which the equipment concerned is designed to be connected either for powering the equipment or for measurement purposes.

Below is a diagram of a sample installation.



# 2 Hardware Overview

This chapter provides an overview of the features and functionality of the NI 562*x*.

## How the NI 562*x* Works

A signal follows this path through the NI 562*x* to the host computer:

1. The signal enters the NI 562*x* through the analog front panel connector, INPUT. Refer to the *Connecting Signals* section to find more about the front panel.
2. The signal is filtered and conditioned. Gain and dither are applied to the signal. Refer to the *Conditioning the Signal—Impedance, Dither, Gain, and AC Coupling* section for more information.
3. The ADC converts the signal from analog to digital. Refer to the *Digitizing the Signal—The ADC* section for more information.
4. (Optional) The digital downconverter (DDC) digitally zooms in on data. Refer to the *Incorporating the DDC* section.
5. The data is sent to onboard memory (the buffer). Refer to the *Storing Data in Memory* section for additional information.
6. The data is transferred to the host computer via the PXI backplane.

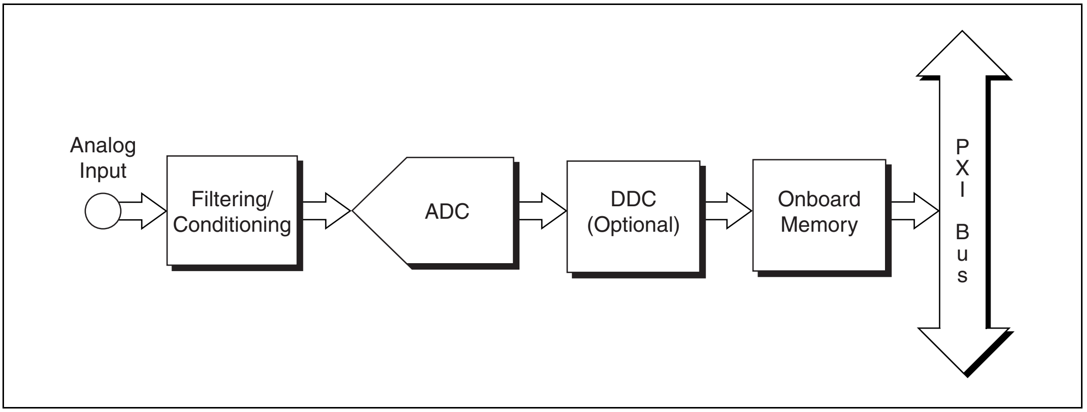



**Figure 2-1.** Basic Signal Flow

# Connecting Signals

Figure 2-2 shows the NI 562*x* front panel, which contains three connectors: two SMA connectors and an SMB connector.

One of the SMA connectors, INPUT, is for attaching the analog input signal you want to measure. The second SMA connector, REF CLK IN, is a 50 Ω, 10 MHz, AC-coupled reference input. The SMB connector, PFI1, is for external digital triggers.

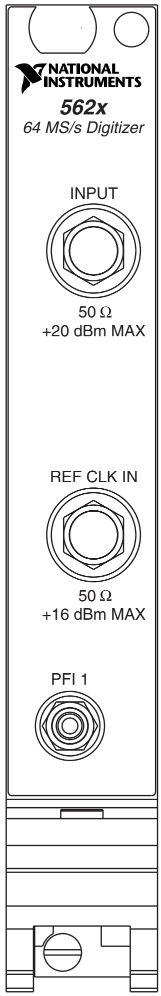



**Figure 2-2.** NI 562*x* Front Panel

## Conditioning the Signal—Impedance, Dither, Gain, and AC Coupling

To minimize distortion, signals receive a minimal amount of conditioning. Gain and coupling are nonadjustable. The NI PXI-5620 is AC coupled, meaning it rejects any DC signal components. The NI PXI-5621 is DC coupled, meaning its wider passband acquires DC signal components also.

Both versions of the NI 562*x* digitizer module have a set input impedance of 50 Ω and may apply dither to the input signal.

