

User Manual

PCIE-1802

8-ch, 24-Bit, 216 kS/s Dynamic
Signal Acquisition PCI Express Card

ADVANTECH

Enabling an Intelligent Planet

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CE

This product has passed the CE test for environmental specifications when shielded cables are used for external wiring. We recommend the use of shielded cables. This kind of cable is available from Advantech. Please contact your local supplier for ordering information.

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1. Visit the Advantech web site at <http://support.advantech.com> where you can find the latest information about the product.
2. Contact your distributor, sales representative, or Advantech's customer service center for technical support if you need additional assistance. Please have the following information ready before you call:
 - Product name and serial number
 - Description of your peripheral attachments
 - Description of your software (operating system, version, application software, etc.)
 - A complete description of the problem
 - The exact wording of any error messages

Packing List

Before setting up the system, check that the items listed below are included and in good condition. If any item does not accord with the table, please contact your dealer immediately.

- PCIE-1802 DA&C card
- Startup or User Manual
- Companion DVD-ROM with DAQNav drivers included

Safety Precaution - Static Electricity

Follow these simple precautions to protect yourself from harm and the products from damage.

- To avoid electrical shock, always disconnect the power from your PC chassis before you work on it. Don't touch any components on the CPU card or other cards while the PC is on.
- Disconnect power before making any configuration changes. The sudden rush of power as you connect a jumper or install a card may damage sensitive electronic components.

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Chapter 1

Introduction

This chapter will provide information on the features of the PCIE-1802 cards, a quick installation guide, together with some brief information on software and accessories.

Sections include:

- Features
- Applications
- Installation Guide
- Software Overview
- Device Drivers Programming Roadmap
- Accessories

1.1 Introduction

The Advantech PCIE-1802 is a high-performance data acquisition module specifically designed for sound and vibration applications. With eight 24 bit analog inputs per module and IEPE constant current signal conditioning, Advantech's PCIE-1802 is ideal for making precision measurements with microphones, accelerometers, and other transducers that have very large dynamic ranges. The modules deliver 115 dB of dynamic range and simultaneous sampling on all 8 channels at rates up to 216 kS/s.

1.2 Features

The PCIE-1802 offers the following main features:

- 8 simultaneous analog input channels
- 24-bit resolution A/D converter
- 216 kS/s maximum sampling rate
- 115 dB dynamic range up to 6 gain settings for ranges from ± 200 mV to ± 10 V
- IEPE for accelerometers and microphones

Some of the features are described in detail on the following pages.

1.2.1 Auto Calibration

The PCIE-1802 card features software auto calibration. It provides a convenient method for user calibration processing.

1.2.2 BoardID Switch

The PCIE-1802 has a built-in DIP switch that helps define each card's ID when multiple PCIE-1802 cards have been installed on the same PC chassis. The BoardID setting function is very useful when building a system with multiple PCIE-1802 cards. With the correct BoardID settings, you can easily identify and access each card during hardware configuration and software programming.

Note! For detailed specifications of the PCIE-1802 card, refer to Appendix A, Specifications.



1.3 Applications

The following are some of the possible applications of PCIE-1802 cards:

- Noise, vibration, and harshness (NVH) detection
- Machine status monitoring
- Structural health monitoring

1.4 Installation Guide

Before you install your PCIE-1802 card, please make sure you have the following components:

- PCIE-1802 DA&C card
- PCIE-1802 Startup Manual
- Driver software
Advantech DAQNav SDK and drivers (included in the companion CD-ROM)
- Wiring cables
PCL-108BNC-0.5E (optional)
- PCL-10119-1E (optional)
- Wiring board
PCLD-8840 (optional)
- Personal computer or workstation with a PCI Express interface (running Windows8 (desktop mode), 7 and XP)

Some optional components are also available for enhanced operation: After you get the necessary components and maybe some of the accessories for enhanced operation of your Multifunction card, you can then begin the installation procedures. Figure 1.1 on the next page provides a concise flow chart for a broad picture of the software and hardware installation procedure:

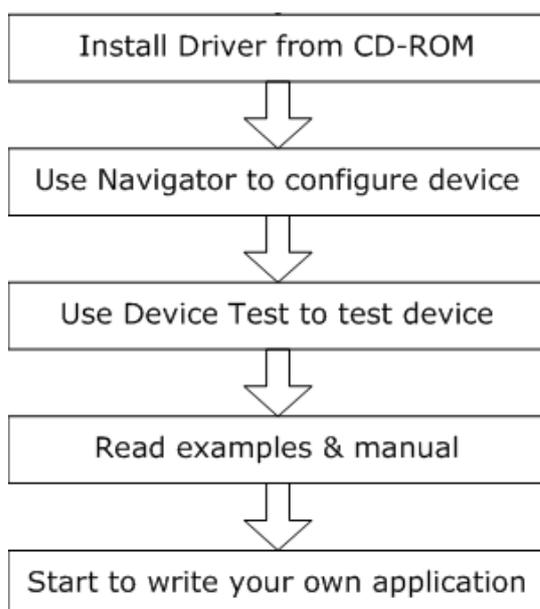


Figure 1.1 Installation Flow Chart

1.5 Software Overview

Advantech offers a rich set of APIs, third-party driver supports and application software to help fully utilize the functions of your PCIE-1802 cards:

- Device Drivers (on the companion DVD-ROM)
- DAQNav SDK

1.5.1 Device Drivers

Advantech Device Driver software is included on the companion CD-ROM. It also comes with all Advantech DA&C cards. Advantech's device drivers feature a complete I/O function library to help boost your application performance. The Advantech Device Drivers for Windows 2000, XP, Vista or Windows 7 works seamlessly with development tools such as Visual C++, Visual C#, Visual Basic.NET, Borland C++ Builder and Borland Delphi.

1.6 DAQNav Device Driver Programming Roadmap

This section will provide you with a roadmap to demonstrate how to build an application from scratch using Advantech DAQNav Device Driver with your favorite development tools such as Visual Studio.Net, Visual C++, Visual Basic, Delphi and C++ Builder. The step-by-step instructions on how to build your own applications using each development tool will be given in the Device Drivers Manual. Moreover, a rich set of example source code is also given for your reference.

1.6.1 Programming Tools

Programmers can develop application programs with their favorite development tools:

- Visual Studio.Net
- Visual C++ and Visual Basic
- Delphi
- C++ Builder

For instructions on how to begin programming works in each development tool, Advantech offers a Tutorial Chapter in the *DAQNav SDK Manual* for your reference.

Refer to the corresponding sections in this chapter on the *DAQNav SDK Manual* to begin your programming efforts. You can also look at the example source code provided for each programming tool, since they can get you very well oriented.

The *DAQNav SDK Manual* can be found on the companion DVD-ROM. Alternatively, if you have already installed the Device Drivers on your system, The *DAQNav SDK Manual* can be readily accessed through the Start button:

Start/Programs/Advantech Automation/DAQNav/DAQNav Manuals/DAQNav SDK Manual

The example source codes can be found under the corresponding installation folder such as the default installation path:

`C:\Advantech\DAQNav\Examples\`

For information about using other function groups or other development tools, please refer to the Using DAQNav SDK chapter in the *DAQNav SDK Manual*, or the video tutorials in the Advantech Navigator.

1.6.2 Programming with DAQNav Device Drivers Function Library

Advantech DAQNav Device Drivers offer a rich function library that can be utilized in various application programs. This function library consists of numerous APIs that support many development tools, such as Visual Studio.Net, Visual C++, Visual Basic, Delphi and C++ Builder.

According to their specific functions or services, APIs can be categorized into several function groups:

- Analog Input Function Group
- Digital Input/Output Function Group
- Event Function Group

For the usage and parameters of each function, please refer to the Using DAQNav SDK chapter in the *DAQNav SDK Manual*.

1.6.3 Troubleshooting Device Drivers Error

Driver functions will return a status code when they are called to perform a certain task for the application. When a function returns a code that is not zero, it means the function has failed to perform its designated function. See Device Driver Manual for detailed information about Error Code.

1.7 Accessories

Advantech offers a complete set of accessory products to support PCIE-1802 cards. These accessories include:

1.7.1 Wiring Cables

PCL-108BNC-0.5E

36-pin MINI SCSI to Eight BNC Cable, 0.5 m

PCL-10119-1E

HDMI Cable, 1 m

1.7.2 Wiring Boards

PCLD-8840-AE

20-pin DIN-rail HDMI Cable Wiring Board for PCIE-1802 and PCIE-1840.

Chapter 2

Installation

2.1 Unpacking

After receiving your PCIE-1802 package, inspect its contents first.

The package should contain the following items:

- PCIE-1802 card
- Companion CD-ROM (DLL driver included)
- Startup Manual

The PCIE-1802 cards harbors certain electronic components vulnerable to electrostatic discharge (ESD). ESD could easily damage the integrated circuits and certain components if preventive measures are not carefully paid attention to.

