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KEITHLEY

KPCI-1800HC Series

PCI Bus Data Acquisition Board

User's Manual

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PCI Bus Data Acquisition Board
User's Manual

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

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If  or  is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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1
Overview

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Preface

This manual is provided for persons needing to understand the installation, interface requirements, functions, and operation of the KPCI-1801HC and KPCI-1802HC boards. The two models differ only in available gains. Unless this manual refers specifically to a KPCI-1801HC board or a KPCI-1802HC board, it refers to the two models collectively as a KPCI-1800HC Series board.

This manual focuses primarily on describing the KPCI-1800HC Series boards and their capabilities, setting up the boards and their associated software, making typical hookups, and operating the test-panel software. There are also sections on calibration and troubleshooting.

To follow the information and instructions contained in this manual, you must be familiar with the operation of Windows 95, 98, or NT, with basic data-acquisition principles, and with your application. However, if you find unfamiliar terms in this manual, check the glossary in Appendix C. To locate topics discussed in this manual, search the index.

The KPCI-1800HC Series User's Manual is organized as follows:

- Section 1 describes general features and system requirements and summarizes supporting software and accessories for the KPCI-1800HC Series boards.
- Section 2 describes operating features of the boards in more detail. This section contains a block diagram and brief descriptions of the features as they relate to setting up and using the board.
- Section 3 contains software descriptions and installation notes and instructions for the following: inspecting the board, installing the board, checking the board and software installation, installing accessories, and connecting signals.
- Section 4 summarizes the test panels that are available in the DriverLINX software.
- Section 5 discusses how to calibrate your board using the DriverLINX calibration utility.
- Section 6 contains detailed procedures for isolating problems with your data acquisition system. This section also contains instructions for obtaining technical support.
- Appendix A contains specifications for the KPCI-1800HC Series boards.
- Appendix B provides pin assignments for the KPCI-1800HC Series board I/O connector and for the four 37-pin accessory connectors of the STA-1800HC and CONN-1800HC accessories.
- Appendix C is a glossary of key terms used in this manual.
- A detailed index completes this manual.

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This section summarizes general hardware characteristics of the KPCI-1800HC board, computer system requirements to run the board, and software that can be used with the board.

Hardware characteristics

The KPCI-1801HC and KPCI-1802HC are high-performance PCI-bus data acquisition boards for PC-compatible computers running Windows 95, 98, or NT. The KPCI-1801HC is a high-gain board, while the KPCI-1802HC is a low-gain board.

PCI-bus data acquisition boards such as the KPCI-1800HC Series, have two major advantages over ISA-bus data acquisition boards:

- The PCI-bus Plug and Play feature allows a user to install the data acquisition board without making manual system configurations. Upon system power-up or reset, the PCI-bus Plug and Play feature automatically configures the board for your system, eliminating the need to set DIP switches on the board.
- Cleaner, faster, direct data transfer to and from memory using bus mastering to bypass the CPU.
  - Data transfer occurs at speeds up to 132 MB/sec rate for the PCI bus, versus 8.33 MB/sec maximum for the ISA bus, due to the 32 bit width and 33 MHz clock speed of the PCI bus.
  - Data transfer causes minimal interruptions to normal processing.

Major features of KPCI-1800HC Series boards include the following:

- The following analog input characteristics:
  - Software-configurable for 64 single-ended or 32 differential analog input channels.
  - Software-configurable individual gains for each analog input channel. The KPCI-1801HC provides gains of 1, 5, 50, and 250. The KPCI-1802 provides gains of 1, 2, 4, and 8.
  - Analog data conversion speeds up to 333 ksamples/s with 12-bit resolution.
  - A 64-location channel/gain queue which supports high-speed sampling of analog input channels at identical or different gains in any desired sequence.
  - A 2048 sample FIFO (First In First Out) data buffer for the A/D converter that ensures data integrity at high sampling rates.
  - Software-selectable edge-polarity detection for hardware trigger and gate signals which are used to start and stop analog-to-digital data conversions.
- Two analog outputs from two independent 12-bit DACs (Digital-to-Analog Converters).
- Two general-purpose digital inputs and two combination digital inputs which can be configured by software as either general-purpose inputs or control inputs.
- Eight general-purpose digital outputs and three digital control outputs. The control outputs include a strobe output to coordinate data movement from the outputs and latching into the registers of other equipment.
- Optional target-mode (pass-through) data transfer capability in addition to bus mastering. Both target-mode data transfer, which is sometimes referred to as pass-through operation, and bus mastering data transfer are software-configurable. To maximize the speed of analog I/O, the KPCI-1800HC Series boards normally implement the bus mastering mode. The target mode provides a simple access port to the PCI bus for digital I/O.
- Very fast board control via a field-programmable gate array (FPGA) instead of a microprocessor. (Refer to glossary for more information about FPGAs).
- 100-pin I/O connector that requires only one slot on the rear panel of the PC.

