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DAQ

PCI/PXI-6711/6713 User Manual

Analog Voltage Output Device for PCI/PXI/CompactPCI

NATIONAL INSTRUMENTS™

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About This Manual

This manual describes the electrical and mechanical aspects of the PCI/PXI-6711/6713 devices and contains information concerning their operation and programming.

The 6711/6713 devices include:

- PXI-6711with four or PXI-6713 with eight analog output (AO) channels, two counters, and eight digital input/output (DIO) channels for PXI/CompactPCI.
- PCI-6711 with four or PCI-6713 with eight AO channels, two counters, and eight DIO channels for PCI.

Your PCI/PXI-6711/6713 device is a multifunction analog output, DIO, and timing input/output (I/O) device for PCI/PXI/CompactPCI and 1394 buses.

Organization of This Manual

The *PCI/PXI-6711/6713 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes your PCI/PXI-6711/6713 device, lists what you need to get started, describes the optional software and optional equipment, and explains how to unpack your 6711/6713 device.
- Chapter 2, *Installation and Configuration*, explains how to install and configure your PCI/PXI-6711/6713 device.
- Chapter 3, *Hardware Overview*, presents an overview of the hardware functions on your PCI/PXI-6711/6713 device.
- Chapter 4, *Signal Connections*, describes how to make input and output signal connections to your PCI/PXI-6711/6713 device via the device I/O connector.
- Chapter 5, *Calibration*, discusses the calibration procedures for your PCI/PXI-6711/6713 device.
- Appendix A, *Specifications*, lists the specifications of your PCI/PXI-6711/6713 device.
- Appendix B, *Common Questions*, contains a list of commonly asked questions and their answers relating to usage and special features of your PCI/PXI-6711/6713 device.

- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including acronyms, abbreviations, definitions metric prefixes, mnemonics, and symbols.
- The *Index* alphabetically lists topics covered in this manual, including the page where you can find the topic.

Conventions Used in This Manual

The following conventions are used in this manual.

<>	Angle brackets enclose the name of a key on the keyboard (for example, <option>). Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit or signal name (for example, DIO<3..0>).
♦	The ♦ indicates that the text following it applies to only to a specific PCI/PXI/CompactPCI device.
☞	This icon to the left of bold italicized text denotes a note, which alerts you to important information.
⚠	This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
bold italic	Bold italic text denotes a note, caution, or warning.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept. This font also denotes text from which you supply the appropriate word or value, as in NI-DAQ 6.*x*.
6711/6713	6711/6713 refers to the National Instruments PCI/PXI-6711/6713 devices unless otherwise noted.
NI-DAQ	NI-DAQ refers to the NI-DAQ driver software for PC compatible computers unless otherwise noted.
PC	Refers to all PC AT series computers with PCI bus unless otherwise noted.
SCXI	SCXI stands for Signal Conditioning eXentsions for Instrumentation and is a National Instruments product line designed to perform front-end signal conditioning for National instruments plug-in DAQ devices.

National Instruments Documentation

The *PCI/PXI-6711/6713 User Manual* is one piece of the documentation set for your DAQ system. You could have any of several types of documentation depending on the hardware and software in your system. Use the documentation you have as follows:

- *Getting Started with SCXI*—If you are using SCXI, this is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.
- Your SCXI hardware user manuals—If you are using SCXI, read these manuals next for detailed information about signal connections and module configuration. They also explain in greater detail how the module works and contain application hints.
- Your DAQ hardware documentation—This documentation has detailed information about the DAQ hardware that plugs into or is connected to your computer. Use this documentation for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software documentation—You may have both application software and NI-DAQ software documentation. National Instruments application software includes ComponentWorks, LabVIEW, LabWindows/CVI, and VirtualBench. After you set up your hardware system, use either your application software documentation or the NI-DAQ documentation to help you write your application. If you have a large, complicated system, it is worthwhile to look through the software documentation before you configure your hardware.
- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.
- SCXI chassis manuals—If you are using SCXI, read these manuals for maintenance information on the chassis and installation instructions.

Related Documentation

The following documents contain information you may find helpful:

- *DAQ-STC Technical Reference Manual*
- National Instruments Application Note 025, *Field Wiring and Noise Considerations for Analog Signals*
- *PCI Local Bus Specification Revision 2.0*

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix C, *Customer Communication*, at the end of this manual.

1

Introduction

This chapter describes your PCI/PXI-6711/6713 device, lists what you need to get started, describes the optional software and optional equipment, and explains how to unpack your 6711/6713 device.

About the 6711/6713 Devices

Thank you for buying a National Instruments 6711/6713 device. Your 6711/6713 device is a completely Plug and Play, analog output, digital, and timing I/O device for PXI/PCI/CompactPCI. The 6711/6713 device features a 12-bit digital-to-analog converter (DAC) per channel with update rates up to Ms/S/channel for voltage outputs, eight lines of TTL-compatible digital I/O, and two 24-bit counter/timers for timing I/O. The 6711 device features four voltage output channels, while the 6713 device features eight voltage output channels. Because the 6711/6713 device has no DIP switches, jumpers, or potentiometers, it is easily software-configured and calibrated.

The 6711/6713 device is a completely switchless and jumperless data acquisition (DAQ) device for the PXI/PCI/CompactPCI. This feature is made possible by the National Instruments MITE bus interface chip that connects the device to the PCI I/O bus. The MITE implements the PCI Local Bus Specification so that the interrupts and base memory addresses are all software configured.

The 6711/6713 device uses the National Instruments DAQ-STC system timing controller for time-related functions. The DAQ-STC consists of three timing groups that control analog input, analog output, and general-purpose counter/timer functions. These groups include a total of seven 24-bit and three 16-bit counters and a maximum timing resolution of 50 ns. The analog input section of the DAQ-STC is unused by the 6711/6713.

Often with other DAQ devices, you cannot easily synchronize several measurement functions to a common trigger or timing event. The PCI-6711/6713 device has the Real-Time System Integration (RTSI) bus to solve this problem. The RTSI bus consists of our RTSI bus interface and a ribbon cable to route timing and trigger signals between several functions

on as many as five DAQ devices in your computer. If you are using the PXI-6711/6713 in a PXI chassis, RTSI lines, known as the PXI trigger bus, are part of the backplane, therefore you do not need the RTSI cable for system triggering and timing on the PXI.

Detailed specifications of the 6711/6713 device are in Appendix A, *Specifications*.

Using PXI with CompactPCI

- PXI-6711/6713 Only

Using PXI-compatible products with standard CompactPCI products is an important feature provided by the *PXI Specification*, revision 1.0. If you use a PXI-compatible plug-in device in a standard CompactPCI chassis, you will be unable to use PXI-specific functions, but you can still use the basic plug-in device functions. For example, the PXI trigger bus on your 6711/6713 device is available in a PXI chassis but not in a CompactPCI chassis.

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses nor between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. Your 6711/6713 device will work in any standard CompactPCI chassis adhering to the *PICMG CompactPCI 2.0 R2.1* document.

PXI-specific features, RTSI bus trigger, RTSI Clock, and Serial Communication, are implemented on the J2 connector of the CompactPCI bus. Table 1-1 lists the J2 pins used by your PXI-6711/6713, which is compatible with any CompactPCI chassis with a sub-bus that does not drive these lines. Even if the sub-bus is capable of driving these lines, the 6711/6713 is still compatible as long as those pins on the sub-bus are disabled by default and are never enabled. Damage can result if these lines are driven by the sub-bus.

Table 1-1. PXI-6711/6713 J2 Pin Assignment

6711/6713 Signal	PXI Pin Name	PXI J2 Pin Number
RTSI Trigger <0..5>	PXI Trigger <0..5>	B16, A16, A17, A18, B18, C18
RTSI Trigger 6	PXI Star Trigger	D17
RTSI Clock	PXI Trigger (7)	E16
Serial Communication	LBR (6, 7, 8, 9, 10, 11, 12)	EI5, A3, C3, D3, E3, A2, B2

What You Need to Get Started

To set up and use the 6711/6713 device, you will need the following:

- ❑ Either the 6711 or 6713 device
- ❑ *PCI/PXI-6711/6713 User Manual*
- ❑ NI-DAQ driver for PC compatibles version 6.5 or higher
- ❑ One of the following software packages and documentation:
  - LabVIEW for Windows
  - LabWindows/CVI for Windows
  - ComponentWorks
  - VirtualBench
  - C language compiler
- ❑ Your computer
- ❑ SH6868 EP cable
- ❑ One of the following
  - BNC 2110 signal connector block
  - SCB-68 shielded terminal block
  - CB-68LP terminal block

Unpacking

The 6711/6713 device is shipped in an antistatic package to prevent electrostatic damage to the device. Electrostatic discharge can damage several components on the device. To avoid such damage in handling the device, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the device from the package.
- Remove the device from the package and inspect the device for loose components or any other sign of damage. Notify National Instruments if the device appears damaged in any way. Do *not* install a damaged device into your computer.
- *Never* touch the exposed pins of connectors.

Software Programming Choices

You have several options to choose from when programming your National Instruments DAQ and SCXI hardware. You can use National Instruments application software, NI-DAQ, or register-level programming.

National Instruments Application Software

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition VI Library, a series of VIs for using LabVIEW with National Instruments DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to NI-DAQ software.

LabWindows/CVI features interactive graphics, state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI Data Acquisition Library, a series of functions for using LabWindows/CVI with National Instruments DAQ hardware, is included with the NI-DAQ software kit. The LabWindows/CVI Data Acquisition Library is functionally equivalent to the NI-DAQ software. ComponentWorks contains tools for data acquisition and instrument control built on NI-DAQ driver software. ComponentWorks provides a higher-level programming interface for building virtual instruments through standard OLE controls and DLLs. With ComponentWorks, you

can use all of the configuration tools, resource management utilities, and interactive control utilities included with NI-DAQ.

VirtualBench features virtual instruments that combine DAQ products, software, and your computer to create a stand-alone instrument with the added benefit of the processing, display, and storage capabilities of your computer. VirtualBench instruments load and save waveform data to disk in the same forms that can be used in popular spreadsheet programs and word processors.

Using ComponentWorks, LabVIEW, LabWindows/CVI, or VirtualBench software will greatly reduce the development time for your data acquisition and control application.

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ hardware. NI-DAQ is not packaged with SCXI or accessory products, except for the SCXI-1200. NI-DAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for analog input (A/D conversion), buffered data acquisition (high-speed A/D conversion), analog output (D/A conversion), waveform generation (timed D/A conversion), digital I/O, counter/timer operations, SCXI, RTSI, self-calibration, messaging, and acquiring data to extended memory.

NI-DAQ has both high-level DAQ I/O functions for maximum ease of use and low-level DAQ I/O functions for maximum flexibility and performance. Examples of high-level functions are streaming data to disk or acquiring a certain number of data points. An example of a low-level function is writing directly to registers on the DAQ device. NI-DAQ does not sacrifice the performance of National Instruments DAQ devices because it lets multiple devices operate at their peak.