Before removing the card from the antistatic plastic bag, you should take following precautions to prevent ESD damage:

- Touch a metal part of your computer chassis with your hand to discharge static electricity accumulated on your body. Or use a grounding strap.
- Touch the anti-static bag to a metal part of your computer chassis before opening the bag.
- Hold the card only by the metal bracket when removing it from the bag.

After taking out the card, you should first inspect the card for any possible signs of external damage (loose or damaged components, etc.). If the card is visibly damaged, please notify our service department or the local sales representative immediately. Avoid installing a damaged card into your system. Also, pay extra caution to the following aspects to ensure proper installation:

- Avoid physical contact with materials that could hold static electricity such as plastic, vinyl and Styrofoam.
- Whenever you handle the card, grasp it only by its edges. DO NOT TOUCH the exposed metal pins of the connector or the electronic components.

Note! *Keep the anti-static bag for future use. You may need the original bag to store the card if you have to remove the card from the PC or transport it elsewhere.*



2.2 Driver Installation

We recommend you install the driver before you install the PCIE-1802 card into your system, since this will guarantee a smooth installation process.

The Advantech DAQNav Device Drivers Setup program for the PCIE-1802 card is included in the companion DVD-ROM that is shipped with your DA&C card package. Please follow the steps below to install the driver software:

1. Insert the companion DVD-ROM into your DVD-ROM drive.
2. The Setup program will be launched automatically if you have the auto play function enabled on your system. When the Setup Program is launched, you can follow the installation guide to correctly install the driver step by step.

2.2.1 Device Auto Installation (Recommended)

You can install the PCIE-1802 module in any PCI Express slot on your computer. Follow the steps below to install the module on your system.

1. Turn off your computer and unplug the power cord and cables. TURN OFF your computer before installing or removing any components on the computer.
2. Remove the cover of the computer.
3. Remove the slot cover on the back panel of your computer.
4. Touch the metal part on the surface of your computer to neutralize the static electricity that might be on your body.
5. Insert the PCIE-1802 card into a PCI Express slot. Hold the card only by its edges and carefully align it with the slot. Insert the card firmly into place. Use of excessive force must be avoided, otherwise the card might be damaged.
6. Fasten the bracket of the PCI card on the back panel rail of the computer with screws.
7. Plug in the power cord and turn on the computer.

2.3 Device Setup & Configuration

The *Advantech Navigator* program is a utility that allows you to set up, configure and test your device, and later stores your settings on the system registry. These settings will be used when you call the APIs of Advantech Device Drivers.

Setting Up the Device

1. To install the I/O device for your card, you must first run the Advantech Navigator program (by accessing Start/Programs/Advantech Automation/DAQNavi/Advantech Navigator).
2. You can then view the device(s) already installed on your system (if any) on the Installed Devices list box. If the software and hardware installation are completed, you will see PCIE-1802 card in the Installed Devices list.

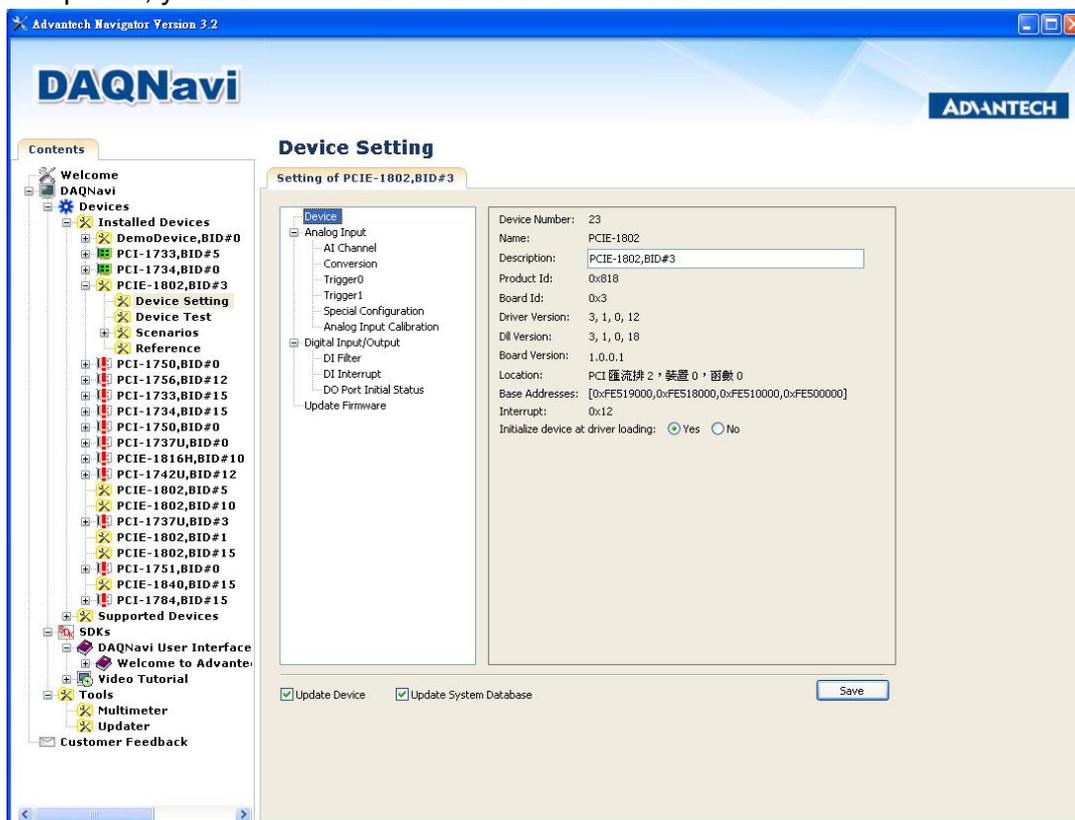


Figure 2.1 The Device Setting of PCIE-1802

Configuring the Device

Go to the Device Setting to configure your device. Here you can configure not only the Analog Input of PCIe-1802 but also Digital Input/Output.

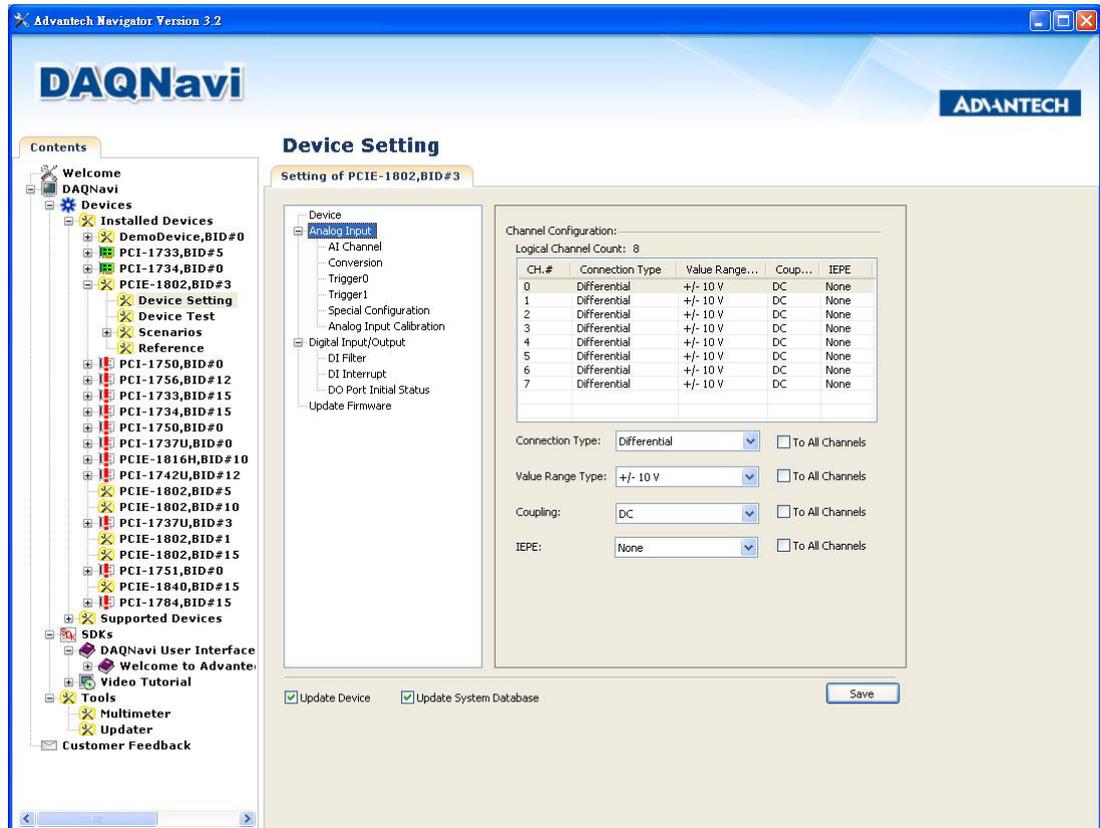


Figure 2.2 The Device Setting page

After your card is properly installed and configured, you can go to the Device Test page to test your hardware by using the testing utility supplied.