### Input Impedance

The input impedance of the NI 562*x* and the output impedance of the source connected to the NI 562*x* 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 unloaded source voltage

$R_{in}$ is the input impedance of the NI 562*x*

$R_s$ is the output impedance of the external device

If the signal you are measuring has an output impedance other than 50 Ω, your measurements are affected by this impedance divider. For example, if the device has 75 Ω output impedance, your measured signal has 80% of the voltage it would have at 50 Ω.

### Dither

Dither is random noise added to the input signal between 0 and 5 MHz. Dither lowers the amount of distortion caused by differential nonlinearity in the ADC when a signal is digitized. When an FFT is applied to the signal, this random noise cancels out most of the distortion created by differential nonlinearity. Dither is not automatically applied, but you can enable it in software.

## Digitizing the Signal—The ADC

Regardless of your requested sample rate, the NI 562*x* ADC is always running at 64 MS/s. If you request a rate less than 64 MS/s, the timing engine of the NI 562*x* stores only one sample in a group of *n* samples, effectively reducing the sample rate to 64/*n* MS/s.

## Incorporating the DDC

Optionally, you can route the data through the DDC before storing it in onboard memory.

The DDC is a digital signal processing (DSP) chip, the Intersil HSP50214B. The first stage uses a digital quadrature mixer that shifts a signal to baseband from any frequency within the range of the digitizer. The next stage decimates (reduces the sample rate) by an integer from 4–16,384. A series of programmable digital lowpass filters prior to each stage of decimation prevents aliasing when the sample rate is reduced. You can retrieve the decimated data as in-phase and quadrature, or as phase and magnitude. A discriminator allows you to take the derivative of the phase to demodulate an FM signal.

By mixing, filtering, and decimating the sampled data, the DDC allows you to zoom in on a band of frequencies much narrower than the Nyquist band of the ADC. The lower sample rate means that signals of longer duration can be stored in the same amount of memory. For spectral analysis, you can use a smaller, faster FFT to look at only the band passed through the DDC.

Refer to the *NI-SCOPE VI Reference Help* for specific DDC attributes you can use to program your NI 562*x*. For more information on using the onboard DDC with LabVIEW, refer to the online help included with NI-SCOPE and the Spectral Measurements Toolset software.

## Storing Data in Memory

Samples are acquired into onboard memory on the NI 562*x* before being transferred to the host computer. The minimum size for a buffer is approximately 256 samples although you can specify smaller buffers in software. When specifying a smaller buffer size, the minimum number of points are still acquired into onboard memory, but only the specified number of points are retrieved into the host computer memory.

During the acquisition, samples are stored in a circular buffer that is continually rewritten until a trigger is received. After the trigger is received, the NI 562*x* 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.

# Block Diagram

The block diagram below illustrates the operation of the NI 562*x*. An explanation of some of these features follows.