NI-DAQ also internally addresses many of the complex issues between the computer and the DAQ hardware such as programming interrupts and DMA controllers. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Whether you are using conventional

programming languages or National Instruments application software, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

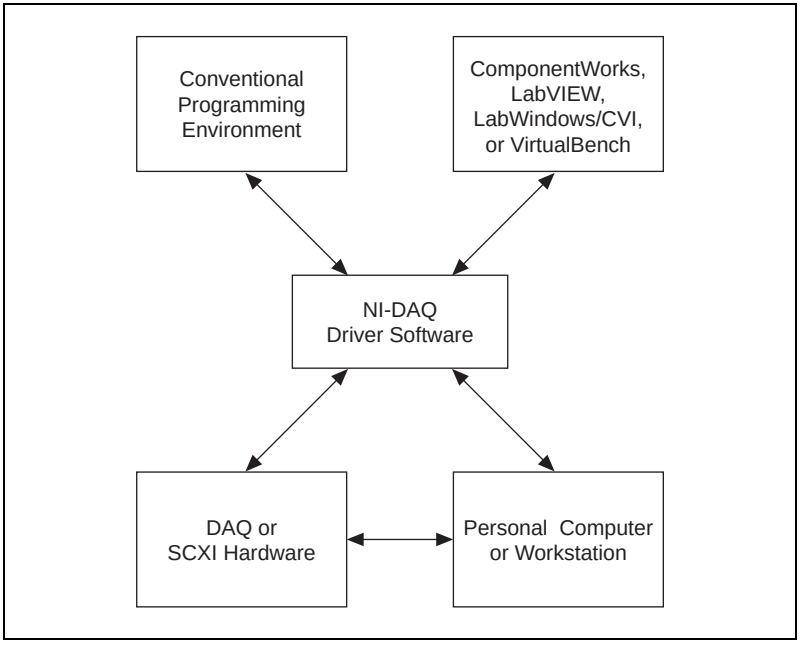


Figure 1-1. The Relationship Between the Programming Environment, NI-DAQ, and Your Hardware

Register-Level Programming

The final option for programming any National Instruments DAQ hardware is to write register-level software. Writing register-level programming software can be very time-consuming and inefficient, and is not recommended for most users.

Even if you are an experienced register-level programmer, using NI-DAQ or application software to program your National Instruments DAQ hardware is easier than, and as flexible as, register-level programming, and can save weeks of development time.

Optional Equipment

National Instruments offers a variety of products to use with the 6711/6713 device, including cables, connector blocks, and other accessories, as follows:

- Cables and cable assemblies
- Connector blocks, shielded and unshielded 50- and 68-pin screw terminals
- RTSI bus cables
- Low channel-count digital signal conditioning modules, devices, and accessories

For more specific information about these products, refer to your National Instruments catalogue or call the office nearest you.

Custom Cabling

National Instruments offers cables and accessories for you to prototype your application or to use if you frequently change device interconnections.

If you want to develop your own cable, however, the following guidelines may be useful:

- Route the analog lines separately from the digital lines.
- When using a cable shield, use separate shields for the analog and digital halves of the cable. Failure to do so results in noise coupling into the analog signals from transient digital signals.

Mating connectors and a backshell kit for making custom 68-pin cables are available from National Instruments.

The following list gives recommended part numbers for connectors that mate to the I/O connector on the 6711/6713 device:

- Honda 68-position, solder cup, female connector (part number PCS-E68FS)
- Honda backshell (part number PCS-E68LKPA)

2

Installation and Configuration

This chapter explains how to install and configure your PCI/PXI-6711/6713 device.

Software Installation

Install your software before you install the 6711/6713 device. Refer to the appropriate release notes indicated below for specific instructions on the software installation sequence.

1. Install your application software—If you are using LabVIEW, LabWindows/CVI, or other National Instruments application software packages, refer to the appropriate release notes.
2. Install the NI-DAQ driver software—Refer to your NI-DAQ release notes and follow the instructions given there for your operating system and application software package.

You can now install your hardware.

Hardware Installation

You can install the PCI/PXI-6711/6713 device in any available PCI/PXI expansion slot in your computer. However, to achieve best noise performance, leave as much room as possible between the 6711/6713 device and other devices and hardware. The following are general installation instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

- PXI-6711/6713
  You can install the PXI-6711/6713 in any available PXI slot in your PXI or CompactPCI chassis.

Note ***The PXI-6711/6713 has connections to several reserved lines on the CompactPCI J2 connector. Before installing the PXI-6711/6713 in a CompactPCI system that uses J2 connector lines for a purpose other than PXI, see Chapter 1, Using PXI with CompactPCI.***

1. Turn off and unplug your PXI or CompactPCI chassis.
2. Choose an unused PXI or CompactPCI peripheral slot. For maximum performance, install the PXI-6711/6713 in a slot that supports bus arbitration or bus-master cards. The PXI-6711/6713 contains onboard bus-master DMA logic that can operate only in such a slot. If you choose a slot that does not support bus masters, you will have to disable the onboard DMA controller using your software. PXI-compliant chassis must have bus arbitration for all slots.
3. Remove the filter panel for the peripheral slot that you have chosen.
4. Touch a metal part on the chassis to discharge any static electricity that might be on your clothes or body.
5. Insert the PXI-6711/6713 device in the 5 V slot. Use the injector/ejector handle to fully inject the device into place.
6. Screw the front panel of the PXI-6711/6713 to the front panel mounting rails of the PXI or CompactPCI chassis.
7. Visually verify the installation.
8. Plug in and turn on the PXI or CompactPCI chassis.

The PXI 6711/6713 is now installed.

- PCI 6711/6713

1. Write down the 6711/6713 device serial number in the *6711/6713 Device Hardware and Software Configuration Form* in Appendix D, *Customer Communication*, of this manual.
2. Turn off and unplug your computer.
3. Remove the top cover or access port to the I/O channel.
4. Remove the expansion slot cover on the back panel of the computer.
5. Insert the 6711/6713 device into a 5 V PCI slot. Gently rock the device to ease it into place. It may be a tight fit, but *do not force* the device into place.
6. If required, screw the mounting bracket of the 6711/6713 device to the back panel rail of the computer.
7. Replace the cover.
8. Plug in and turn on your computer.

The PCI-6711/6713 device is installed. You are now ready to configure your software. Refer to your software documentation for configuration instructions.

Device Configuration

Due to the National Instruments standard architecture for data acquisition, the PCI bus specification for the 6711/6713 device is completely software configurable. There are two types of configuration on the 6711/6713 device—bus-related and data acquisition-related configuration.

The PCI/PXI-6711/6713 device is fully compatible with the industry-standard *PCI Local Bus Specification Revision 2.0*. This specification allows the PCI system to automatically perform all bus-related configurations and requires no user interaction. Bus-related configuration includes setting the device base memory address and interrupt channel.

Data acquisition-related configuration includes such settings as analog output range, reference selection, and others. You can modify these settings using NI-DAQ C language API, or application level software, such as ComponentWorks, LabVIEW, LabWindows/CVI, and VirtualBench.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your PCI/PXI-6711/6713 device. Figure 3-1 shows a block diagram of the 6711/6713 device.

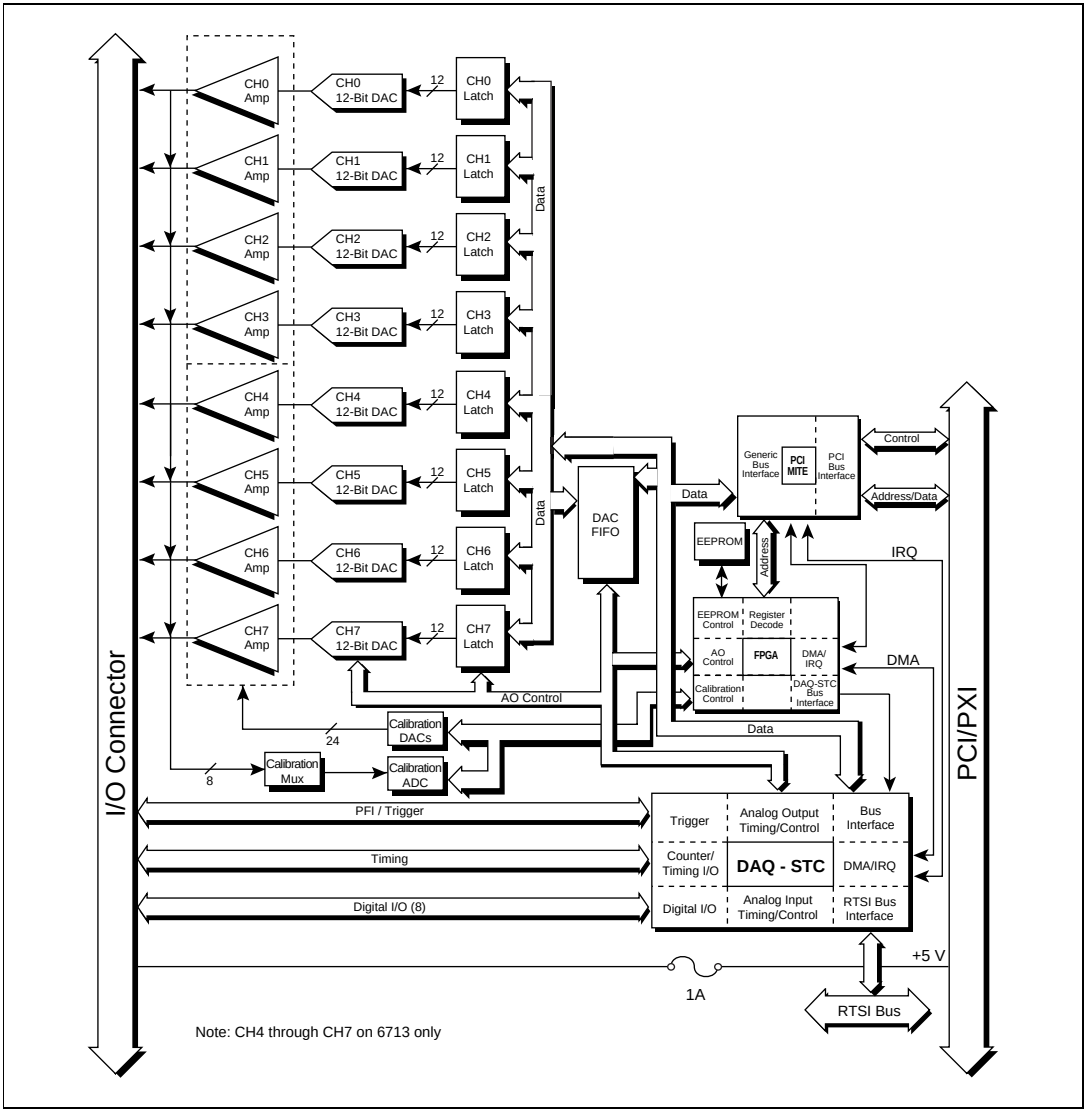


Figure 3-1. 6711/6713 Block Diagram

Analog Output

The 6711 has four channels and the 6713 has eight channels of voltage output at the I/O connector. The reference for the analog output circuitry is software selectable per channel. The reference can be either internal or external, whereas the range is always bipolar. This means that you can

output signals up to ±10 V with internal reference selected or ± EXTREF voltage with external reference selected.

Analog Output Reference Selection

You can connect each D/A converter (DAC) to the internal reference of 10 V or to the external reference signal connected to the external reference (EXTREF) pin on the I/O connector. This signal applied to EXTREF should be within ±11 V. You can configure each channel to use either internal or external reference. The default reference value selection is internal reference.

Analog Output Reglitch Selection

In normal operation, a DAC output will glitch whenever it is updated with a new value. The glitch energy differs from code to code and appears as distortion in the frequency spectrum. Each analog output channel contains a reglitch circuit that generates uniform glitch energy at every code rather than large glitches at the major code transitions. This uniform glitch energy appears as a multiple of the update rate in the frequency spectrum. Notice that this reglitch circuit does *not* eliminate the glitches; it only makes them more uniform in size. By default, reglitching is disabled for all channels, however you can use NI-DAQ to independently enable reglitching for each channel.