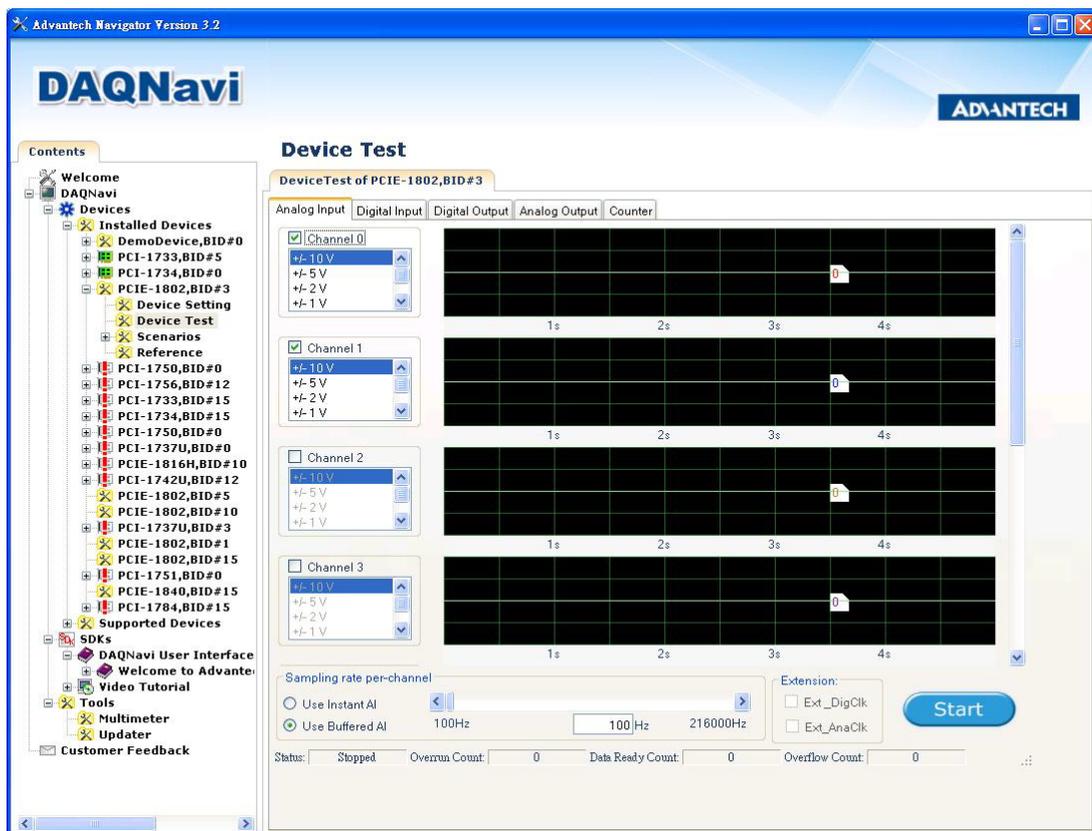


Figure 2.3 The Device Testing of PCI-E-1802

For more detailed information, refer to the DAQNav SDK Manual or the User Interface Manual in the Advantech Navigator.

Chapter 3

Signal Connections

This chapter provides useful information about how to connect input and output signals to the PCIE-1802 cards via the I/O connector.

Sections include:

- Overview
- Switch Settings
- Signal Connections
- Field Wiring Considerations

3.1 Overview

Maintaining signal connections is one of the most important factors in ensuring that your application system is sending and receiving data correctly. A good signal connection can avoid unnecessary and costly damage to your PC and other hardware devices. This chapter provides useful information about how to connect input and output signals to the PCIE-1802 cards via the I/O connector.

3.2 Jumper Settings

Setting the BoardID Switch (SW1)

The PCIE-1802 has a built-in DIP switch (SW1), which is used to define each card's board ID. You can determine the board ID on the register as shown in Table 2.1. When there are multiple cards on the same chassis, this board ID setting function is useful for identifying each card's device number through board ID. We set the PCIE-1802 board ID as 0 at the factory. If you need to adjust it to other board ID, set the SW1 by referring to DIP switch setting.

Table 3.1: Board ID Settings

SW1	3	2	1	0
BoardID	ID3	ID2	ID1	ID0
0*	ON	ON	ON	ON
1	ON	ON	ON	OFF
2	ON	ON	OFF	ON
3	ON	ON	OFF	OFF
4	ON	OFF	ON	ON
5	ON	OFF	ON	OFF
6	ON	OFF	OFF	ON
7	ON	OFF	OFF	OFF
8	OFF	ON	ON	ON
9	OFF	ON	ON	OFF
10	OFF	ON	OFF	ON
11	OFF	ON	OFF	OFF
12	OFF	OFF	ON	ON
13	OFF	OFF	ON	OFF
14	OFF	OFF	OFF	ON
15	OFF	OFF	OFF	OFF

* Default Setting

3.3 Signal Connections

Pin Assignment

The I/O connector on the PCIE-1802 are a 36-pin and 19-pin connectors that enable you to connect to accessories with the PCL-108BNC mini SCSI and PCL-10119 HDMI cable. Figure 3.1 and Figure 3.2 show the pin assignments for the 36-pin and 19-pin I/O connector separately, and Table 3.1 shows its I/O connector signal description.

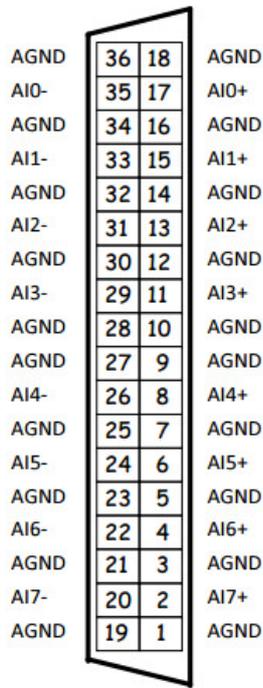


Figure 3.1 36-pin I/O Connector Pin Assignments

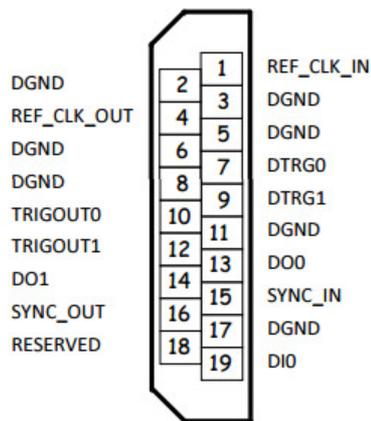


Figure 3.2 19-pin I/O Connector Pin Assignments

3.3.1 I/O Connector Signal Description

Signal Name	Reference	Direction	Description
AI<0..7>+	AGND	Input	Analog positive input channels 0 through 7
AI<0..7>-	AGND	Input	Analog negative input channels 0 through 7
AGND	----	----	Analog ground
REF_CLK_IN	DGND	Input	25 MHz reference clock input
REF_CLK_OUT	DGND	Output	25 MHz reference clock output
DTRG<0..1>	DGND	Input	Digital trigger inputs
TRIGOUT<0..1>	DGND	Output	Trigger outputs
SYNC_IN	DGND	Input	Synchronization input
SYNC_OUT	DGND	Output	Synchronization output
DIO	DGND	Input	Digital input channel
DO<0..1>	DGND	Output	Digital output channels
DGND	----	----	Digital ground

3.3.2 Analog Input Connections

3.3.2.1 Differential Inputs

The PCIE-1802 supports two terminal configurations for analog input: differential and pseudo-differential. The term pseudo-differential refers to the 50 Ω resistance between the outer connector shell and chassis ground.

If the signal source is floating, use the pseudo-differential configuration. The pseudo-differential configuration provides a ground reference between the floating source and the PCIE-1802 by connecting a 50 Ω resistor from the negative input to ground. Without this, the floating source can drift outside of the input common-mode range of the PCIE-1802.

If the signal source is grounded or ground referenced, both the pseudo-differential and differential input configurations are acceptable. However, the differential input configuration is preferred, since using the pseudo-differential input configuration on a grounded signal source creates more than one ground-reference point. This condition may allow ground loop current, which can introduce errors or noise into the measurement. The 50 Ω resistor between the negative input and ground is usually sufficient to reduce these errors to negligible levels, but results can vary depending on your system setup.

Configure the channels based on the signal source reference or DUT configuration. Refer to Table 1-1 to determine how to configure the channel.

The default configuration of the PCIE-1802 is differential.