For more detailed information on these features, refer to Section 2, *Functional Description*.

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Specifications

General specifications are listed in Appendix A. I/O connections are identified in Section 3 and Appendix B.

System requirements

The system capabilities required to run the KPCI-1800HC Series board, and to use the DriverLINX software supplied with the board, are listed in Table 1-1.

Table 1-1
System requirements

CPU Type	Pentium or higher processor on motherboard with PCI bus version 2.1
Operating system	Windows 95 or 98
	Windows NT version 4.0 or higher
Memory	16 MB or greater RAM when running Windows 95 or 98
	32 MB or greater RAM when running Windows NT
Hard disk space	4 MB for minimum installation
	50 MB for maximum installation
Other	A CD-ROM drive*
	A free PCI-bus expansion slot capable of bus mastering
	Enough reserve computer power supply capacity to power the KPCI-1800HC Series board, which draws 10W at 5VDC and 6W at +12VDC.

* Any CD-ROM drive that came installed with the required computer should be satisfactory. However, if you have post-installed an older CD-ROM drive or arrived at your present system by updating the microprocessor or replacing the motherboard, some early CD-ROM drives may not support the long file names often used in 32 bit Windows files.

Software

The user can select a fully integrated data acquisition software package such as TestPoint or LabVIEW or write a custom program supported by DriverLINX.

DriverLINX is the basic Application Programming Interface (API) for the KPCI-1800HC series boards:

- It supports programmers who wish to create custom applications using Visual C/C++, Visual Basic, or Delphi.
- It accomplishes foreground and background tasks to perform data acquisition.
- It is the needed interface between TestPoint and LabVIEW and a KPCI-1800HC Series board.

DriverLINX software and user's documentation on a CD-ROM are included with your board.

TestPoint is an optional, fully featured, integrated application package with a graphical drag-and-drop interface which can be used to create data acquisition applications without programming.

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LabVIEW is an optional, fully featured graphical programming language used to create virtual instrumentation.

Refer to Section 3, *Installation*, for more information about DriverLINX, TestPoint, and LabView.

Accessories

Accessories available to interface your KPCI-1800HC board to external circuits are listed in Table 1-2.

Table 1-2
Interface accessories for KPCI-1800HC Series boards

Category	Part number	Description
Primary interfaces to KPCI-1800HC Series boards. They connect to KPCI-1800HC Series boards via CAB-1800 series cables.	STP-100	Basic screw-terminal accessory. Interfaces each KPCI-1800HC Series I/O connector-pin to a corresponding screw terminal.
	STA-1800HC	Screw-terminal accessory and secondary connector interface. Interfaces KPCI-1800HC Series I/O connector-pins both to screw terminals and to four secondary connectors. The secondary connectors interface signal conditioning modules to a KPCI-1800HC Series board. Also provides a breadboarding area for user circuits and an onboard temperature measurement circuit that facilitates thermocouple Cold-Junction Compensation (CJC).
	CONN-1800HC	Secondary connector interface only. Effectively an STA-1800HC without the screw terminals, the breadboarding area, or the CJC temperature measurement circuit. Interfaces signal conditioning modules to a KPCI-1800HC Series board.
CAB-1800 Series cables.	CAB-1800	18-inch, 100-wire ribbon cable.
	CAB-1801	36-inch, 100-wire ribbon cable.
	CAB-1800/S CAB-1801/S	18-inch, 100-wire, shielded, ribbon cable. 36-inch, 100-wire, shielded, ribbon cable.
Secondary, signal conditioning interfaces. They connect to primary interfaces via cables listed below.	MB Series modules and MB01 backplanes	Plug-in, isolated, signal-conditioning modules and the backplanes that hold them.
Cables to connect secondary interfaces to primary interfaces.	C-16MB1	Cable for connecting an STA-1800HC or CONN-1800HC to an MB01 signal-conditioning backplane.
Other accessories.	RMT-04	Rack-mount enclosure for the STA-1800HC.