Digital I/O

The 6711/6713 device contains eight lines of digital I/O for general-purpose use. You can individually software-configure each line for either input or output. At system startup and reset, the digital I/O ports are all high impedance.

The hardware up/down control for general-purpose counters 0 and 1 are connected onboard to DIO6 and DIO7, respectively. Thus, you can use DIO6 and DIO7 to control the general-purpose counters. The up/down control signals are input only and do not affect the operation of the DIO lines.

Timing Signal Routing

The DAQ-STC provides a very flexible interface for connecting timing signals to other devices or external circuitry. The 6711/6713 device uses the RTSI bus to interconnect timing signals between devices, and the

Programmable Function Input (PFI) pins on the I/O connector to connect the device to external circuitry. These connections are designed to enable the 6711/6713 device to both control and be controlled by other devices and circuits.

There are a total of 13 timing signals internal to the DAQ-STC that can be controlled by an external source. These timing signals can also be controlled by signals generated internally to the DAQ-STC, and these selections are fully software configurable. For example, the signal routing multiplexer for controlling the UPDATE* signal is shown in Figure 3-2.

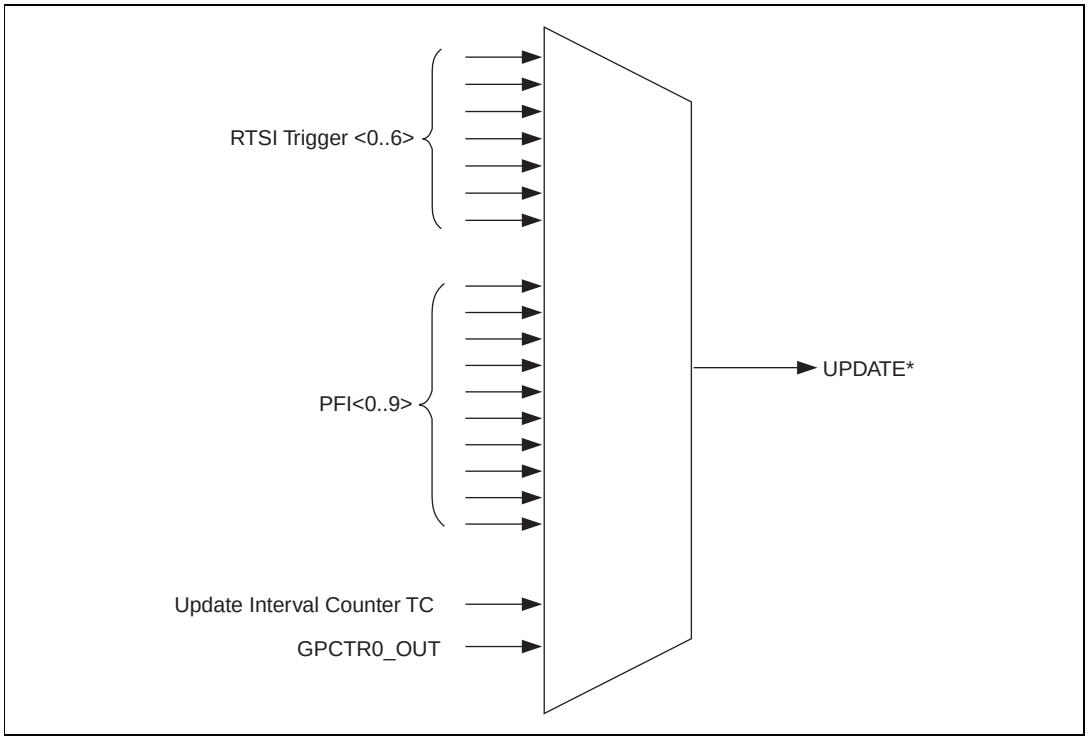


Figure 3-2. UPDATE* Signal Routing

This figure shows that UPDATE* can be generated from a number of sources, including the external signals RTSI<0..6> and PFI<0..9> and the internal signals Sample Interval Counter TC and GPCTR0_OUT.

Many of these timing signals are also available as outputs on the RTSI pins, as indicated in the *RTSI Triggers* section later in this chapter, and on the PFI pins, as indicated in Chapter 4, *Signal Connections*.

Programmable Function Inputs

The 10 PFIs are connected to the signal routing multiplexer for each timing signal, and software can select one of the PFIs as the external source for a given timing signal. It is important to note that any of the PFIs can be used as an input by any of the timing signals and that multiple timing signals can use the same PFI simultaneously. This flexible routing scheme reduces the need to change physical connections to the I/O connector for different applications. You can also individually enable each of the PFI pins to output a specific internal timing signal. For example, if you need the UPDATE* signal as an output on the I/O connector, software can turn on the output driver for the PFI5/UPDATE* pin.

Device and RTSI Clocks

Many functions performed by the 6711/6713 device require a frequency timebase to generate the necessary timing signals for controlling DAC updates or general-purpose signals at the I/O connector.

The 6711/6713 device can use either its internal 20 MHz timebase or a timebase received over the RTSI bus. In addition, if you configure the device to use the internal timebase, you can also program the device to drive its internal timebase over the RTSI bus to another device that is programmed to receive this timebase signal. This clock source, whether local or from the RTSI bus, is used directly by the device as the primary frequency source. The default configuration at startup is to use the internal timebase without driving the RTSI bus timebase signal. This timebase is software selectable.

RTSI Triggers

The seven RTSI trigger lines on the RTSI bus provide a very flexible interconnection scheme for the 6711/6713 device sharing the RTSI bus. These bidirectional lines can drive any of five timing signals onto the RTSI

bus and can receive any of these timing signals. This signal connection scheme is shown in Figure 3-3.

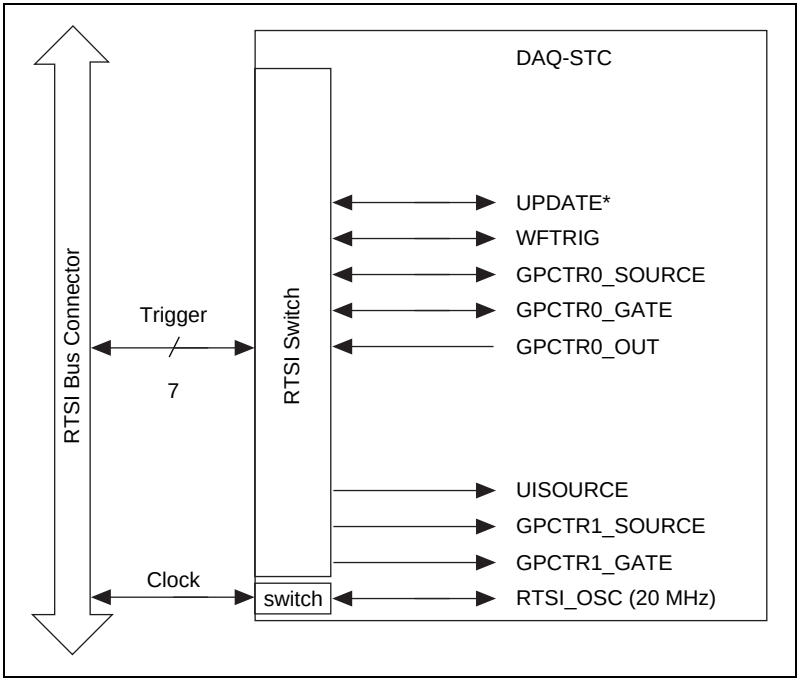


Figure 3-3. RTSI Bus Signal Connection

Refer to the *Timing Connections* section of Chapter 4, *Signal Connections*, for a description of the signals.

4

Signal Connections

This chapter describes how to make input and output signal connections to your PCI/PXI-6711/6713 device via the device I/O connector.

The I/O connector for the 6711/6713 device has 68 pins that you can connect to 68-pin accessories with the SH68-68-EP or similar 68-pin shielded cable.

I/O Connector

Figure 4-1 shows the pin assignments for the 68-pin I/O connector on the PCI/PXI-6711/6713 device. A signal description follows the connector pinouts.

Caution ***Connections that exceed any of the maximum ratings of input or output signals on the 6711/6713 device can damage the 6711/6713 device and the computer. Maximum input ratings for each signal are given in the Protection column of Table 4-2. National Instruments is not liable for any damages resulting from such signal connections.***

AOGND	34	68	NC
NC	33	67	AOGND
AOGND	32	66	AOGND
AOGND	31	65	DAC7OUT[1]
DAC6OUT[1]	30	64	AOGND
AOGND	29	63	AOGND
DAC5OUT[1]	28	62	NC
AOGND	27	61	AOGND
AOGND	26	60	DAC4OUT[1]
DAC3OUT	25	59	AOGND
AOGND	24	58	AOGND
AOGND	23	57	DAC2OUT
DAC0OUT	22	56	AOGND
DAC1OUT	21	55	AOGND
EXTREF	20	54	AOGND
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5 V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	NC
PFI0	11	45	EXTSTROBE*
PFI1	10	44	DGND
DGND	9	43	PFI2
+5 V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] No Connect on PCI/PXI 6711

Figure 4-1. I/O Connector Pin Assignment for the PCI/PXI-6711/6713 Device

I/O Connector Signal Descriptions

Table 4-1. Signal Descriptions for I/O Connector Pins

Signal Name	Reference	Direction	Description
AOGND	—	—	Analog Output Ground—The analog output voltages are referenced to this node.
DAC<0..7>OUT	AOGND	Output	Analog Output Channels 0 through 7—These pins supply the voltage output of the respective channel.
DGND	—	—	Digital Ground—This pin supplies the reference for the digital signals at the I/O connector as well as the +5 VDC supply.
DIO<0..7>	DGND	Input or Output	Digital I/O signals—DIO6 and 7 can control the up/down signal of general-purpose counters 0 and 1, respectively.
+5 V	DGND	Output	+5 VDC Source—These pins are fused for up to 1 A of +5 V supply. The fuse is self-resetting.
EXTREF	AOGND	Input	External Reference—This is the external reference input for the analog output circuitry.
EXTSTROBE*	DGND	Output	External Strobe—This output is used for controlling SCXI devices.
PFI0	DGND	Input	PFI0—As an input, this is one of the Programmable Function Inputs (PFIs). PFI signals are explained in the Timing Connections section later in this chapter. PF<0 cannot be output.
PFI1	DGND	Input	PFI1—As an input, this is one of the PFIs. PFI1 cannot be an output.
PFI2	DGND	Input	PFI2—As an input, this is one of the PFIs. PFI2 cannot be an output.
PFI3/GPCTR1_SOURCE	DGND	Input Output	PFI3/Counter 1 Source—As an input, this is one of the PFIs. As an output, this is the GPCTR1_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 1.
PFI4/GPCTR1_GATE	DGND	Input Output	PFI4/Counter 1 Gate—As an input, this is one of the PFIs. As an output, this is the GPCTR1_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 1.
GPCTR1_OUT	DGND	Output	Counter 1 Output—This output is from the general-purpose counter 1 output.

Table 4-1. Signal Descriptions for I/O Connector Pins (Continued)

Signal Name	Reference	Direction	Description
PFI5/UPDATE*	DGND	Input	PFI5/Update—As an input, this is one of the PFIs.
		Output	As an output, this is the UPDATE* signal. A high-to-low edge on UPDATE* indicates that the analog output waveform generation group is being updated.
PFI6/WFTRIG	DGND	Input	PFI6/Waveform Trigger—As an input, this is one of the PFIs.
		Output	As an output, this is the WFTRIG signal. In timed analog output sequences, a low-to-high transition indicates the initiation of the waveform generation.
PFI7	DGND	Input	PFI7—As an input, this is one of the PFIs. PFI7 cannot be an output.
PFI8/GPCTR0_SOURCE	DGND	Input	PFI8/Counter 0 Source—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 0.
PFI9/GPCTR0_GATE	DGND	Input	PFI9/Counter 0 Gate—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 0.
GPCTR0_OUT	DGND	Output	Counter 0 Output—This output is from the general-purpose counter 0 output.
FREQ_OUT	DGND	Output	Frequency Output—This output is from the frequency generator output.