Table 3.2: Recommended Analog input Channel Configuration

Source Reference	Channel Configuration
Floating	Pseudo-differential
Grounded	Differential

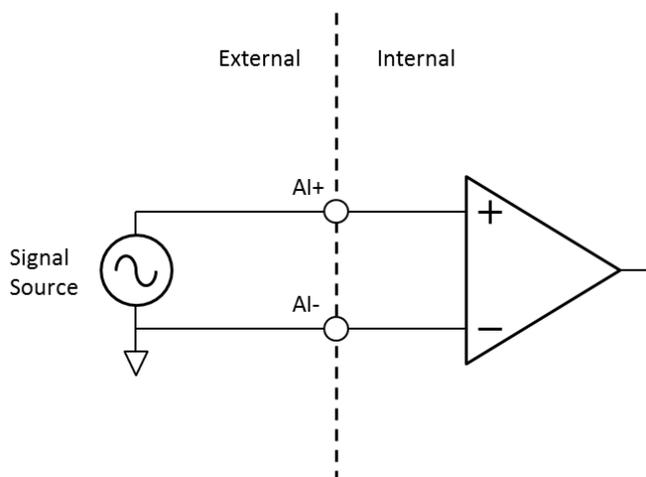


Figure 3.3 AI Differential Input Signal Connection

3.3.2.2 Pseudo-Differential Inputs

A pseudo-differential input is much like a differential input in that it provides common-mode voltage rejection (unlike single-ended inputs). However, pseudo-differential inputs are all referred, but not directly tied, to a common ground. This connection is typically made by a relatively low value resistor to give some isolation between the sensor/signal ground and the measurement device ground. DSA measurement devices have a $50\ \Omega$ resistance between the negative signal connector the outer shell of a BNC, and the device ground. A diagram showing the pseudo-differential input configuration of the PCIE-1802 is shown below with a floating source.

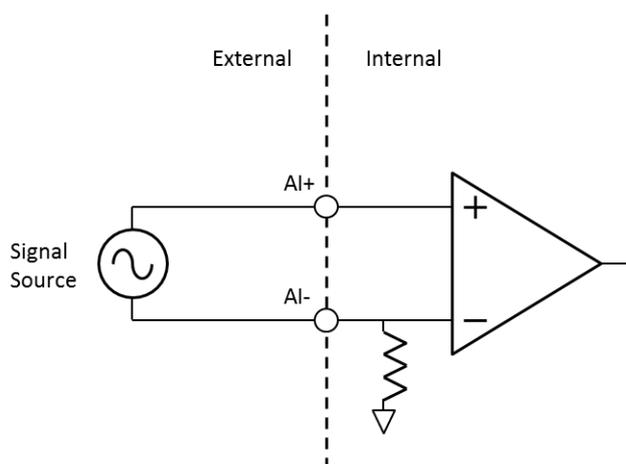


Figure 3.4 AI Pseudo-Differential Input Signal Connection

3.3.2.3 IEPE for Input

For applications that require sensors such as microphones or accelerometers, the PCIE-1802 provides an excitation current source to excite IEPE sensors. A DC voltage offset is generated due to the excitation current and sensor impedance. When IEPE current sources are enabled, the PCIE-1802 automatically sets input configuration to AC coupling and pseudo-differential.

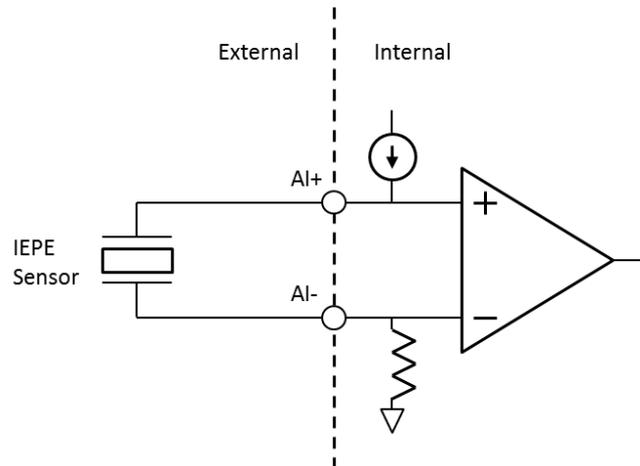


Figure 3.5 AI IEPE Sensor Input Signal Connection

3.3.3 Digital Input/Output Connections

PCIE-1802 provides 2 Channels DO and 1 channel DI.

3.3.3.1 Digital Input Channel Connections

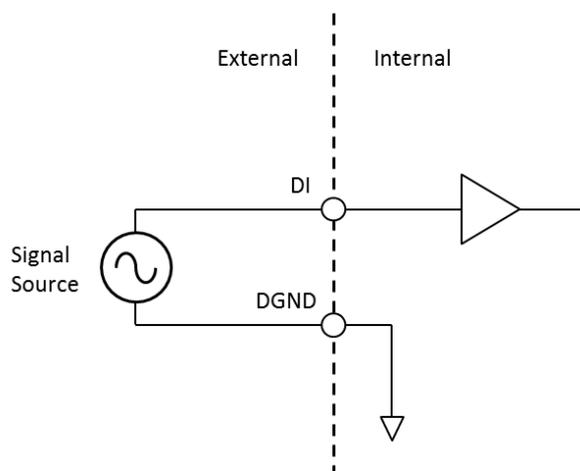


Figure 3.6 Digital Input Channel Connections

3.3.3.2 Digital Output Channel Connections

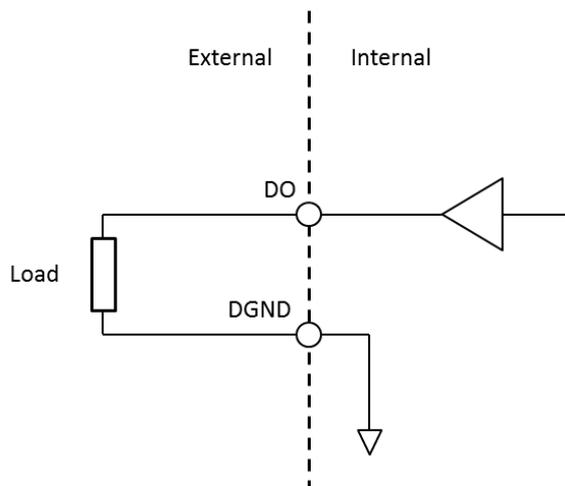


Figure 3.7 Digital Output Channel Connections

3.3.4 Trigger Type

The PCIE-1802 supports two types of triggers: start triggers and stop triggers.

The returned data consists of samples acquired between a start trigger and a stop trigger. That is, only data acquired after the start trigger occurred and before the stop trigger occurred are returned.

Both start triggers and stop triggers can be delayed. When the delay number is applied to a trigger, the trigger is effective only when the number of samples has reached after the trigger occurs. For example, if delay number of 5 is applied to the start trigger, the returned data will consist of samples acquired after the start trigger occurred except the first 5 samples. If delay number of 3 is applied to the stop trigger, the returned data will consist of samples acquired before the stop trigger occurred plus 3 samples acquired after the stop trigger.

Both triggers can be configured independently, and can be set to use a variety of sources, both analog and digital. Triggers can be configured to occur on either the rising or falling edge of a signal. Moreover, analog triggers support other modes of operation, including triggering on edges with hysteresis, and triggering when a signal enters or leaves a predefined window. Since all three types of triggers are configured independently, alternate edges of a signal can be used for different types of triggers.

During repetitive triggering on a waveform, you might observe jitter because of the uncertainty of where a trigger level falls compared to the actual digitized data. Although this trigger jitter is never greater than one sample period, it might be significant when the sample rate is only twice the bandwidth of interest. This jitter usually has no effect on data processing, and you can decrease this jitter by sampling at a higher rate.

3.3.4.1 Digital Trigger Connections

You can configure the PCIE-1802 to trigger in response to digital signals on DTRG0 or DTRG1 pin of the HDMI connector, located on the device front panel. The trigger circuit can respond either to a rising or a falling edge. The trigger signal must comply to 3.3 V or 5 V TTL voltage levels.

A diagram showing the DTRG input configuration of the PCIE-1802 is shown below with a signal source.

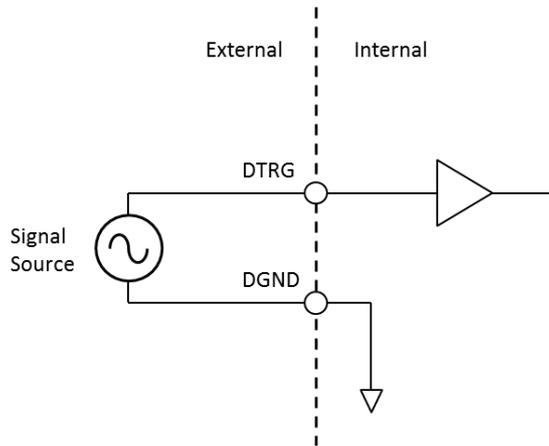


Figure 3.8 Digital Trigger Signal Connection

3.3.4.2 Analog Trigger

You can configure the PCIE-1802 analog trigger circuitry to monitor any input channel from which you acquire data. Choosing an input channel as the trigger channel does not influence the input channel acquisition capabilities.

The trigger circuit generates an internal digital trigger based on the input signal and the defined trigger levels. For example, you can configure the device to start acquiring samples after the input signal crosses a specific threshold. PCIE-1802 offers several analog triggering modes, including analog edge, analog edge with hysteresis, and window triggering.