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2
Functional Description

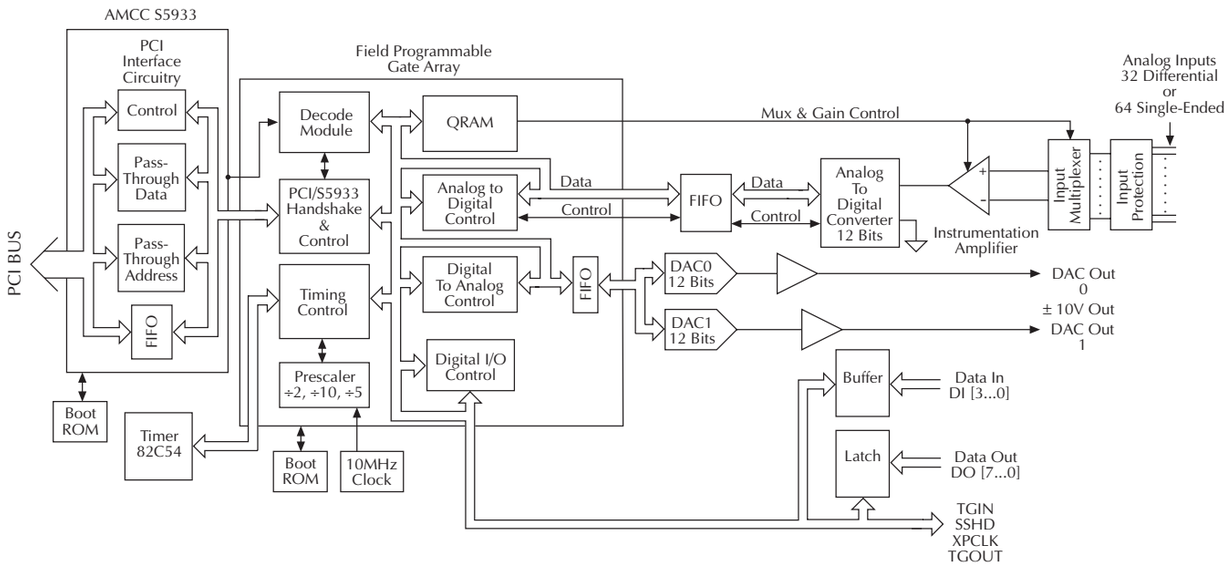
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This section describes features of the following KPCI-1800HC Series board sections: the analog input, the analog output, and the digital I/O. These descriptions help familiarize you with operating options and enable you to make the best use of your board.

NOTE *Features described in this section are typically configured using custom or commercial application software which interfaces to your KPCI-1800HC Series board via DriverLINX. For information on how to configure and apply these features, consult the appropriate manuals. Application software developers should consult your DriverLINX manuals located on the DriverLINX CD-ROM shipped with your board. Application software users should consult the manuals provided by the vendor or developer of your software.*

The block diagram in Figure 2-1 represents both the KPCI-1801HC and the KPCI-1802HC.

Figure 2-1
Block diagram of KPCI-1800HC board



Analog input features

This section discusses the following:

- Understanding and choosing the software-configurable analog input modes.
- Maximum data throughput specifications and tips on optimizing throughput.
- Signal conversion modes.
- Signal conversion clock sources.
- The use of triggers and gates to start and stop signal conversions.

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Understanding and choosing analog input modes

Using software, you can select between various analog input options as follows:

- The differential input mode or the single-ended input mode for all channels.
- The unipolar input mode or the bipolar input mode for all channels.
- The input channels to be scanned to the instrumentation amplifier, in any order or combination.
- The instrumentation amplifier gain to be used at each step in the input scan.