Table 4-2 shows the I/O signal summary for the 6711/6713 devices.

Table 4-2. I/O Signal Summary for the 6711/6713 Device

Signal Name	Signal Type and Direction	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)/ Slew Rate	Bias
DAC<0..7>OUT	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at -10	20 V/µs	—
AOGND	AO	—	—	—	—	—	—
DGND	DIO	—	—	—	—	—	—

Table 4-2. I/O Signal Summary for the 6711/6713 Device (Continued)

Signal Name	Signal Type and Direction	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)/ Slew Rate	Bias
VCC	DO	0.1 Ω	Short-circuit to ground	1 A	—	—	—
DIO<0..7>	DIO	—	V_{cc} +0.5	13 at (V_{cc} -0.4)	24 at 0.4	1.1	50 kΩ pu
EXTSTROBE*	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
EXTREF	AI	10 kΩ	25/15	—	—	—	—
PFI0	DI	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pd
PFI1	DI	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI2	DI	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI3/GPCTR1_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI4/GPCTR1_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR1_OUT	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI5/UPDATE*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI6/WFTRIG	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI7	DI	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI8/GPCTR0_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu

Table 4-2. I/O Signal Summary for the 6711/6713 Device (Continued)

Signal Name	Signal Type and Direction	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)/ Slew Rate	Bias
PFI9/GPCTR0_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR0_OUT	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
FREQ_OUT	DO	—	—	3.5 at (V_{cc}-0.4)	5 at 0.4	1.5	50 kΩ pu

AI = Analog Input, DIO = Digital Input/Output, pu = pull-up, AO = Analog Output, DO = Digital Output

The tolerance on the 50 kΩ pull-up and pull-down resistors is very large. Actual value may range between 17 and 100 kΩ.

Analog Output Signal Connections

The analog output signals are DAC<0..7>OUT, AOGND, and EXTREF.

DAC0OUT is the voltage output signal for analog output channel 0.

EXTREF is the external reference input for all analog output channels. You can use this input to reduce the voltage swing on the DAC outputs while preserving the dynamic range. For example, with internal reference the minimum change (LSB) on a voltage output is:

$$\frac{20\ \text{V}}{4096} = 4.88\ \text{mV}$$

For an external reference at 5 V, you can output ±5 V with the LSB on a voltage output reduced to 2.44 mV. This gives you a higher resolution at lower voltage.

You must configure each analog output channel individually for external reference selection in order for the signal applied at the external reference input to be used by that channel. If you do not specify an external reference, the channel will use the internal reference. Analog output configuration options are explained in the *Analog Output* section in Chapter 3, *Hardware Overview*. The following ranges and ratings apply to the EXTREF input:

- Usable input voltage range: ±11 V peak with respect to AOGND
- Absolute maximum ratings: ±15 V peak with respect to AOGND

AOGND is the ground reference signal for the analog output channels. DAC<0..7>OUT as well as EXTREF is referenced to AOGND.

The external reference signal can be either a DC or an AC signal. The device multiplies this reference signal by the DAC code, divided by the full-scale DAC code, to generate the output voltage.

Figure 4-2 shows how to make analog output connections to the 6711/6713 device.

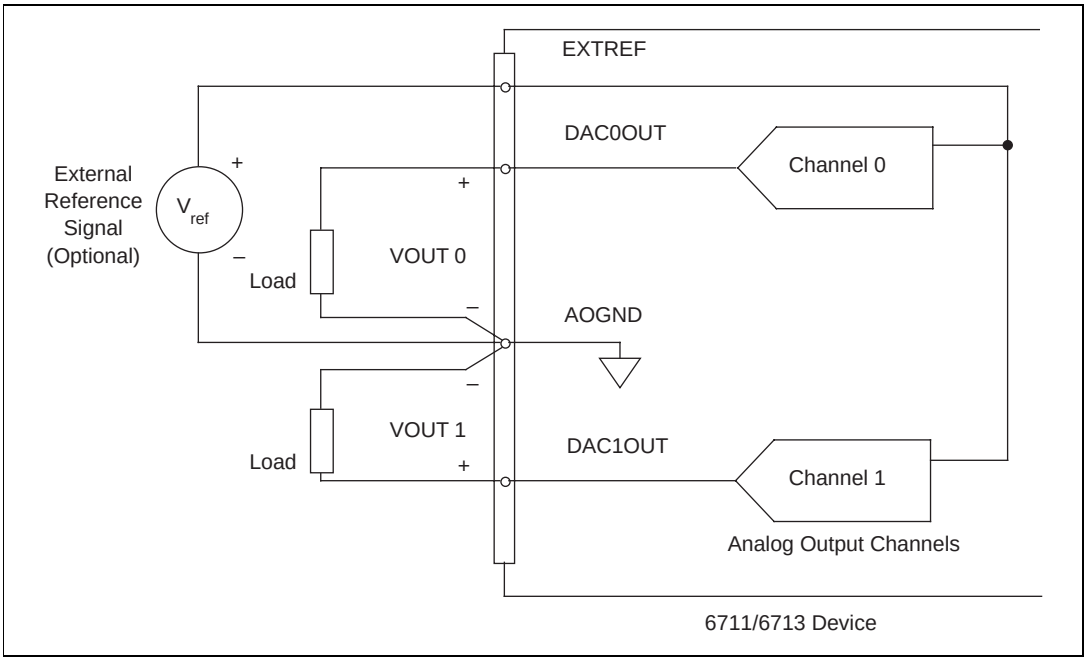


Figure 4-2. Analog Output Connections

Digital I/O Signal Connections

The digital I/O signals are DIO<0..7> and DGND. DIO<0..7> are the signals making up the DIO port, and DGND is the ground reference signal for the DIO port. You can program all lines individually to be inputs or outputs.

Caution ***Exceeding the maximum input voltage ratings, which are listed in Table 4-2, can damage the 6711/6713 device and the computer. National Instruments is NOT liable for any damages resulting from such signal connections.***

Figure 4-3 shows signal connections for three typical digital I/O applications.

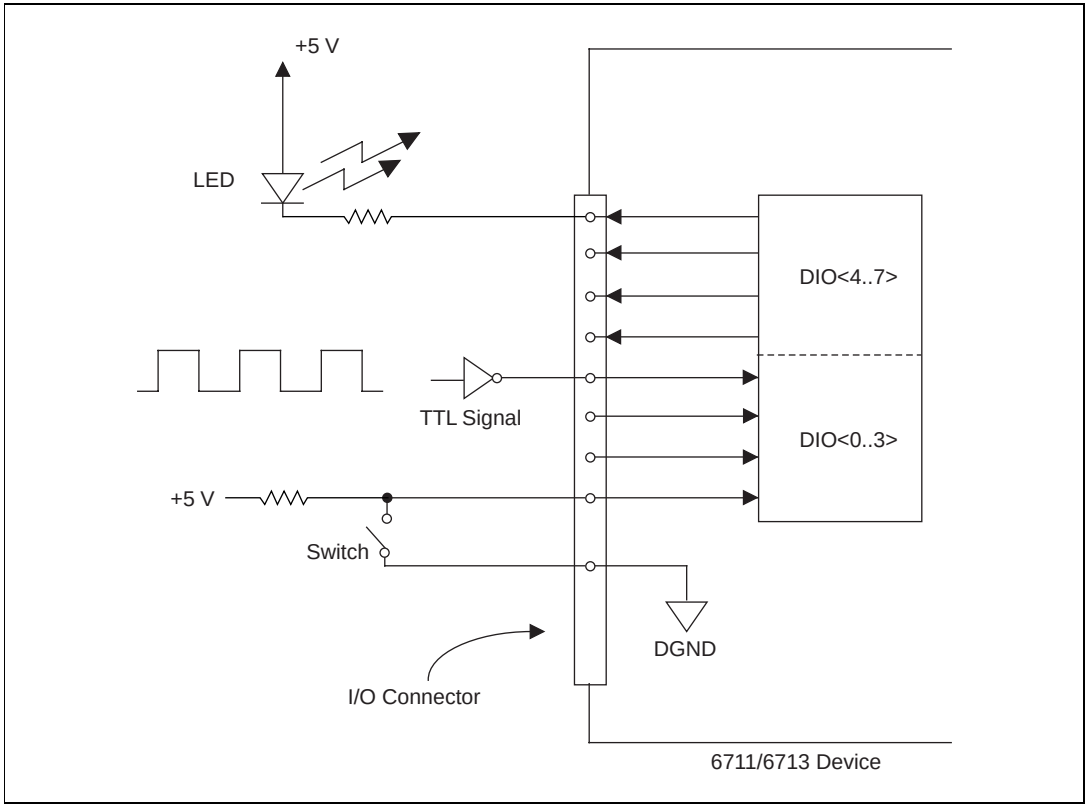


Figure 4-3. Digital I/O Connections

Figure 4-3 shows DIO<0..3> configured for digital input and DIO<4..7> configured for digital output. Digital input applications include receiving TTL signals and sensing external device states such as the switch state shown in Figure 4-3. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 4-3.

The hardware up/down control for general-purpose counters 0 and 1 are connected onboard to DIO6 and DIO7, respectively. Thus, you can use DIO6 and DIO7 to control the general-purpose counters. The up/down control signals are input only and do not affect the operation of the DIO lines.

Power Connections

Two pins on the I/O connector supply +5 V from the computer power supply via a self-resetting fuse. The fuse will reset automatically within a few seconds after the overcurrent condition is removed. These pins are referenced to DGND and can be used to power external digital circuitry.

- Power rating +4.65 to +5.25 VDC at 1 A

Caution ***Under no circumstances should you connect these +5 V power pins directly to analog or digital ground or to any other voltage source on the 6711/6713 device or any other device. Doing so can damage the 6711/6713 device and the computer. National Instruments is not liable for damages resulting from such a connection.***

Timing Connections

Caution ***Exceeding the maximum input voltage ratings, which are listed in Table 4-2, can damage the 6711/6713 device and the computer. National Instruments is NOT liable for any damages resulting from such signal connections.***

All external control over the timing of the 6711/6713 device is routed through the 10 programmable function inputs labeled PFI0 through PFI9. These signals are explained in detail in the next section, *Programmable Function Input Connections*. These PFIs are bidirectional; as outputs they are not programmable and reflect the state of many DAQ, waveform generation, and general-purpose timing signals. On 6711/6713 device, six PFIs are bidirectional and four PFIs are input only (PFI0, PFI1, PFI2, PFI7). There are four other dedicated outputs for the remainder of the timing signals (on the 6711/6713 SCANCLK is not used). As inputs, the PFI signals are programmable and can control any DAQ, waveform generation, and general-purpose timing signals.

The waveform generation signals are explained in the *Waveform Generation Timing Connections* section later in this chapter. The general-purpose timing signals are explained in the *General-Purpose Timing Signal Connections* section later in this chapter.

All digital timing connections are referenced to DGND. This reference is demonstrated in Figure 4-4, which shows how to connect an external PFI0 source and an external PFI2 source to two 6711/6713 device PFI pins.