Analog trigger connections are the same as **Analog Input Connections**, please refer to differential input (Figure 3.3) or pseudo-differential input (Figure 3.4).

Analog Trigger- Rising Edge

For rising edge trigger, ± 10 V input range, +2 V trigger level, 0.1% trigger hysteresis (equivalent to $20 \text{ V} \times 0.1\% = 0.02 \text{ V}$).

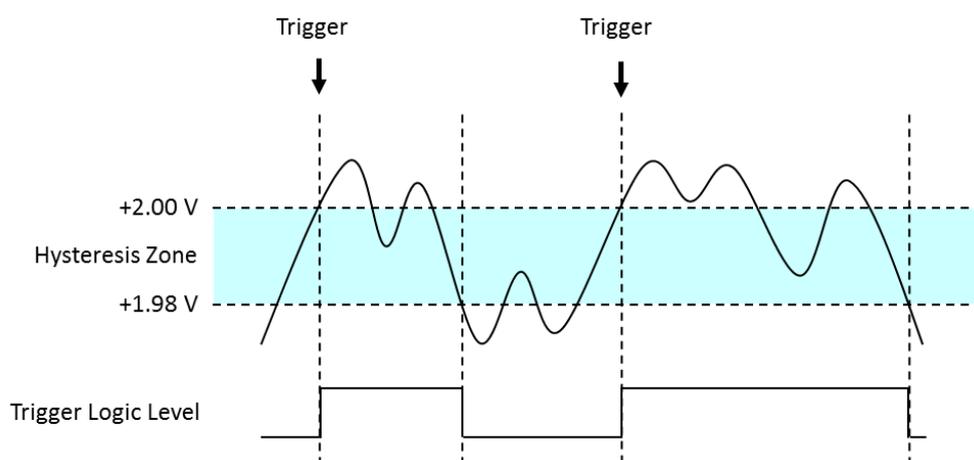


Figure 3.9 Analog Trigger - Rising Edge

Analog Trigger- Falling Edge

For falling edge trigger, ± 10 V input range, +2 V trigger level, 0.1% trigger hysteresis (equivalent to $20 \text{ V} \times 0.1\% = 0.02 \text{ V}$).

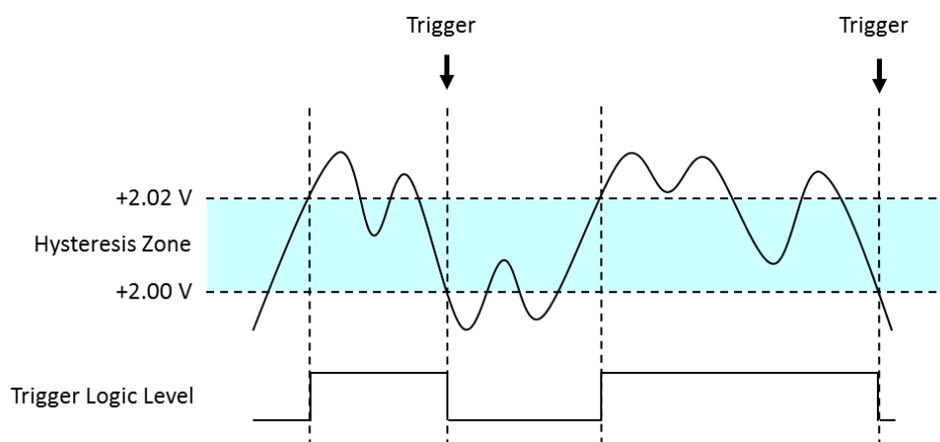


Figure 3.10 Analog Trigger - Falling Edge

3.3.5 Multiple Cards Synchronization Signal Connection

The below figure shows how to synchronize multiple PCIE-1802 cards. The synchronization is done through the reference clock and synchronization signal lines. The boards in both master and slave, share the same clock, sync pulse and a start trigger.

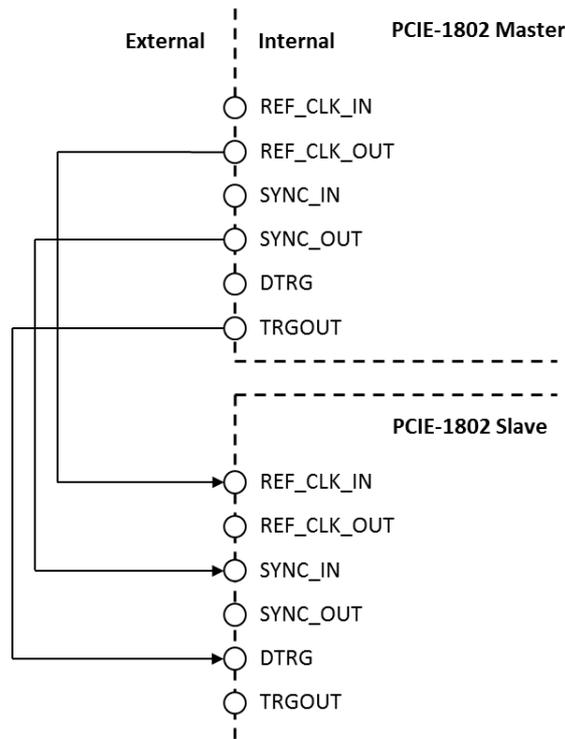


Figure 3.11 Multiple Cards Synchronization Signal Connection

3.4 Field Wiring Considerations

When you use PCIE-1802 cards to acquire data from outside, noises in the environment might significantly affect the accuracy of your measurements if due cautions are not taken. The following measures will be helpful to reduce possible interference running signal wires between signal sources and the PCIE-1802 card.

- The signal cables must be kept away from strong electromagnetic sources such as power lines, large electric motors, circuit breakers or welding machines, since they may cause strong electromagnetic interference. Keep the analog signal cables away from any video monitor, since it can significantly affect a data acquisition system.
- If the cable travels through an area with significant electromagnetic interference, you should adopt individually shielded, twisted-pair wires as the analog input cable. This type of cable has its signal wires twisted together and shielded with a metal mesh. The metal mesh should only be connected to one point at the signal source ground.
- Avoid running the signal cables through any conduit that might have power lines in it.
- If you have to place your signal cable parallel to a power line that has a high voltage or high current running through it, try to keep a safe distance between them. Alternatively, you can place the signal cable at a right angle to the power line to minimize the undesirable effect.
- The signals transmitted on the cable will be directly affected by the quality of the cable. In order to ensure better signal quality, we recommend that you use the PCL-108BNC-0.5E shielded cable.

Appendix **A**

Specifications

A.1 General Specifications

A.1.1 Bus Interface

- **Form factor:** x1 PCI Express, specification v1.1 compliant
- **Slot compatibility:** x1, x4, x8, and x16 PCI Express slots
- **DMA channel:** 1, analog input

A.1.2 Power Requirements

- **Typical:** +3.3 V @ 400 mA, +12 V @ 850 mA

A.1.3 Physical

- **Printed circuits board dimensions:** 9.9 × 16.8 cm (3.9 × 6.6 in.)
- **I/O connector:** 1 × 36-pin VHDCI (mini-SCSI), and 1 × HDMI

A.1.4 Environmental

- **Operating temperature:** 0 to 60°C
- **Storage temperature:** -40 to 70°C
- **Operating humidity:** 10 to 90% RH, non-condensing
- **Storage humidity:** 5 to 95% RH, non-condensing

Indoor use only.

A.2 Input Characteristics

- **Number of simultaneously sampled input channels:** 8, can be enabled/disabled each channel independently by software
- **Input configuration:** Differential/Pseudo-differential (50 Ω between negative input and chassis ground), software selectable per channel
- **Input coupling:** AC/DC, software selectable per channel
- **A/D converter (ADC) resolution:** 24 bits
- **A/D converter (ADC) type:** Delta-sigma
- **Sample rates (fs):**
 - Range: 100 S/s to 216 kS/s
 - Resolution: 90.95 μS/s (100 S/s to 54 kS/s)
181.90 μS/s (54 kS/s to 108 kS/s)
363.80 μS/s (108 kS/s to 216 kS/s)
- **FIFO buffer size:** 4,096 samples
- **Data transfers:** Direct memory access (DMA)

A.2.1 Maximum Operating Voltage

IEPE	Input Coupling	Input Configuration	Positive Terminal (+)*	Negative Terminal (-)*
Disabled	AC	Differential	±24 V	±24 V
Disabled	AC	Pseudo-differential	±24 V	±10 V
Disabled	DC	Differential	±10 V	±10 V
Disabled	DC	Pseudo-differential	±10 V	±10 V
Enabled	AC	Pseudo-differential	0 ~ +24 V	0 ~ +1 V
Enabled	DC	Pseudo-differential	0 ~ +10 V	0 ~ +1 V

* Voltages with respect to chassis ground.

Note! Input configuration must be pseudo-differential when IEPE is enabled.