The next four subsections, as well as the subsequent section entitled *Optimizing throughput*, explain these options and provide guidance for making choices.

Understanding the analog inputs

Each KPCI-1800HC Series board provides 64 analog input terminals. These terminals are configurable by software either as single-ended inputs or, in pairs, as differential inputs. Each single-ended or differential input is commonly referred to as an input channel. The characteristics of single ended and differential inputs are as follows:

- A single-ended input measures the voltage at one input terminal relative to a common ground. When the 64 analog input terminals are configured as single-ended, you can connect each of the 64 input terminals to 64 external signals, maximum. In other words, each KPCI-1800HC Series board provides up to 64 single-ended input channels.
- A differential input measures the difference between the voltages at two input terminals, designated input-high and input-low. Signals at both the input-high and input-low terminals are referenced to a common ground. When the 64 analog input terminals are configured for differential input, you can connect 32 external signals, maximum, because a pair of input terminals is needed for each differential input. In other words, each KPCI-1800HC Series board provides up to 32 differential input channels.

  Differential inputs reject the common mode voltage, the voltage that each "sees" in common, except for a small fraction determined by the common mode rejection ratio (refer to the glossary in Appendix C). Differential inputs are commonly used to:

  - Reject noise and other unwanted voltages in a signal ground.
  - Reject a common power supply voltage, such as the excitation voltage of a bridge circuit.

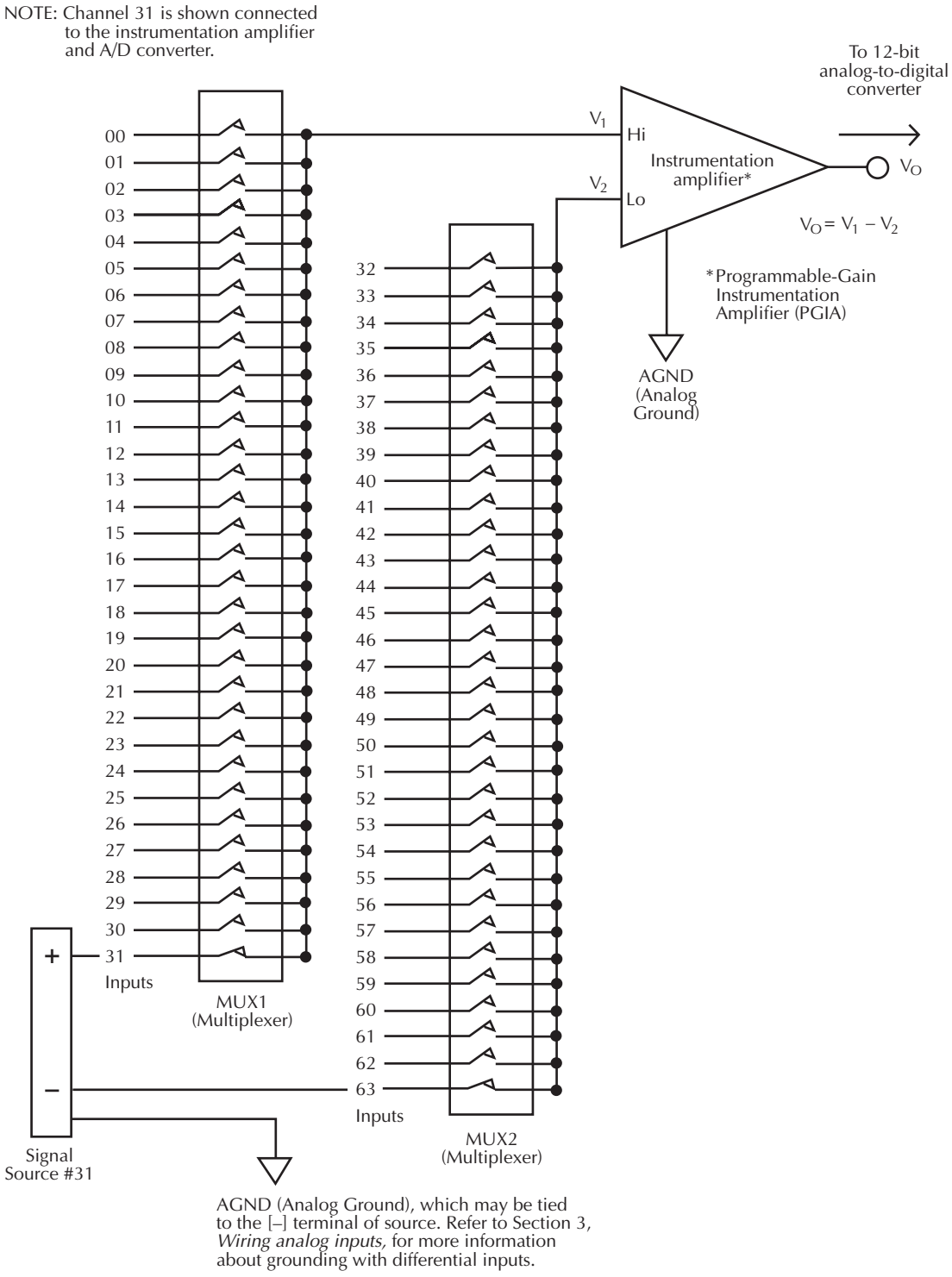
  A single-ended input cannot reject these voltages. Refer to Section 3, *Wiring analog input signals* for more information about using differential inputs.