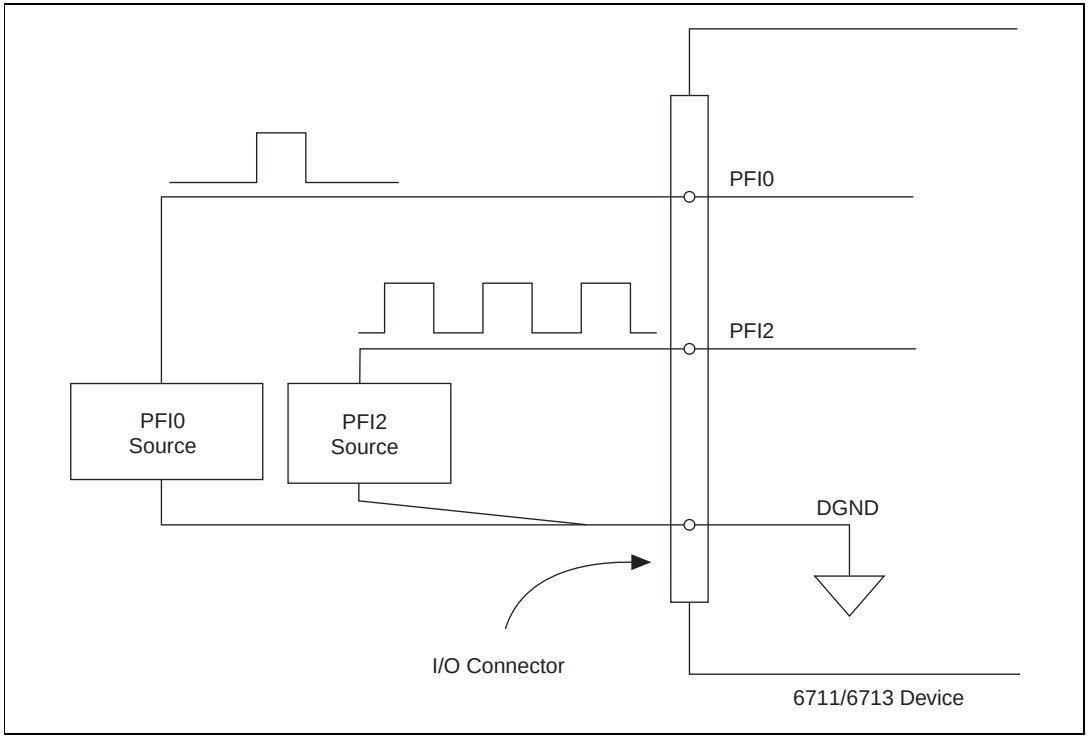


Figure 4-4. Timing I/O Connections

Programmable Function Input Connections

There are a total of seven internal timing signals that you can externally control from the PFI pins. The source for each of these signals is software-selectable from any of the PFIs when you want external control. This flexible routing scheme reduces the need to change the physical wiring to the device I/O connector for different applications requiring alternative wiring.

You can individually enable six of the PFI pins to output a specific internal timing signal. For example, if you need the UPDATE* signal as an output on the I/O connector, software can turn on the output driver for the PFI5/UPDATE* pin. Be careful not to drive a PFI signal externally when it is configured as an output.

As an input, you can individually configure each PFI for edge or level detection and for polarity selection, as well. You can use the polarity selection for any of the seven timing signals, but the edge or level detection will depend upon the particular timing signal being controlled. The detection requirements for each timing signal are listed within the section that discusses that individual signal.

In edge-detection mode, the minimum pulse width required is 10 ns. This applies for both rising-edge and falling-edge polarity settings. There is no maximum pulse-width requirement in edge-detect mode.

In level-detection mode, there are no minimum or maximum pulse-width requirements imposed by the PFIs themselves, but there may be limits imposed by the particular timing signal being controlled. These requirements are listed later in this chapter.

EXTSTROBE* Signal

EXTSTROBE* is an output-only signal that is used for controlling SCXI devices.

Waveform Generation Timing Connections

The analog group defined for the 6711/6713 device is controlled by WFTRIG, UPDATE*, and UISOURCE.

WFTRIG Signal

Any PFI pin can externally input the WFTRIG signal, which is available as an output on the PFI6/WFTRIG pin.

As an input, the WFTRIG signal is configured in the edge-detection mode. You can select any PFI pin as the source for WFTRIG and configure the polarity selection for either rising or falling edge. The selected edge of the WFTRIG signal starts the waveform generation for the DACs. The update interval (UI) counter is started if you select internally generated UPDATE*.

As an output, the WFTRIG signal reflects the trigger that initiates waveform generation. This is true even if the waveform generation is being externally triggered by another PFI. The output is an active high pulse with a pulse width of 25 to 50 ns. This output is set to tri-state at startup.

Figures 4-5 and 4-6 show the input and output timing requirements for the WFTRIG signal.

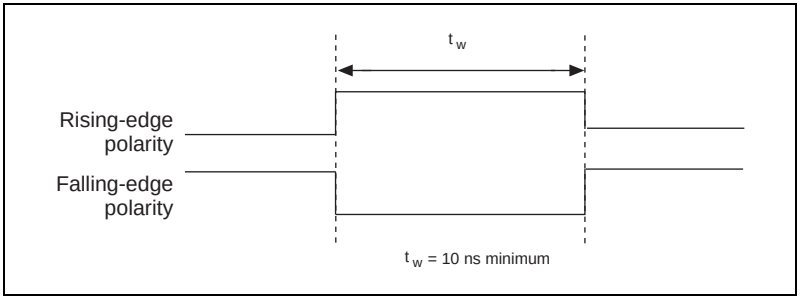


Figure 4-5. WFTRIG Input Signal Timing

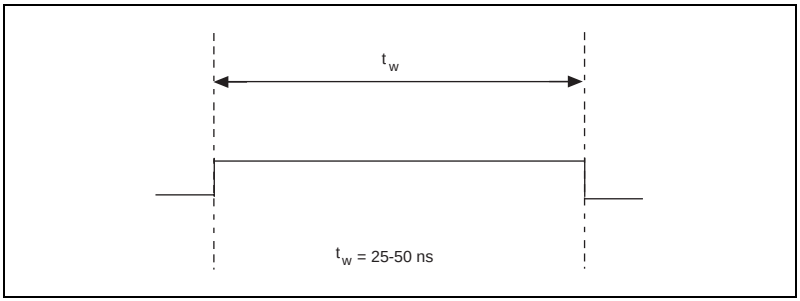


Figure 4-6. WFTRIG Output Signal Timing

UPDATE* Signal

Any PFI pin can externally input the UPDATE* signal, which is available as an output on the PFI5/UPDATE* pin.

As an input, the UPDATE* signal is configured in the edge-detection mode. You can select any PFI pin as the source for UPDATE* and configure the polarity selection for either rising or falling edge. The selected edge of the UPDATE* signal updates the outputs of the DACs. In order to use UPDATE*, you must set the DACs to posted-update mode.

As an output, the UPDATE* signal reflects the actual update pulse that is connected to the DACs. This is true even if the updates are being externally generated by another PFI. The output is an active low pulse with a pulse width of 50 to 75 ns. This output is set to tri-state at startup.

Figures 4-7 and 4-8 show the input and output timing requirements for the UPDATE* signal.

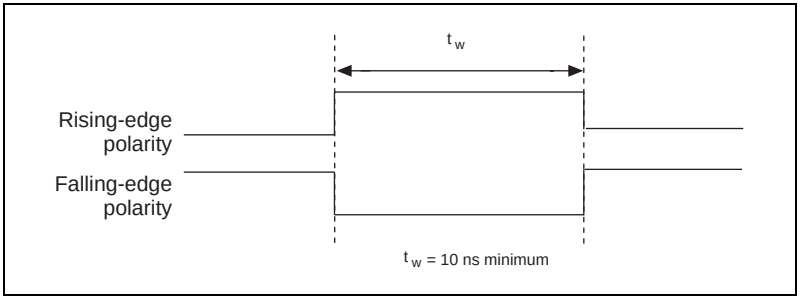


Figure 4-7. UPDATE* Input Signal Timing

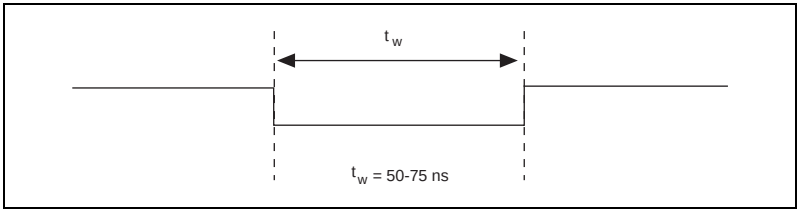


Figure 4-8. UPDATE* Output Signal Timing

The DACs are updated within 100 ns of the leading edge. Separate the UPDATE* pulses with enough time that new data can be written to the DAC latches.

The UI counter for the 6711/6713 device normally generates the UPDATE* signal unless you select some external source. The UI counter is started by the WFTRIG signal and can be stopped by software or the internal Buffer Counter.

D/A conversions generated by either an internal or external UPDATE* signal do not occur when gated by the software command register gate.

UISOURCE Signal

Any PFI pin can externally input the UISOURCE signal, which is not available as an output on the I/O connector. The UI counter uses the UISOURCE signal as a clock to time the generation of the UPDATE* signal. You must configure the PFI pin you select as the source for the UISOURCE signal in the level-detection mode. You can configure the

polarity selection for the PFI pin for either active high or active low. Figure 4-9 shows the timing requirements for the UISOURCE signal.

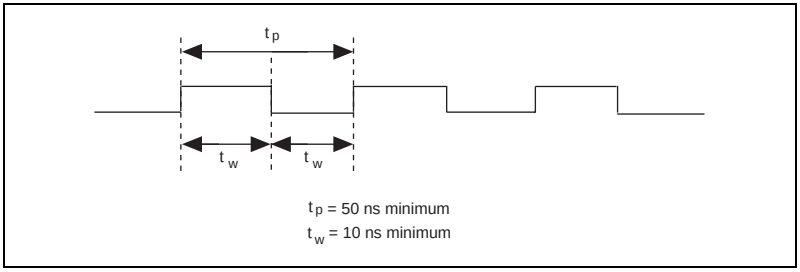


Figure 4-9. UISOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 10 ns high or low. There is no minimum frequency limitation.

Either the 20 MHz or 100 kHz internal timebase normally generates the UISOURCE signal unless you select some external source.

General-Purpose Timing Signal Connections

The general-purpose timing signals are GPCTR0_SOURCE, GPCTR0_GATE, GPCTR0_OUT, GPCTR0_UP_DOWN, GPCTR1_SOURCE, GPCTR1_GATE, GPCTR1_OUT, GPCTR1_UP_DOWN, and FREQ_OUT.

GPCTR0_SOURCE Signal

Any PFI pin can externally input the GPCTR0_SOURCE signal, which is available as an output on the PFI8/GPCTR0_SOURCE pin.

As an input, the GPCTR0_SOURCE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, the GPCTR0_SOURCE signal reflects the actual clock connected to general-purpose counter 0. This is true even if another PFI is externally inputting the source clock. This output is set to tri-state at startup.

Figure 4-10 shows the timing requirements for the GPCTR0_SOURCE signal.