A.2.2 Input Overvoltage Protection

Input Configuration	Positive Terminal (+)*	Negative Terminal (-)*
Differential	±24 V	±24 V
Pseudo-differential	±24 V	±12 V

* Voltages with respect to chassis ground.

A.2.3 Input Signal Range

Gain	Full-Scale Range*, **
0.28	±10.0 V
0.56	±5.0 V
1.4	±2.0 V
2.8	±1.0 V
5.6	±0.5 V
14	±0.2 V

*Each input channel gain is independently software selectable.

**Voltages on the positive terminal with respect to the negative terminal.

A.3 AC Coupled Measurement Accuracy

- **Gain error (fin = 1 kHz):**
 - Operating temperature within 5 °C of last auto-calibration temperature: < ±0.6%
 - Over full operating temperature range: < ±1.0%
- **Offset error:**
 - Operating temperature within 5 °C of last auto-calibration temperature: < 0.5 mV
 - Over full operating temperature range: < 1 mV

A.4 Flatness

Frequency Band	$f_s \geq 54 \text{ kS/s}$ $20 \text{ Hz} \leq f_{in} \leq 20 \text{ kHz}$	$f_s \geq 108 \text{ kS/s}$ $20 \text{ kHz} < f_{in} \leq 45 \text{ kHz}$	$f_s \geq 216 \text{ kS/s}$ $45 \text{ kHz} < f_{in} \leq 92.2 \text{ kHz}$
Flatness* (dB)	± 0.004	± 0.006	± 0.008

* Relative to 1 kHz.

A.5 DC Coupled Measurement Accuracy

- **Gain error:**
 - Operating temperature within 5 °C of last auto-calibration temperature: < $\pm 0.2\%$
 - Over full operating temperature range: < $\pm 0.4\%$
- **Offset error:**
 - Operating temperature within 5 °C of last auto-calibration temperature: < 0.5 mV
 - Over full operating temperature range: < 1 mV

A.6 Amplifier Characteristics

A.6.1 Input Impedance

Input Configuration	Between Positive Terminal (+) and Chassis Ground	Between Negative Terminal (-) and Chassis Ground
Differential	1 M Ω	1 M Ω
Pseudo-differential	1 M Ω	50 Ω

A.6.2 Common-Mode Rejection Ratio (CMRR)

- Input frequency < 20 kHz: 80 dB

A.7 Dynamic Characteristics

A.7.1 Bandwidth

Sample Rate	$f_s < 25.6 \text{ kS/s}$	$f_s \geq 25.6 \text{ kS/s}$
Alias rejection	> 90 dB	> 90 dB
-3 dB bandwidth	$0.4805 \times f_s$	$0.4852 \times f_s$

* f_s : Sample frequency

For example, the -3 dB bandwidth of 10 kS/s sample frequency is $0.4805 \times 10 \text{ kHz} = 4.805 \text{ kHz}$.

A.7.2 AC Coupling

- -3 dB cutoff frequency : 0.727 Hz
- -0.1 dB cutoff frequency: 4.727 Hz

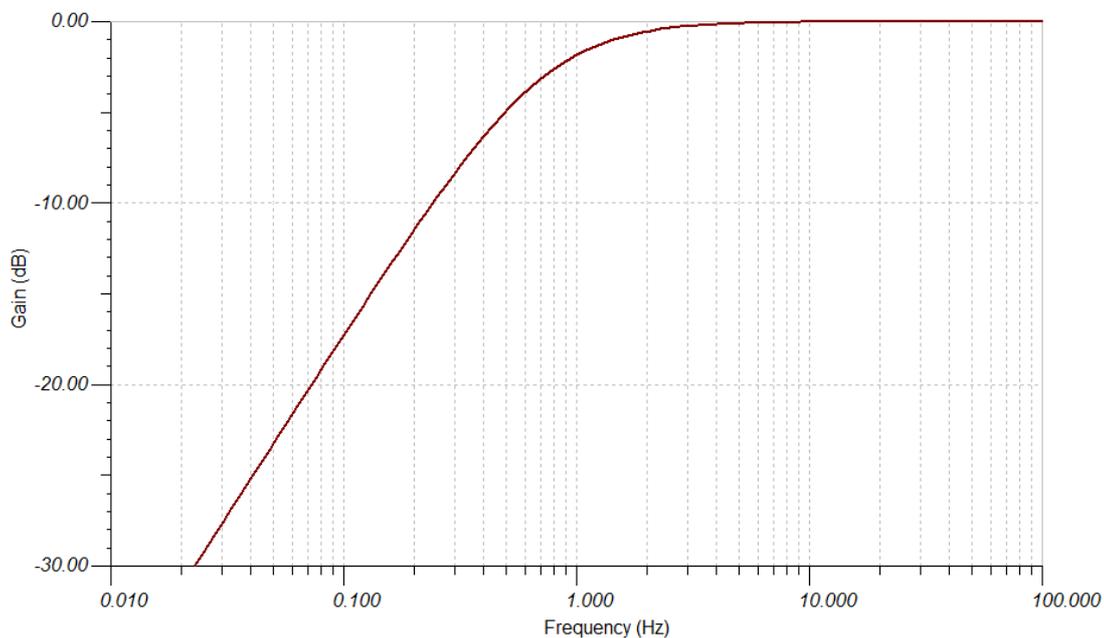


Figure A.1 Magnitude response of AC coupling circuit

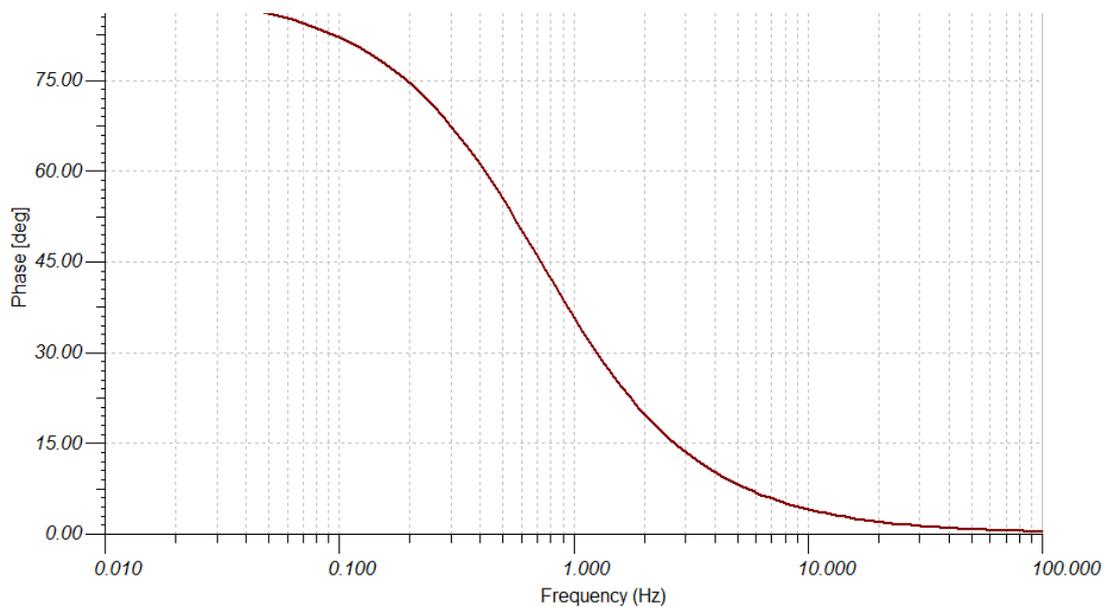


Figure A.2 Phase response of AC coupling circuit.

A.7.3 Idle Channel Noise

Input Range	54 kS/s		108 kS/s		216 kS/s	
	LSBrms	μVrms	LSBrms	μVrms	LSBrms	μVrms
$\pm 10.0\text{ V}$	6.59	7.86	9.50	11.32	60.80	72.48
$\pm 5.0\text{ V}$	6.87	4.09	9.85	5.87	60.75	36.21
$\pm 2.0\text{ V}$	7.84	1.87	11.31	2.70	60.83	14.50
$\pm 1.0\text{ V}$	9.92	1.18	14.36	1.71	63.22	7.54
$\pm 0.5\text{ V}$	14.49	0.86	21.13	1.26	66.13	3.94
$\pm 0.2\text{ V}$	30.47	0.73	42.85	1.02	85.09	2.03

A.7.4 Representative Measurement FFTs

Test conditions for all FFTs: 10 RMS averages of 65,536 samples using a 7-term Blackman-Harris window at $\pm 10\text{ V}$ input range. Source: Krohn-Hite 4402B.