Signals from all 64 single-ended inputs or 32 differential inputs are amplified by one instrumentation amplifier — a type of high performance differential amplifier — and are digitized by one 12-bit analog-to-digital converter (A/D converter or ADC). This is made possible by a time-sharing arrangement in which inputs are scanned and connected intermittently to the instrumentation amplifier and A/D converter according to a user-defined sequence. The inputs are connected through a pair of 32-channel multiplexers, each of which is effectively a solid-state 32-pole, single-throw switch. Additional solid-state switches connecting the multiplexer to the instrumentation amplifier determine whether inputs are configured as differential or single-ended.

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When the inputs are configured as differential inputs, the two multiplexers act together as a 32-pole, double throw switch, connecting one input signal at a time to both the high and low terminals of the instrumentation amplifier. See Figure 2-2.

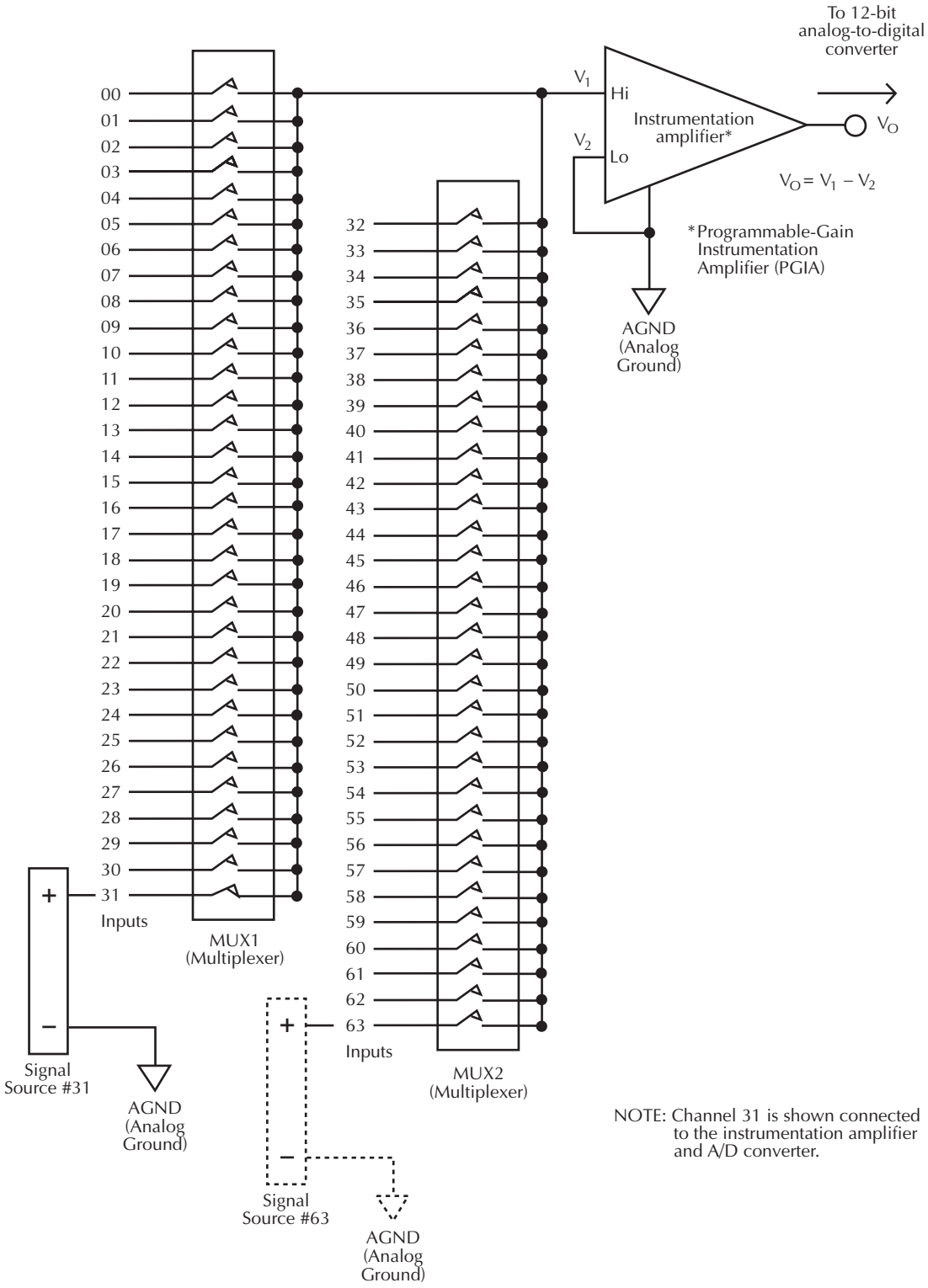
Figure 2-2
Multiplexing of 32 channels in differential input mode