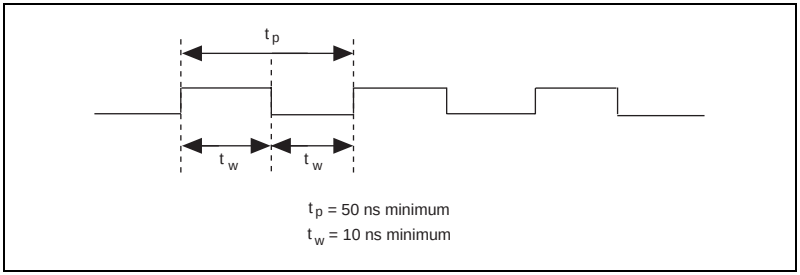


Figure 4-10. GPCTR0_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 10 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates the GPCTR0_SOURCE signal unless you select some external source.

GPCTR0_GATE Signal

Any PFI pin can externally input the GPCTR0_GATE signal, which is available as an output on the PFI9/GPCTR0_GATE pin.

As an input, the GPCTR0_GATE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform actions such as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, the GPCTR0_GATE signal reflects the actual gate signal connected to general-purpose counter 0. This is true even if the gate is being externally generated by another PFI. This output is set to tri-state at startup.

Figure 4-11 shows the timing requirements for the GPCTR0_GATE signal.

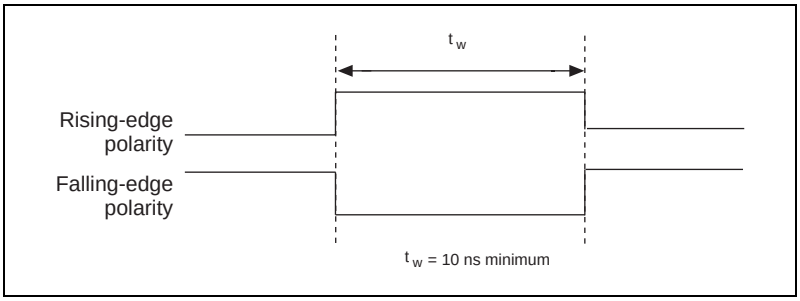


Figure 4-11. GPCTR0_GATE Signal Timing in Edge-Detection Mode

GPCTR0_OUT Signal

This signal is available only as an output on the GPCTR0_OUT pin. The GPCTR0_OUT signal reflects the terminal count (TC) of general-purpose counter 0. You have two software-selectable output options—pulse on TC and toggle output polarity on TC. The output polarity is software selectable for both options. This output is set to tri-state at startup. Figure 4-12 shows the timing of the GPCTR0_OUT signal.

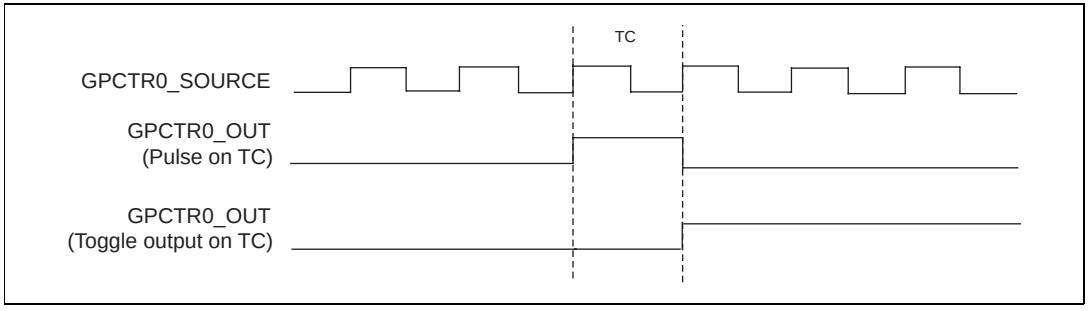


Figure 4-12. GPCTR0_OUT Signal Timing

GPCTR0_UP_DOWN Signal

This signal can be externally input on the DIO6 pin and is not available as an output on the I/O connector. The general-purpose counter 0 will count down when this pin is at a logic low and count up when it is at a logic high. You can disable this input so that software can control the up-down functionality and leave the DIO6 pin free for general use.

GPCTR1_SOURCE Signal

Any PFI pin can externally input the GPCTR1_SOURCE signal, which is available as an output on the PFI3/GPCTR1_SOURCE pin.

As an input, the GPCTR1_SOURCE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR1_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, the GPCTR1_SOURCE monitors the actual clock connected to general-purpose counter 1. This is true even if the source clock is being externally generated by another PFI. This output is set to tri-state at startup.

Figure 4-13 shows the timing requirements for the GPCTR1_SOURCE signal.

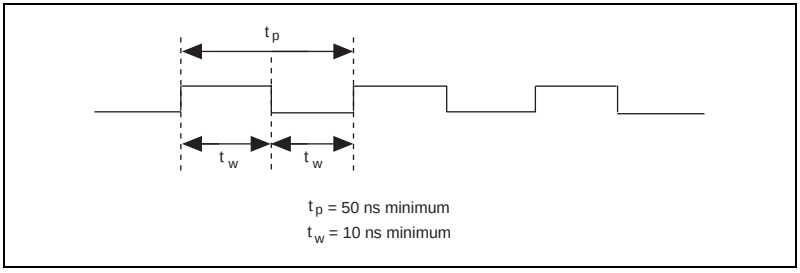


Figure 4-13. GPCTR1_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 10 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates the GPCTR1_SOURCE unless you select some external source.

GPCTR1_GATE Signal

Any PFI pin can externally input the GPCTR1_GATE signal, which is available as an output on the PFI4/GPCTR1_GATE pin.

As an input, the GPCTR1_GATE signal is configured in edge-detection mode. You can select any PFI pin as the source for GPCTR1_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform such actions as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, the GPCTR1_GATE signal monitors the actual gate signal connected to general-purpose counter 1. This is true even if the gate is being externally generated by another PFI. This output is set to tri-state at startup.

Figure 4-14 shows the timing requirements for the GPCTR1_GATE signal.

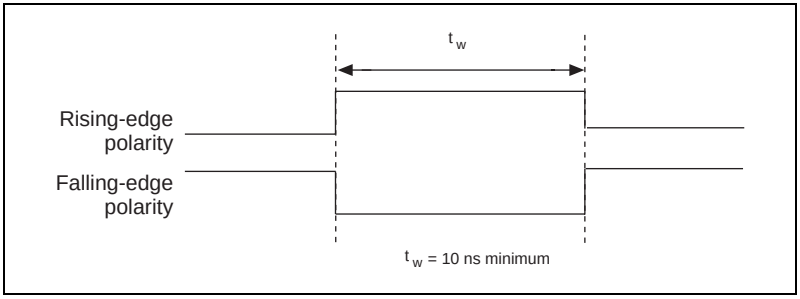


Figure 4-14. GPCTR1_GATE Signal Timing in Edge-Detection Mode

GPCTR1_OUT Signal

This signal is available only as an output on the GPCTR1_OUT pin. The GPCTR1_OUT signal monitors the TC device general-purpose counter 1. You have two software-selectable output options—pulse on TC and toggle output polarity on TC. The output polarity is software selectable for both options. This output is set to tri-state at startup. Figure 4-15 shows the timing requirements for the GPCTR1_OUT signal.

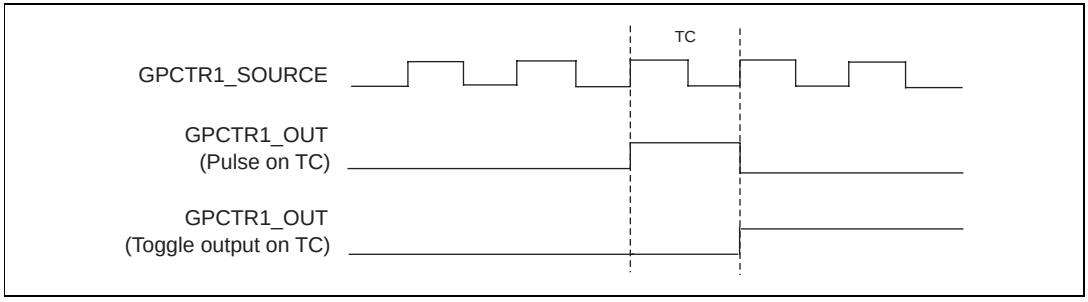


Figure 4-15. GPCTR1_OUT Signal Timing

GPCTR1_UP_DOWN Signal

This signal can be externally input on the DIO7 pin and is not available as an output on the I/O connector. General-purpose counter 1 counts down when this pin is at a logic low and counts up at a logic high. This input can be disabled so that software can control the up-down functionality and leave the DIO7 pin free for general use. Figure 4-16 shows the timing requirements for the GATE and SOURCE input signals and the timing specifications for the 6711/6713 device OUT output signals.

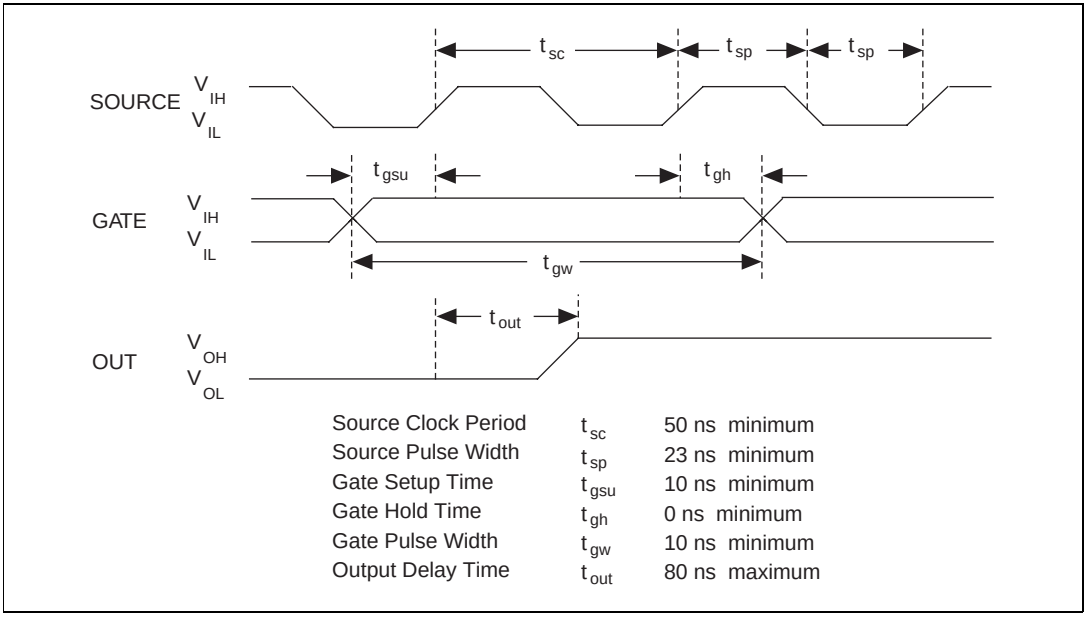


Figure 4-16. GPCTR Timing Summary

The GATE and OUT signal transitions shown in Figure 4-16 are referenced to the rising edge of the SOURCE signal. This timing diagram assumes that the counters are programmed to count rising edges. The same timing diagram, but with the source signal inverted and referenced to the falling edge of the source signal, would apply when the counter is programmed to count falling edges.

The GATE input timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated signals on the 6711/6713 device. Figure 4-16 shows the GATE signal referenced to the rising edge of a source signal. The gate must be valid (either high or low) for at least 10 ns before the rising or falling edge of a source signal for the gate to take effect at that source edge, as shown by t_{gsu} and t_{gh} in

Figure 4-16. The gate signal is not required to be held after the active edge of the source signal.

If you use an internal timebase clock, the gate signal cannot be synchronized with the clock. In this case, gates applied close to a source edge take effect either on that source edge or on the next one. This arrangement results in an uncertainty of one source clock period with respect to unsynchronized gating sources.