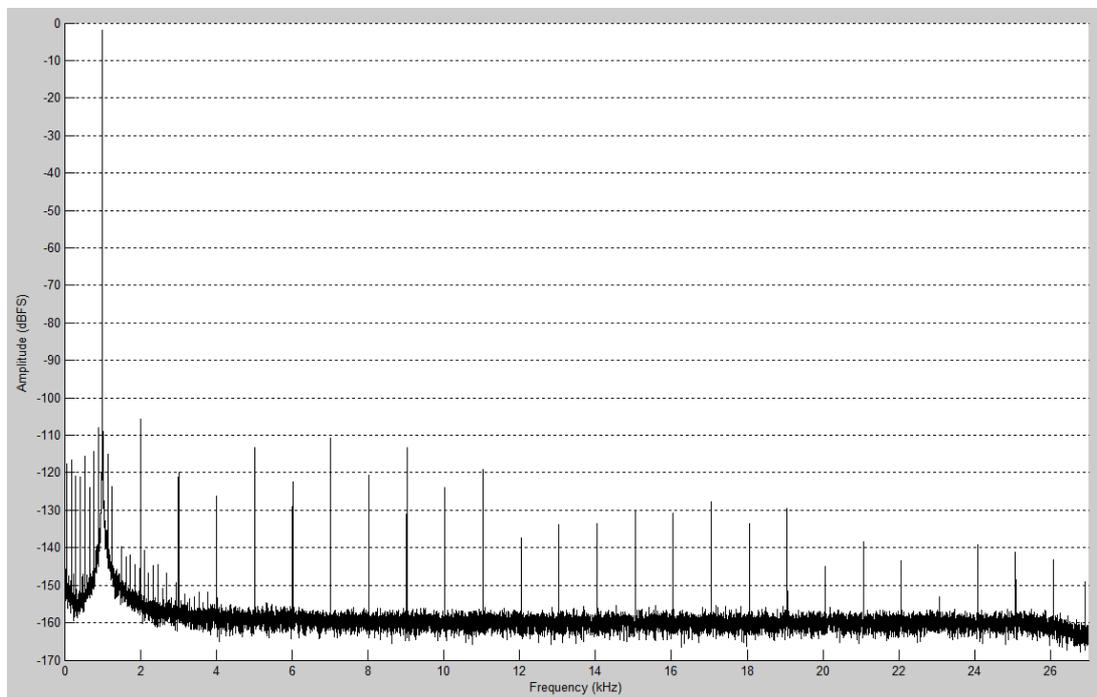


Figure A.3 FFT of -1 dBFS, 1 kHz Tone Acquired at 54 kS/s.

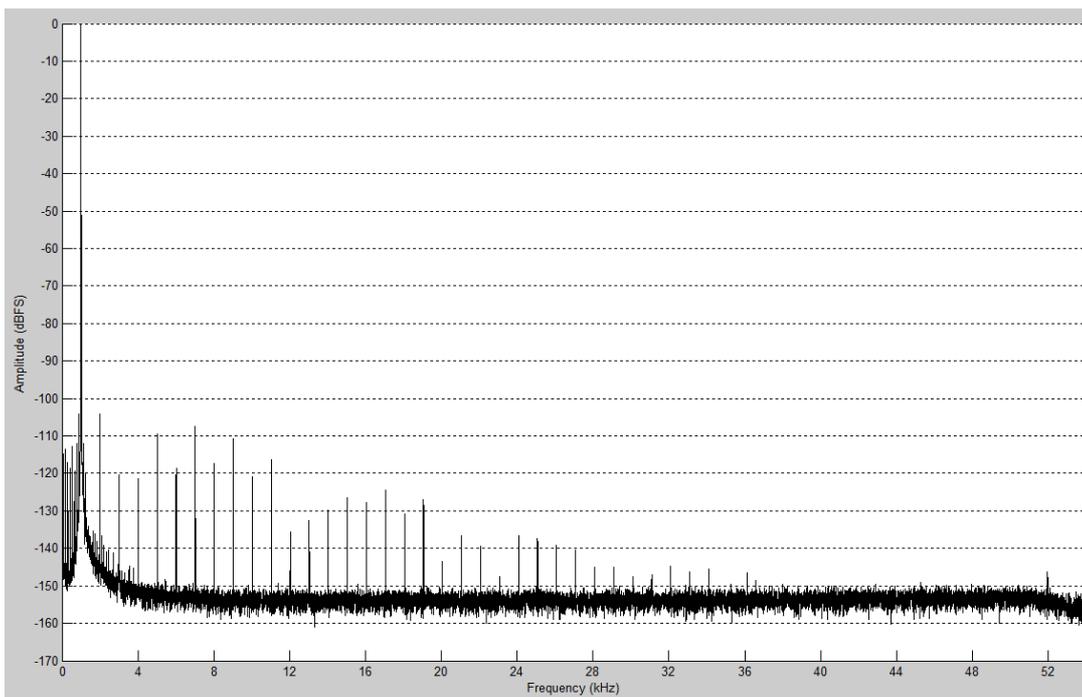


Figure A.4 FFT of -1 dBFS, 1 kHz Tone Acquired at 108 kS/s.

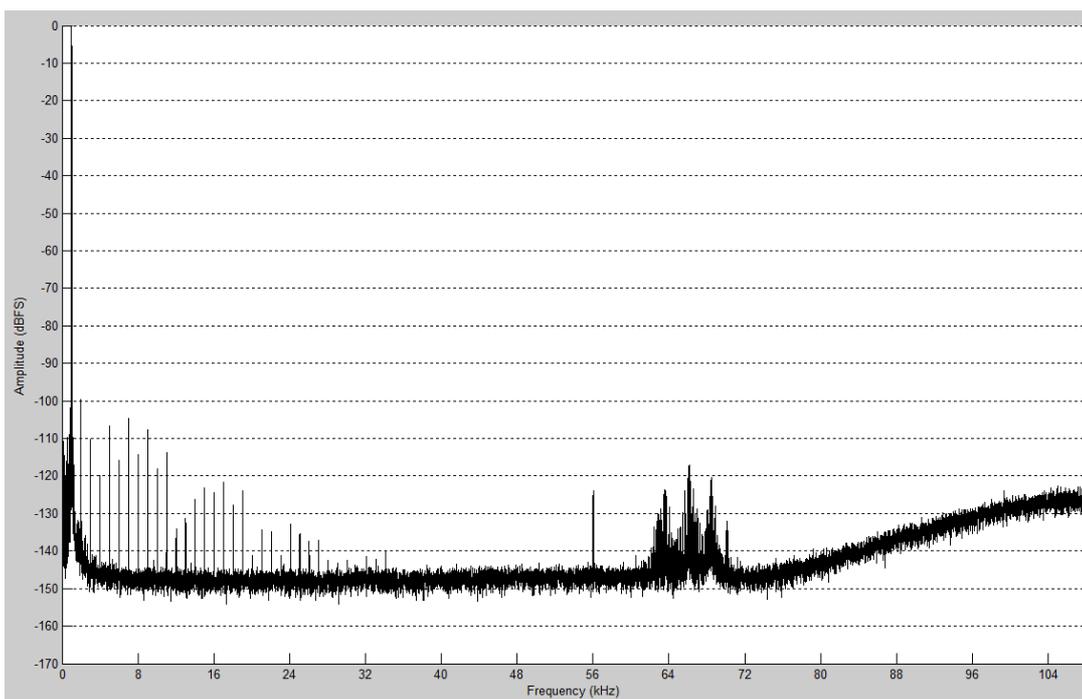


Figure A.5 FFT of -1 dBFS, 1 kHz Tone Acquired at 216 kS/s.

A.7.5 Dynamic Range (DR)

Input Range	Dynamic Range (dB)*		
	fs = 54 kS/s	fs = 108 kS/s	fs = 216 kS/s
±10.0 V	117	114	100
±5.0 V	114	112	98
±2.0 V	108	107	98
±1.0 V	105	102	96
±0.5 V	96	96	92
±0.2 V	88	88	86

* 1 kHz input tone, unweighted. Input amplitude is -60 dBFS.

A.7.6 Spurious Free Dynamic Range (SFDR)

Input Range	Spurious Free Dynamic Range (dBc)*,**		
	fs = 54 kS/s	fs = 108 kS/s	fs = 216 kS/s
±10.0 V	104	105	104
±5.0 V	106	106	106
±2.0 V	106	106	106
±1.0 V	104	102	102
±0.5 V	97	97	96
±0.2 V	89	89	89

* 1 kHz input tone, input amplitude is -1 dBFS.

** Measurement includes all harmonics.

A.7.7 Signal-to-Noise Ratio (SNR)

Input Range	Signal-to-Noise Ratio (dB)*		
	fs = 54 kS/s	fs = 108 kS/s	fs = 216 kS/s
±10.0 V	99	99	97
±5.0 V	100	100	97
±2.0 V	99	99	96
±1.0 V	97	97	94
±0.5 V	93	92	89
±0.2 V	86	85	82

* 1 kHz input tone, input amplitude is -1 dBFS.

A.7.8 Total Harmonic Distortion (THD)

Input Range	Total Harmonic Distortion (dB)*		
	fs = 54 kS/s	fs = 108 kS/s	fs = 216 kS/s
±10.0 V	-103	-104	-103
±5.0 V	-106	-106	-106
±2.0 V	-107	-107	-107
±1.0 V	-105	-105	-105
±0.5 V	-102	-101	-101
±0.2 V	-95	-95	-95

* 1 kHz input tone, input amplitude is -1 dBFS.