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When the inputs are configured as single-ended inputs, the input-low terminal of the instrumentation amplifier is connected to ground. At any given time, only one multiplexer is active. The active multiplexer connects only one pole of a signal source to the input-high terminal of the instrumentation amplifier. See Figure 2-3.

Figure 2-3
Multiplexing of 64 channels in single-ended input mode



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Choosing between the differential and single-ended input modes

Generally, you should use a differential input for a low-level signal having a significant noise component and/or for a signal having a non-zero common-mode voltage. You should use a single-ended input for a high-level signal having a relatively small noise component.

There is no absolute level at which one of these input configurations becomes more effective than the other. However, you should generally use a differential input for a voltage range of 100mV or below.

NOTE *You must specify all analog inputs to be either all differential or all single-ended. You cannot use a mixture of differential and single-ended inputs.*

Choosing between the unipolar and bipolar input modes

Using software, you can configure the KPCI-1800HC Series boards to operate in either the unipolar or bipolar input mode. A unipolar signal is always positive (0 to +5V, for example). A bipolar signal can swing between positive and negative values (±5V maximum, for example). For exapmle, an unbiased sinusoidal AC signal is bipolar.

For maximum resolution, use the bipolar mode only if you must measure signals having both positive and negative polarity. The KPCI-1800HC Series boards represent a unipolar signal as an unsigned 12 bit number and a bipolar signal as a 2's complement 12 bit number. Because one bit of a 2's complement number is effectively used up as a sign bit, a bipolar range provides only half the resolution of a unipolar range of the same magnitude. Looked at another way, the dual polarity of the bipolar range effectively doubles the magnitude that must be covered by the same 12 bits. For example, the 12 bits must cover a span of 10V for a ±5V, bipolar range [+5V – (-5V) = 10V]. However, the 12-bits must only cover a span of 5V for a 0 to 5V, unipolar range [+5V – (0V) = 5V].

Resolutions for unipolar and bipolar inputs are listed in the next section in Tables 2-1 and 2-2.