The OUT output timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated clock signals on the 6711/6713 device. Figure 4-16 shows the OUT signal referenced to the rising edge of a source signal. Any OUT signal state changes occur within 80 ns after the rising or falling edge of the source signal.

FREQ_OUT Signal

This signal is available only as an output on the FREQ_OUT pin. The frequency generator for the 6711/6713 device outputs the FREQ_OUT pin. The frequency generator is a 4-bit counter that can divide its input clock by the numbers 1 through 16. The input clock of the frequency generator is software-selectable from the internal 10 MHz and 100 kHz timebases. The output polarity is software selectable. This output is set to tri-state at startup.

Field Wiring Considerations

The following recommendations apply for all signal connections to the 6711/6713 device:

- Separate the 6711/6713 device signal lines from high-current or high-voltage lines. These lines can induce currents in or voltages on the 6711/6713 device signal lines if they run in parallel paths at a close distance. To reduce the magnetic coupling between lines, separate them by a reasonable distance if they run in parallel, or run the lines at right angles to each other.
- Do not run signal lines through conduits that also contain power lines.
- Protect signal lines from magnetic fields caused by electric motors, welding equipment, breakers, or transformers by running them through special metal conduits.

For more information, refer to the application note, *Field Wiring and Noise Consideration for Analog Signals*, available from National Instruments.

5

Calibration

This chapter discusses the calibration procedures for your PCI/PXI-6711/6713 device. If you are using the NI-DAQ device driver, that software includes calibration functions for performing all of the steps in the calibration process.

Calibration refers to the process of minimizing measurement and output voltage errors by making small circuit adjustments. On the 6711/6713 device, these adjustments take the form of writing values to onboard calibration DACs (CalDACs).

Some form of device calibration is required for all but the most forgiving applications. If you do not calibrate your device, your signals and measurements could have very large offset, gain, and linearity errors.

Three levels of calibration are available to you and described in this chapter. The first level is the fastest, easiest, and least accurate; whereas, the last level is the slowest, most difficult, and most accurate.

Loading Calibration Constants

The 6711/6713 device is factory calibrated before shipment at approximately 25° C to the levels indicated in Appendix A, *Specifications*. The associated calibration constants—the values that were written to the CalDACs to achieve calibration in the factory—are stored in the onboard nonvolatile memory (EEPROM). Because the CalDACs have no memory capability, they do not retain calibration information when the device is unpowered. Loading calibration constants refers to the process of loading the CalDACs with the values stored in the EEPROM. NI-DAQ software determines when this is necessary and does it automatically. If you are not using NI-DAQ, you must load these values yourself.

In the EEPROM there is a user-modifiable calibration area in addition to the permanent factory calibration area. This means that you can load the CalDACs with values either from the original factory calibration or from a calibration that you subsequently performed.

The loading factory calibration constants method of calibration is not very accurate because it does not take into account the fact that the device measurement and output voltage errors can vary with time and temperature. It is better to self-calibrate when the device is installed in the environment in which it will be used.

Self-Calibration

The 6711/6713 device can measure and correct for almost all of its calibration-related errors without any external signal connections. Your National Instruments software provides a self-calibration method. This self-calibration process, which generally takes less than two minutes, is the preferred method of assuring accuracy in your application. Initiate self-calibration to minimize the effects of any offset, gain, and linearity drifts, particularly those due to warmup.

Immediately after self-calibration, the only significant residual calibration error could be gain error due to time or temperature drift of the onboard voltage reference. This error is addressed by external calibration, which is discussed in the following section. If you are interested primarily in relative measurements and you can ignore a small[1] amount of gain error self-calibration should be sufficient.

External Calibration

The 6711/6713 device has an onboard calibration reference to ensure the accuracy of self-calibration. Its specifications are listed in Appendix A, *Specifications*. The reference voltage is measured at the factory and stored in the EEPROM for subsequent self-calibrations. This voltage is stable enough for most applications, but if you are using your device at an extreme temperature or if the onboard reference has not been measured for a year or more, you may wish to externally calibrate your device.

An external calibration refers to calibrating your device with a known external reference rather than relying on the onboard reference. Redetermining the value of the onboard reference is part of this process and the results can be saved in the EEPROM, so you should not have to perform an external calibration very often. You can externally calibrate your device by calling the NI-DAQ calibration function.

[1] The onboard voltage reference has a temperature coefficient of 5 ppm/° C max (25 µV/° C). Therefore if the temperature difference between the factory calibration and the service environment is less than 10° C, the maximum gain error is less than 50 ppm, 0.005 percent at full scale output, after performing self-calibration.

To externally calibrate your device, be sure to use a very accurate external reference. The reference should be several times more accurate than the device itself. For example, to calibrate a 12-bit device, the external reference should be at least ±0.0062% (±62 ppm) accurate.

Note ***National Instruments recommends using a +5 V external reference voltage when performing calibration.***

Other Considerations

The CalDACs adjust the gain error of each analog output channel by adjusting the value of the reference voltage supplied to that channel. This calibration mechanism is designed to work only with the internal 10 V reference. Thus, in general, it is not possible to calibrate the analog output gain error when using an external reference. In this case, it is advisable to account for the nominal gain error of the analog output channel either in software or with external hardware. See Appendix A, *Specifications*, for analog output gain error information.

A

Specifications

This appendix lists the specifications of your 6711/6713 device. These specifications are typical at 25° C unless otherwise noted.

6711/6713 Device

Analog Output

Output Characteristics

Number of channels ..... 8 voltage outputs (6713 devices)
4 voltage outputs (6711 devices)

Resolution ..... 12 bits, 1 in 4,096

Max update rate

Number of Channels	Max Update Rate	
	Using Local FIFO (kS/s)[1]	Using Host PC Memory (kS/s)[2]
1 through 5	1000	1000
6	952	1000
7	833	869
8	740	769

[1] These numbers apply to continuous waveform generation, which allows for the time it takes to reset the FIFO to the beginning when cycling through it. This additional time, about 200 ns, is not incurred when using host PC memory for waveform generation. Max update rate in FIFO mode will not change irrespective of the number of devices in the system.

[2] These number were measured using one PCI-6711/6713 device with a 90 MHz Pentium machine. These numbers may change when using more devices or when other CPU or bus activity is taking place.

Type of DAC .....Double buffered, multiplying

FIFO buffer size

6713 .....16,384 samples

6711 .....8,192 samples

Data transfers .....DMA, interrupts, programmed I/O

DMA modes .....Scatter gather

Accuracy Information

Nominal Range (V)		Absolute Accuracy				
		% of Reading			Offset	Temp Drift
Positive FS	Negative FS	24 Hours	90 Days	1 Year	(mV)	(%/° C)
10	–10	0.0177%	0.0197%	0.0219%	±5.933	0.0005%

Absolute accuracy = (% of Reading × Voltage) + Offset + (Temp Drift × Voltage)
Note: Temp drift applies only if ambient is greater than ±10° C of previous external calibration.

Transfer Characteristics

Relative accuracy (INL)

After calibration.....±0.3 LSB typ, ±0.5 LSB max

Before calibration .....±4 LSB max

DNL

After calibration.....±0.3 LSB typ, ±1.0 LSB max

Before calibration .....±3 LSB max

Monotonicity .....12 bits guaranteed after calibration

Offset error

After calibration.....±1.0 mV typ, ±5.9 mV max

Before calibration .....±200 mV max

Gain error (relative to internal reference)

After calibration ..... ±0.01% of output max

Before calibration ..... ±0.5% of output max

Gain error
(relative to external reference) ..... +0% to +0.5% of output max, not adjustable

Voltage Output

Ranges ..... ±10 V, ± EXTREF

Output coupling ..... DC

Output impedance ..... 0.1 Ω max

Current drive ..... ±5 mA max

Output stability ..... Any passive load, up to 1500 pF

Protection ..... Short-circuit to ground

Power-on state ..... 0 V

External Reference Input

Range ..... ±11 V

Overvoltage protection ..... ±25 V powered on,
±15 V powered off

Input impedance ..... 10 kΩ

Bandwidth (-3 dB) ..... 1 MHz

Dynamic Characteristics

Slew rate ..... 20 V/µs

Noise ..... 200 μV_{rms}, DC to 1 MHz

Channel crosstalk.....– 70 dB with SH6868EP cable (generating a 10 V, 10 pt sinusoidal at 100 KHz on the reference channel)

Total harmonic distortion .....– 60 dB typ (generating a 10 V, 100 points, 10 kHz sinewave, summing 9 harmonics)

Stability

Offset temperature coefficient.....±50 µV/° C

Gain temperature coefficient

Internal reference.....±25 ppm/° C

External reference.....±25 ppm/° C

Onboard calibration reference

Level.....5.000 V (±2.5 mV) (actual value stored in EEPROM)

Temperature coefficient.....±5.0 ppm/° C max

Long-term stability .....±15 ppm/$\sqrt{1,000\ \text{h}}$

Digital I/O

Number of channels.....8 input/output

Compatibility .....TTL/CMOS

Digital logic levels

Level	Min	Max
Input low voltage	0.0 V	0.8 V
Input high voltage	2.0 V	5.0 V
Input low current (V_{in} = 0 V)	—	–320 µA
Input high current (V_{in} = 5 V)	—	10 µA
Output low voltage (I_{OL} = 24 mA)	—	0.4 V
Output high voltage (I_{OH} = 13 mA)	4.35 V	—

Power-on state ..... Input (High-Z)

Data transfers ..... Programmed I/O

Timing I/O

Number of channels ..... 2 up/down counter/timers, 1 frequency scaler

Resolution

- Counter/timers ..... 24 bits
- Frequency scaler ..... 4 bits

Compatibility ..... TTL/CMOS

Base clocks available

- Counter/timers ..... 20 MHz, 100 kHz
- Frequency scaler ..... 10 MHz, 100 kHz

Base clock accuracy ..... ±0.01% over operating temperature

Max source frequency ..... 20 MHz

Min source pulse duration ..... 10 ns, edge-detect mode

Min gate pulse duration ..... 10 ns, edge-detect mode

Data transfers ..... DMA, interrupts, programmed I/O

DMA modes ..... Scatter-gather

Triggers

Digital Trigger

Compatibility ..... TTL

Response ..... Rising or falling edge

Pulse width ..... 10 ns min

RTSI and PXI Trigger Lines

- PCI-6711/6713

  Trigger lines <0..6> 7

  RTSI clock.....1

- PXI-6711/6713

  Trigger lines <0..5> 6

  Star trigger 1

  Clock.....1

Bus Interface

- PCI-6711/6713

  Type .....5 V PCI master, slave

- PXI-6711/6713

  Type .....PXI/CompactPCI master, slave

Power Requirement

PCI/PXI-6711

+5 VDC (±5% .....0.80 A typ, 1.0 A max

Power available at I/O connector ....+4.65 to +5.25 VDC at 1 A

PCI/PXI-6713

+5 VDC (±5%) .....1.25 A typ, 1.5 A max

Power available at I/O connector ....+4.65 to +5.25 VDC at 1 A

Physical

Dimensions (not including connectors)

PCI-6711/6713..... 17.5 by 10.7 cm (6.87 by 4.2 in.)

PXI-6711/6713..... 16 by 10 cm (6.3 by 3.9 in.)

I/O connector

PCI/PXI-6711/6713 ..... 68-pin male SCSI-II type

Environment

Operating temperature..... 0° to 50° C

Storage temperature ..... –55° to 150° C

Relative humidity..... 5% to 90% noncondensing

B

Common Questions

This appendix contains a list of commonly asked questions and their answers relating to usage and special features of your 6711/6713 device.

General Information

What is the 6711/6713 device?