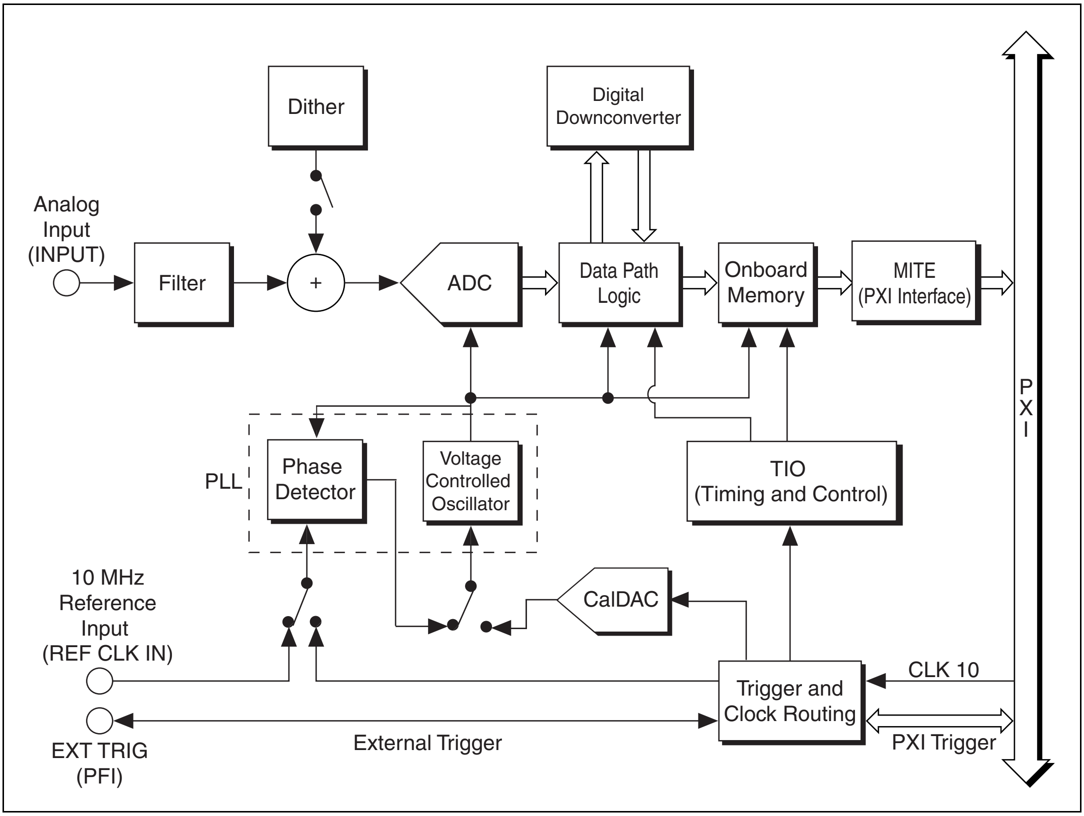



**Figure 2-3.** NI 562*x* Block Diagram

The digital downconverter is a digital signal processor (DSP) that allows you to digitally zoom in on data, which reduces the amount of data transferred into memory and speeds up the rate of data transfer. The digital downconverter performs frequency-translation, filtering, and decimation after signals go through the ADC. Refer to the *Incorporating the DDC* section for more information.

The PLL uses a phase detector to synchronize the acquisition clock to either a 10 MHz reference clock supplied through REF CLK IN or to the CLK 10 signal from the PXI backplane. You can also leave the acquisition clock in a free-running state, in which the acquisition clock is not synchronized to any external reference.

The voltage controlled crystal oscillator (VCXO) is a 64 MHz clock.

The trigger and clock routing area directs clock signals and triggers.

The TIO is the timing engine used for the NI 562*x*.

The MITE is the PXI bus interface. The MITE provides high-speed direct memory access (DMA) transfers from the NI 562*x* to the host computer memory.

# Other Features

This section contains information on other features on the NI 562*x*.

## Multiple-Record Acquisitions

After the trigger has been received and the posttrigger samples have been stored, you can configure the NI 562*x* to begin another acquisition that is stored in another memory record on the device. This process is a multiple-record acquisition. To perform multiple-record acquisitions, configure the NI 562*x* to the number of records to be acquired before starting the acquisition. The NI 562*x* acquires an additional record each time a trigger is accepted until all the requested records are stored in memory. After the initial setup, this process does not require software intervention.

Between each record, a dead time exists during which the trigger is not accepted. If the record length is greater than 80 μs, the dead time is 500 ns. If, however, the record length is less than 80 μs, the dead time is 80 μs. During this time, the memory controller sets up for the next record. Also, additional dead time may exist while the minimum number of pretrigger samples are being acquired.

Figure 2-4 shows a timing diagram of a multiple-record acquisition.