A.7.9 Total Harmonic Distortion Plus Noise (THD+N)

Input Range	Total Harmonic Distortion Plus Noise (dB)*		
	fs = 54 kS/s	fs = 108 kS/s	fs = 216 kS/s
±10.0 V	98	98	96
±5.0 V	99	99	96
±2.0 V	98	98	96
±1.0 V	96	96	94
±0.5 V	93	91	89
±0.2 V	86	84	82

* 1 kHz input tone, input amplitude is -1 dBFS.

A.7.10 Crosstalk

Input Range	Crosstalk for Adjacent (Non-adjacent) Channels (dBc)*, **	
	54 kS/s, fin = 1 kHz	216 kS/s, fin = 92.2 kHz
±10.0 V	-139 (-158)	-128 (-137)
±5.0 V	-149 (-157)	-109 (-132)
±2.0 V	-149 (-155)	-110 (-133)
±1.0 V	-144 (-154)	-113 (-136)
±0.5 V	-144 (-152)	-118 (-135)
±0.2 V	-143 (-144)	-124 (-135)

* Input amplitude is -1 dBFS.

** Using the Mini-SCSI 36-pin to 8-BNC cable assembly.

A.7.11 Inter-channel Gain Mismatch

Input Range	AC/DC Coupled Mismatch (dB)*, **			
	fin = 10 Hz	fin = 100 Hz	fin = 20 kHz	fin = 92.2 kHz
±10.0 V	< 0.005	< 0.005	< 0.005	< 0.005
±5.0 V	< 0.005	< 0.005	< 0.005	< 0.005
±2.0 V	< 0.005	< 0.005	< 0.005	< 0.005
±1.0 V	< 0.005	< 0.005	< 0.005	< 0.005
±0.5 V	< 0.005	< 0.005	< 0.005	< 0.005
±0.2 V	< 0.02	< 0.01	< 0.01	< 0.02

* Identical channel configurations.

** Operating temperature within 5 °C of last auto-calibration temperature.

A.7.12 Inter-channel Phase Mismatch

Input Range	AC/DC Coupled Mismatch*, **			
	fin = 10 Hz	fin = 100 Hz	fin = 20 kHz	fin = 92.2 kHz
±10.0 V	< 0.01°	< 0.005°	< 0.01°	< 0.04°
±5.0 V	< 0.01°	< 0.005°	< 0.02°	< 0.06°
±2.0 V	< 0.01°	< 0.005°	< 0.02°	< 0.06°
±1.0 V	< 0.01°	< 0.005°	< 0.02°	< 0.08°
±0.5 V	< 0.01°	< 0.005°	< 0.02°	< 0.08°
±0.2 V	< 0.01°	< 0.005°	< 0.03°	< 0.11°

* Identical channel configurations.

** Operating temperature within 5 °C of last auto-calibration temperature.

A.8 Integrated Electronic Piezoelectric Excitation (IEPE)

- **Current:** 0, 4, or 10 mA ± 5%, each channel independently software selectable
- **Compliance:** 24 V min
- **Channel input impedance with IEPE enabled:** 200 kΩ @ 1 kHz, pseudo-differential

A.9 Reference Clock Characteristics

- **Using external reference clock (25 MHz):**
 - Accuracy: Equal to accuracy of external reference clock
- **Using internal reference clock:**
 - Accuracy: ±20 ppm, over operating temperature range, in first year
 - Aging: 3 ppm/year

A.10 Triggers

- **Analog trigger input:**
 - Type: Start, delay to start, stop, or delay to stop trigger
 - Source: Any analog input channel
 - Level: Full scale, programmable
 - Slope: Positive (rising) or negative (falling), software selectable
 - Resolution: 24 bits
 - Hysteresis: Programmable
- **Digital trigger input:**
 - Type: Start, delay to start, stop, or delay to stop trigger
 - Source: 2 external digital trigger inputs
 - Compatibility: 3.3 V CMOS, 5 V compatible
 - Low: 0.8 V max.
 - High: 2.0 V min.
 - Pull-down resistor: 50 k Ω
 - Polarity: Rising or falling edge, software selectable
 - Minimum pulse width: 20 ns
- **Digital trigger output:**
 - Number of digital trigger output: 2
 - Source: Analog trigger input, digital trigger input, or software trigger
 - Compatibility: 3.3 V CMOS
 - Low: 0.6 V max.
 - High: 2.3 V min.

A.11 Digital I/O

- **Digital Input:**
 - Number of digital input: 1
 - Number of Interrupt: 1
 - Compatibility: 3.3 V CMOS
 - Low: 0.6 V max.
 - High: 2.3 V min.
 - Pull-down resistor: 50 k Ω
- **Digital Output:**
 - Number of digital output: 2
 - Compatibility: 3.3 V CMOS
 - Low: 0.6 V max.
 - High: 2.3 V min.

A.12 Synchronization Input & Output

- **Synchronization Input:**
 - Compatibility: 3.3 V CMOS, 5 V compatible
 - Pull-down resistor: 50 k Ω
- **Synchronization Output:**
 - Compatibility: 3.3 V CMOS
 - Low: 0.6 V max.
 - High: 2.3 V min.

Appendix **B**

Block Diagram

B.1 Function Block Diagrams

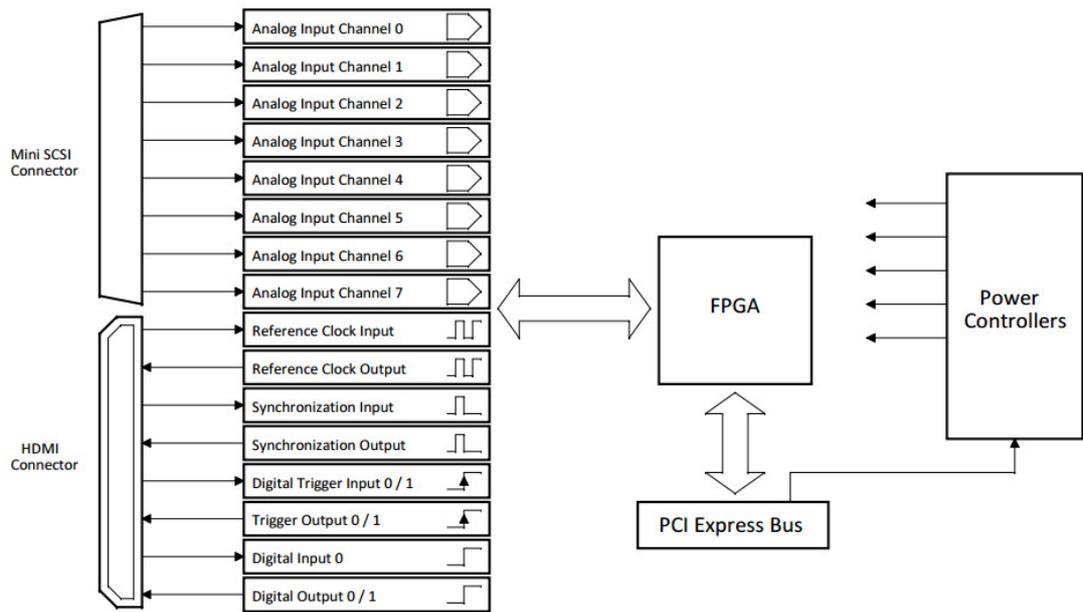


Figure B.1 Function block diagram - overview

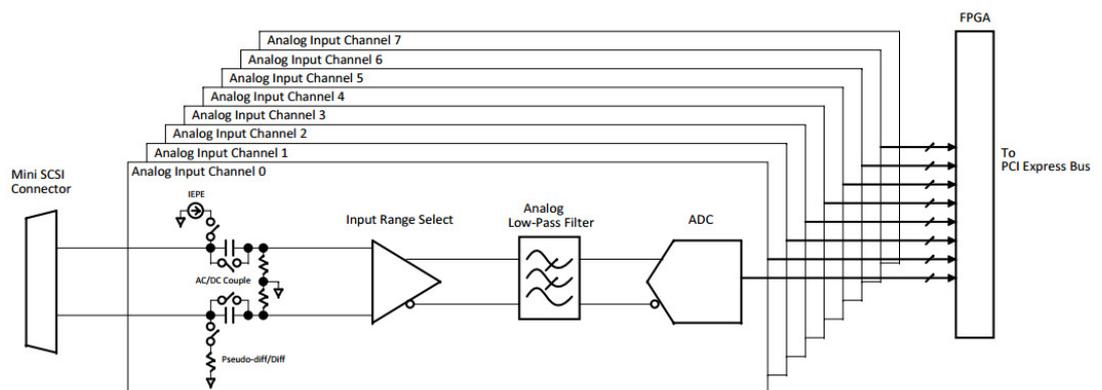


Figure B.2 Function block diagram - analog input

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