The 6711/6713 device is a switchless and jumperless analog output device that uses the DAQ-STC for timing.

What is the DAQ-STC?

The DAQ-STC is the system timing control application-specific integrated circuit (ASIC) designed by National Instruments and is the backbone of the 6711/6713 device. The DAQ-STC contains seven 24-bit counters and three 16-bit counters. The counters are divided into the following three groups:

- Analog input—two 24-bit, two 16-bit counters (not used on 6711/6713)
- Analog output—three 24-bit, one 16-bit counters
- General-purpose counter/timer functions—two 24-bit counters

The groups can be configured independently with timing resolutions of 50 ns or 10 µs. With the DAQ-STC, you can interconnect a wide variety of internal timing signals to other internal blocks. The interconnection scheme is quite flexible and completely software configurable. New capabilities such as buffered pulse generation, and seamlessly changing the sampling rate are possible.

What does update rate mean to me?

It means that this is the fastest you can output data from your device and still achieve accurate results. The 6711/6713 device has a update rate of 1 MS/s at up to 4 channels.

What type of 5 V protection does the 6711/6713 device have?

The 6711/6713 device has 5 V lines equipped with a self-resetting 1 A fuse.

Installation and Configuration

How do you set the base address for the 6711/6713 device?

The base address of the 6711/6713 device is assigned automatically through the bus protocol. This assignment is completely transparent to you.

What jumpers should I be aware of when configuring my 6711/6713 device?

The 6711/6713 device is jumperless and switchless.

Which National Instruments document should I read first to get started using DAQ software?

Your NI-DAQ or application software release notes documentation is always the best starting place.

Analog Output

I'm using the DACs to generate a waveform, but I discovered with a digital oscilloscope that there are glitches on the output signal. Is this normal?

When it switches from one voltage to another, any DAC produces glitches due to released charges. The largest glitches occur when the most significant bit (MSB) of the D/A code switches. You can use a lowpass deglitching filter to remove some of these glitches, depending on the frequency and nature of your output signal. In addition, if you are using this output as a source to a system that has low bandwidth characteristics, the glitches are ignored by the system.

Timing and Digital I/O

What types of triggering can be hardware-implemented on my 6711/6713 device?

Hardware digital triggering is supported on the 6711/6713 device.

What functionality does the DAQ-STC make possible?

The DAQ-STC has the complexity of more than 24 chips. The DAQ-STC makes possible PFI lines, selectable logic level, and frequency shift keying. The DAQ-STC also makes buffered operations possible, such as direct up/down control, single pulse or pulse train generation, equivalent time sampling, buffered period, and buffered semiperiod measurement.

I'm using one of the general-purpose counter/timers on my 6711/6713 device, but I do not see the counter/timer output on the I/O connector. What am I doing wrong?

If you are using the NI-DAQ language interface or LabWindows/CVI, you must configure the output line to output the signal to the I/O connector. Use the `Select_Signal` call in NI-DAQ to configure the output line. By default, all timing I/O lines except EXTSTROBE* are tri-stated.

What are the PFIs and how do I configure these lines?

PFIs are Programmable Function Inputs. These lines serve as connections to virtually all internal timing signals.

If you are using the NI-DAQ language interface or LabWindows/CVI, use the `Select_Signal` function to route internal signals to the I/O connector, route external signals to internal timing sources, or tie internal timing signals together.

If you are using NI-DAQ with LabVIEW and you want to connect external signal sources to the PFI lines, you can use AO Clock Config, AO Trigger and Gate Config, CTR Mode Config, and CTR Pulse Config advanced level VIs to indicate which function the connected signal will serve. Use the Route Signal VI to enable the PFI lines to output internal signals.

Caution ***If you enable a PFI line for output, do not connect any external signal source to it; if you do, you can damage the device, the computer, and the connected equipment.***

What are the power-on states of the PFI and DIO lines on the I/O connector?

At system power-on and reset, both the PFI and DIO lines are set to high impedance by the hardware. This means that the device circuitry is not actively driving the output either high or low. However, these lines may have pull-up or pull-down resistors connected to them as shown in Table 4-2. These resistors weakly pull the output to either a logic high or logic low state. For example, DIO(0) will be in the high impedance state after power on, and Table 4-2 shows that there is a 50 kΩ pull-up resistor. This pull-up resistor will set the DIO(0) pin to a logic high when the output is in a high impedance state.

C

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

United States: 512 794 5422
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 01 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as `anonymous` and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.

Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

E-Mail Support (Currently USA Only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

`support@natinst.com`

Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

Country	Telephone	Fax
Australia	03 9879 5166	03 9879 6277
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Brazil	011 288 3336	011 288 8528
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Québec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 6120092	03 6120095
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
United Kingdom	01635 523545	01635 523154
United States	512 795 8248	512 794 5678

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

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Mouse ___yes ___no Other adapters installed_____

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Configuration _____

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Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem: _____

_____

_____

_____

_____

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Part Number: 322080A-01

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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}
t-	tera-	10^{12}

Numbers/Symbols

°	degrees
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
/	per
%	percent
±	plus or minus
+	positive of, or plus
–	negative of, or minus
Ω	ohms

$\sqrt{}$	square root of
+5 V	+5 VDC source signal

A

A	amperes
AC	alternating current
A/D	analog-to-digital
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
ANSI	American National Standards Institute
AO	analog output
AOGND	analog output ground signal
ASIC	Application-Specific Integrated Circuit—a proprietary semiconductor component designed and manufactured to perform a set of specific functions.

B

bipolar	a signal range that includes both positive and negative values (for example, –5 V to +5 V)

C

C	Celsius
CalDAC	calibration DAC
CH	channel—pin or wire lead to which you apply or from which you read the analog or digital signal. Analog signals can be single-ended or differential. For digital signals, you group channels to form ports. Ports usually consist of either four or eight digital channels
cm	centimeter

CMOS	complementary metal-oxide semiconductor
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)
CONVERT*	convert signal
counter/timer	a circuit that counts external pulses or clock pulses (timing)
CTR	counter

D

D/A	digital-to-analog
DAC	digital-to-analog converter—an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current
DAQ	data acquisition—a system that uses the computer to collect, receive, and generate electrical signals
DAQ-STC	Data acquisition system timing controller. An application-specific integrated circuit (ASIC) for the system timing requirements of a general A/D and D/A system, such as a system containing the National Instruments E Series devices.
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
DGND	digital ground signal
DI	digital input
DIFF	differential mode
DIO	digital input/output
DIP	dual inline package
dithering	the addition of Gaussian noise to an analog input signal

DMA	direct memory access—a method by which data can be 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.
DNL	differential nonlinearity—a measure in least significant bit of the worst-case deviation of code widths from their ideal value of 1 LSB
DO	digital output

E

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

F

FIFO	first-in first-out memory buffer—FIFOs are often used on DAQ devices to temporarily store incoming or outgoing data until that data can be read or written. For example, an analog input FIFO stores the results of A/D conversions until the data can be read into system memory. Programming the DMA controller and servicing interrupts can take several milliseconds in some cases. During this time, data accumulates in the FIFO for future retrieval. With a larger FIFO, longer latencies can be tolerated. In the case of analog output, a FIFO permits faster update rates, because the waveform data can be stored in the FIFO ahead of time. This again reduces the effect of latencies associated with getting the data from system memory to the DAQ device.
FREQ_OUT	frequency output signal
ft	feet

G

GATE	gate signal
GPCTR	general-purpose counter signal

GPCTR0_GATE	general-purpose counter 0 gate signal
GPCTR0_OUT	general-purpose counter 0 output signal
GPCTR0_SOURCE	general-purpose counter 0 clock source signal
GPCTR0_UP_DOWN	general-purpose counter 0 up down signal
GPCTR1_GATE	general-purpose counter 1 gate signal
GPCTR1_OUT	general-purpose counter 1 output signal
GPCTR1_SOURCE	general-purpose counter 1 clock source signal
GPCTR1_UP_DOWN	general-purpose counter 1 up down signal

H

h	hour
hex	hexadecimal
Hz	hertz

I

INL	integral nonlinearity–For an ADC, deviation of codes of the actual transfer function from a straight line.
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
I_{OH}	current, output high
I_{OL}	current, output low

K

kHz	kilohertz

L

LED	light emitting diode
LSB	least significant bit

M

m	meter
MB	megabytes of memory
MHz	megahertz
MIO	multifunction I/O
MITE	MXI Interface to Everything
MSB	most significant bit
mux	multiplexer—a switching device with multiple inputs that sequentially connects each of its inputs to its output, typically at high speeds, in order to measure several signals with a single analog input channel
mV	millivolts

N

NC	normally closed, or not connected
NI-DAQ	National Instruments driver software for DAQ hardware
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, 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.
NRSE	nonreferenced single-ended mode—all measurements are made with respect to a common (NRSE) measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground

O

OUT	output pin—a counter output pin where the counter can generate various TTL pulse waveforms

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. It is achieving widespread acceptance as a standard for PCs and work-stations; it offers a theoretical maximum transfer rate of 132 MB/s.
PFI	Programmable Function Input
PFI3/GPCTR1_ SOURCE	PFI3/general purpose counter 1 source
PFI4/GPCTR1_GATE	PFI4/general-purpose counter 1 gate
PFI5/UPDATE*	PFI5/update
PFI6/WFTRIG	PFI6/waveform trigger
PFI8/GPCTR0_ SOURCE	PFI8/general-purpose counter 0 source
PFI9/GPCTR0_GATE	PFI9/general-purpose counter 0 gate
PGIA	Programmable Gain Instrumentation Amplifier
port	(1) a communications connection on a computer or a remote controller (2) a digital port, consisting of four or eight lines of digital input and/or output
ppm	parts per million
pu	pull-up

R

RAM	random access memory
rms	root mean square

RSE	referenced single-ended mode—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system
RTD	resistive temperature detector—a metallic probe that measures temperature based upon its coefficient of resistivity
RTSIbus	Real-Time System Integration bus—the National Instruments timing bus that connects DAQ devices directly, by means of connectors on top of the devices, for precise timing synchronization between multiple devices
RTSI_OSC	RTSI Oscillator—RTSI bus master clock

S

s	seconds
S	samples
SCANCLK	scan clock signal
SCXI	Signal Conditioning eXtensions for Instrumentation—the National Instruments product line for conditioning low-level signals within an external chassis near sensors so only high-level signals are sent to DAQ devices in the noisy computer environment
SE	single-ended—a term used to describe an analog input that is measured with respect to a common ground
settling time	the amount of time required for a voltage to reach its final value within specified limits
signal conditioning	the manipulation of signals to prepare them for digitizing
SISOURCE	SI counter clock signal
SOURCE	source signal
S/s	samples per second—used to express the rate at which a DAQ device 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

TC	terminal count—the ending value of a counter
t_{gh}	gate hold time
t_{gsu}	gate setup time
t_{gw}	gate pulse width
t_{out}	output delay time
THD	total harmonic distortion—the ratio of the total rms signal due to harmonic distortion to the overall rms signal, in decibel or a percentage
thermocouple	a temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.
TRIG	trigger signal
t_{sc}	source clock period
t_{sp}	source pulse width
TTL	transistor-transistor logic

U

UI	update interval
UISOURCE	update interval counter clock signal
unipolar	a signal range that is always positive (for example, 0 to +10 V)
UPDATE	update signal

V

V	volts
VDC	volts direct current

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_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
V_m	measured voltage
V_{OH}	volts, output high
V_{OL}	volts, output low
V_{ref}	reference voltage
V_{rms}	volts, root mean square

W

WFTRIG	waveform generation trigger signal

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