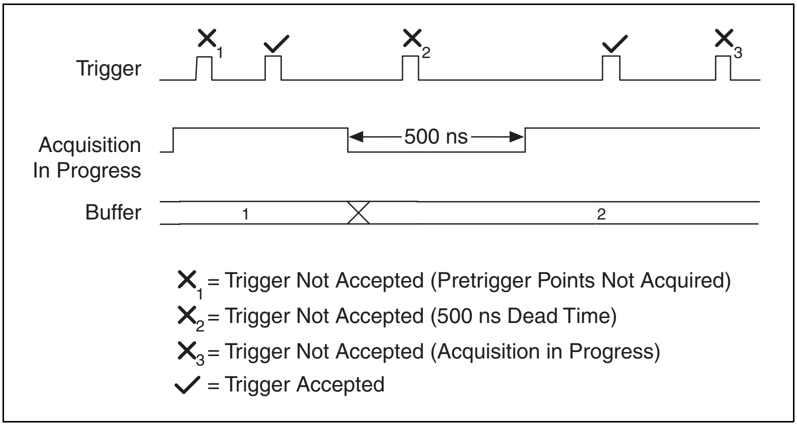



**Figure 2-4.** Multiple-Record Acquisition Timing Diagram

## Triggering

You can externally trigger the NI 562*x* through the digital line, PFI1. You can also use software to trigger the NI 562*x*. Figure 2-5 shows the different trigger sources. The digital triggers are TTL-level signals with a minimum pulse-width requirement of 100 ns or 16 ns times the DDC decimation.

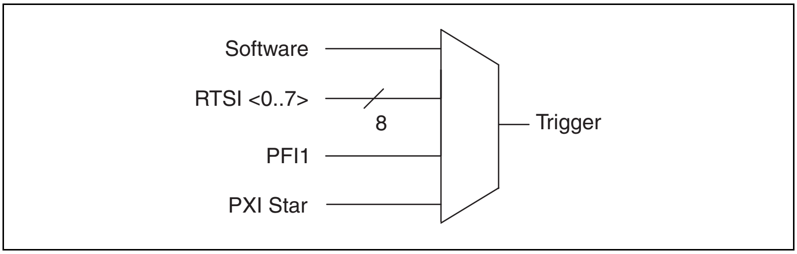



**Figure 2-5.** Digital Trigger Sources

# Calibration

Although the NI 562*x* is factory calibrated, it needs periodic 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/support/calibrat`.

# Synchronizing Multiple PXI Devices

The NI 562*x* uses a PLL to synchronize the 64 MHz sample clock to a 10 MHz reference clock. You can either supply the reference clock through the SMA connector (REF CLK IN) on the front panel or use the system reference clock on the PXI backplane.

The PXI bus and the NI 562*x* have the following timing and triggering features that you can use for synchronizing multiple digitizers:

- System Reference Clock—A 10 MHz clock on the PXI backplane with ±100 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, which allows each NI 562*x* to phase lock to the system reference clock.
- SMA connector (REF CLK IN)—A 10 MHz reference input that you can use to connect an external frequency source for synchronization.

# A

# Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Online technical support resources include the following:
  - **Self-Help Resources**—For immediate answers and solutions, visit our extensive library of technical support resources available in English, Japanese, and Spanish at `ni.com/support`. These resources are available for most products at no cost to registered users and include software drivers and updates, a KnowledgeBase, product manuals, step-by-step troubleshooting wizards, hardware schematics and conformity documentation, example code, tutorials and application notes, instrument drivers, discussion forums, a measurement glossary, and so on.
  - **Assisted Support Options**—Contact NI engineers and other measurement and automation professionals by visiting `ni.com/ask`. Our online system helps you define your question and connects you to the experts by phone, discussion forum, or email.
- **Training**—Visit `ni.com/custed` for self-paced tutorials, videos, and interactive CDs. You also can register for instructor-led, hands-on courses at locations around the world.
- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, NI Alliance Program members can help. To learn more, call your local NI office or visit `ni.com/alliance`.

If you searched `ni.com` and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

# 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

< less than

## A

A amperes

A/D analog-to-digital

AC alternating current

| | |
|---|---|
| AC coupled | allowing the transmission of AC signals while blocking DC signals |
| 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 with 16 bits has a higher resolution, and thus a higher degree of accuracy, than a 12-bit ADC. |
| ADE | application development environment |
| 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 |
| analog bandwidth | the range of frequencies to which a measuring device can respond |
| attenuate | to decrease the amplitude of a signal |

## 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. |
| 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 the PC bus is the PCI bus. |

## C

| | |
|---|---|
| C | Celsius |
| CMOS | complementary metal oxide semiconductor—a process used in making chips. |

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)

coupling — the manner in which a signal is connected from one location to another

## D

data path logic — a signal router

dB — decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB = 20log10 V1/V2, for signals in volts

dBm — decibels with reference to 1 mW, the standard unit of power level used in RF and microwave work. Using this standard, 0 dBm equals 1 mW, 10 dBm equals 10 mW, and so on. In a 50 Ω system, 0 dBm equals ±0.224 $V_{rms}$.