NOTE *You must specify all analog inputs to be either all unipolar or all bipolar. You cannot use a mixture of unipolar and bipolar inputs.*

Table 2-1
Gains, ranges, and resolutions for the KPCI-1801HC

	Unipolar		Bipolar	
Gain	Range	Resolution	Range	Resolution
1	0 to 5V	1.2mV	–5.0 to +5.0V	2.4mV
5	0 to 1V	240µV	–1.0 to +1.0V	490µV
50	0 to 100mV	24µV	–100 to +100mV	49µV
250	0 to 20mV	4.9µV	–20 to +20mV	9.8µV

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Table 2-2
Gains, ranges, and resolutions for the KPCI-1802HC

Gain	Unipolar		Bipolar	
	Range	**Resolution**	**Range**	**Resolution**
1	0.0 to +10.0V	2.4mV	−10 to +10V	4.9mV
2	0.0 to +5.0V	1.2mV	−5.0 to +5.0V	2.4mV
4	0 to 2.5V	610µV	−2.5 to + 2.5V	1.2mV
8	0 to 1.25V	310µV	−1.25 to +1.25V	610µV

Choosing channel gains and positions in the scan sequence

Each channel may be assigned an individual gain and a particular position in a channel-gain queue. The channel gain queue is a user-defined scan sequence that specifies both the position in the sequence and the gain at which each channel is scanned. Up to sixty-four gains and positions may be specified in the channel-gain queue, without regard to sequential channel number. Channel numbers may be skipped or be repeated in the queue if desired. For example, by repeating a channel number in the queue, you can do the following:

- Sample some channels more frequently than others.
- Provide extra settling time to wash out residual signals between gain changes.
- Provide extra samples for averaging.

Figure 2-4 illustrates use of a channel-gain queue.

Figure 2-4
Channel-gain queue example

Position in queue	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	-------	49th	50th	51st
Channel number	21	03	11	11	21	09	25	25	21	07	-------	00	29	17
Channel gain*	250	250	50	50	50	50	5	5	5	5		1	1	1

* Note: Gains available on the KPCI-1801HC are used in this illustration. Though gains available on the KPCI-1802HC are different, the capabilities of the channel-gain queue are otherwise identical.

All 64 combinations of gain and position in the channel-gain queue are held in a 64-position RAM. You need not specify channels and gains for all 64 positions of the channel-gain queue.

Available gains and corresponding input ranges are listed in Table 2-1 for the KPCI-1801HC and in Table 2-2 for the KPCI-1802HC.

NOTE *Optimum selection and sequencing of channel gains may be affected by your required throughput and by noise and other stray signals. Refer to "Optimizing throughput" for general recommendations about channel-gain selection and sequencing. Refer to "Avoiding wiring problems at high gain" in Section 3 for recommendations to minimize signal errors at high gains.*

The gains and positions in the channel-gain queue are specified using software.

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Throughput

Throughput is the maximum rate at which the data acquisition card can perform repetitive conversions within a specified accuracy. Signal throughput depends on the gain settings for individual channels and for adjacent channels in the channel-gain queue. This section discusses general recommendations to optimize throughput and lists KPCI-1800HC Series throughput for specific conditions.

Optimizing throughput

Because you can change input ranges on a per-channel basis, throughput is likely to drop if you group channels with varying gains in sequence. This throughput drop occurs for two reasons. Firstly, channels with low-level inputs (100mV or less) are inherently slower than channels with high-level inputs signals left by high-level inputs. Secondly, extra settling time is required for low-level inputs to wash out residual signals. The best way to maximize throughput is to use a combination of sensible channel grouping and external signal conditioning. When using the channel-gain queue, consider the following suggestions:

- Put all channels that use the same range in the same group, even if you must arrange the channels out of sequence.
- To acquire low-level signals at high-speeds, preamplify the signal to the maximum input range of the board using external signal. External amplification increases total system throughput and reduces noise.
- If low-level inputs are relatively slow and high-level inputs are relatively fast, maintain two channel lists: one for slow inputs and the other for fast inputs.
- If some channels are not used, you can provide extra settling time for a channel that is used, as follows:
  - Assign two (or more) consecutive, identical channel-gain entries to this channel.
  - Ignore the measurement results from the first channel-gain entry.

  This approach allows the input signal measured through the first entry to largely wash out residuals before the same input signal is measured through the second entry.