DC — direct current

DDC — *See* digital downconverter.

dead time — a period of time in which no activity can occur

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*.

differential input — an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured

digital downconverter — a DSP that selects only a narrow portion of the frequency spectrum, thereby eliminating unwanted data before it is transferred into memory

dither — random noise added to a signal before it is digitized to minimize distortion created by differential nonlinearity

DMA — direct memory access—a method by which data is transferred to/from computer memory from/to a device or memory on the bus while the processor does something else. DMA is the fastest method of transferring data to/from computer memory.

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 |
| DSP | digital signal processor |

## E

| | |
|---|---|
| EEPROM | electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed |

## F

| | |
|---|---|
| FFT | fast Fourier transform |
| filtering | a type of signal conditioning that allows you to remove unwanted signals or frequency components 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—the number of scans read or updates written per second |

## I

| | |
|---|---|
| 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 |
| impedance | resistance |
| in. | inch or inches |
| inductance | the relationship of induced voltage to current |

| | |
|---|---|
| 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 |
| 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 |
| ISA | industry standard architecture |

## L

| | |
|---|---|
| LabVIEW | Laboratory Virtual Instrument Engineering Workbench—a program development application based on the programming language G and used commonly for test and measurement purposes |
| LSB | least significant bit |

## M

| | |
|---|---|
| m | meters |
| M | (1) Mega, the standard metric prefix for 1 million or $10^6$, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or $2^{20}$, when used with B to quantify data or computer memory |
| MB | megabytes of memory |
| MITE | MXI Interface to Everything—a custom ASIC designed by NI that implements the PCI bus interface. The MITE supports bus mastering for high-speed data transfers over the PCI bus. |
| multiple-record acquisition | multiple, distinct chunks (or records) of data |

## 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. |

## O

| | |
|---|---|
| Ohm's Law | (R = V/I)—the relationship of voltage to current in a resistance |
| onboard memory | the device memory. Onboard memory is distinct from computer memory. |
| overcurrent | amperages above the maximum power level specified for a device |
| 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. |

## 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 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 |
| PLL | phase-locked loop—an electronic circuit that controls an oscillator so that it maintains a constant phase angle relative to a reference signal |
| PXI | PCI eXtensions for Instrumentation—PXI is an open specification that builds on the CompactPCI specification by adding instrumentation-specific features |

## R

| | |
|---|---|
| R | resistor |
| RAM | random-access memory |
| random interleaved sampling (RIS) | method of increasing sample rate by repetitively sampling a repeated waveform |
| real-time sampling | sampling that occurs immediately |
| record length | the size of a chunk (or record) of data that can be or has been acquired by a device |
| resolution | The smallest amount of input signal change that an instrument or sensor can detect. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244% of full scale. |
| 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 |

## S

| | |
|---|---|
| s | seconds |
| S | samples |
| S/s | samples per second—used to express the rate at which an instrument samples an analog signal |
| sample rate | the speed that a device can acquire data |
| sense | in 4-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 |

| | |
|---|---|
| Shannon Sampling Theorem | a theorem stating that a signal must be sampled at least twice as fast as the bandwidth of the signal to accurately reconstruct the signal as a waveform |
| source impedance | a parameter of signal sources that reflects current-driving ability of voltage sources (lower is better) and the voltage-driving ability of current sources (higher is better) |
| 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. |
| TIO | timing input/output—the engine used for timing and control. |
| 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 |
| trigger | any event that causes or starts some form of data capture |
| TTL | transistor-transistor logic—a digital circuit composed of bipolar transistors wired in a certain manner |

## V

| | |
|---|---|
| V | volts |
| $V_{AC}$ | volts alternating current |
| $V_{DC}$ | volts direct current |

$V_{error}$ voltage error

vertical sensitivity the smallest voltage change a device can detect

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

# Index

## T



## V



## W