You must take special care when directly measuring low-level signals with the KPCI-1801HC. When using the ±20mV, 0 to 20mV, ±100mV, or 0 to 100mV ranges, measurement throughput drops for two reasons:

- The amplifier settles more slowly (particularly in the ±20mV and 0 to 20mV ranges).
- Noise in the measurements is higher and therefore requires post-acquisition filtering (averaging) to achieve accurate results.

Because the KPCI-1801HC has a very high bandwidth — about 8 to 10MHz for low level signals — any noise is amplified and digitized. Therefore, you must measure low-level signals carefully to minimize noise effects.

Low-level transducers are best used with signal conditioning. Always use the differential input mode when making measurements with the ±20mV, 0 to 20mV, ±100mV, and 0 to 100mV ranges.

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Subsequent sections show throughput for various configurations. Note that these throughputs are based on driving an input with an ideal voltage source. The output impedance and drive capabilities of the source are far more critical when making large gain changes between two channels, especially when the gains are at opposite extremes of the input range. Examples follow:

- Consider the measurement of a signal near –20mV just after measurement of a signal near +5V. You get better performance when driving adjacent channels at the same gain.
- The source must be able to drive both the capacitance of the cable and the RC for the multiplexer and board (the product of the multiplexer resistance and output capacitance). The multiplexer typically presents about 1kΩ (2kΩ maximum) in series with 150pF output capacitance.

Throughput for channel-to-channel sampling at fixed gain

If you are sampling at only one channel at any gain, the maximum throughput is 333 ksamples/s.

If you are sampling multiple channels at a fixed gain, the maximum throughput for channel-to-channel sampling is as listed in Table 2-3 for bipolar mode and in Table 2-4 for unipolar mode. In both cases, a 0.024% maximum error applies, assuming an ideal voltage source.

Table 2-3
Maximum throughput for channel-to-channel sampling at fixed gain: bipolar mode

KPCI-1801HC Range	KPCI-1802HC Range	Throughput
—	±10.0V	312.5 ksamples/s
±5.00V	±5.00V	312.5 ksamples/s
—	±2.50V	312.5 ksamples/s
—	±1.25V	312.5 ksamples/s
±1.00V	—	312.5 ksamples/s
±100mV	—	312.5 ksamples/s
±20mV	—	75 ksamples/s

Table 2-4
Maximum throughput for channel-to-channel sampling at fixed gain: unipolar mode

KPCI-1801HC range	KPCI-1802HC range	Throughput
—	0 to 10.0V	312.5 ksamples/s
0 to 5.00V	0 to 5.00V	312.5 ksamples/s
—	0 to 2.50V	312.5 ksamples/s
—	0 to 1.25V	312.5 ksamples/s
0 to 1.00V	—	312.5 ksamples/s
0 to 100mV	—	200 ksamples/s
0 to 20mV	—	60 ksamples/s

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Throughput for channel-to-channel sampling at variable gain

If you have a KPCI-1801HC board and are changing gains between channels, the maximum throughputs are as listed in Table 2-5 for bipolar mode and in Table 2-6 for unipolar mode. In both cases, a 1 LSB (Least Significant Bit) maximum error applies, assuming an ideal voltage source.

Table 2-5
Maximum KPCI-1801HC throughput when changing gain between channels: bipolar mode

When changing range...	Maximum throughput			
	To ±5V	**To ±1.0V**	**To ±100mV**	**To ±20mV**
From ±5.0V	312.5 ksamples/s	250 ksamples/s	200 ksamples/s	70 ksamples/s
From ±1.0V	250 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	70 ksamples/s
From ±100mV	200 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	70 ksamples/s
From ±20mV	70 ksamples/s	70 ksamples/s	70 ksamples/s	75 ksamples/s

Table 2-6
Maximum KPCI-1801HC throughput when changing gain between channels: unipolar mode

When changing range...	Maximum throughput			
	To 0 to 5V	**To 0 to 1.0V**	**To 0 to 100mV**	**To 0 to 20mV**
From 0 to 5.0V	312.5 ksamples/s	200 ksamples/s	200 ksamples/s	50 ksamples/s
From 0 to 1.0V	200 ksamples/s	312.5 ksamples/s	250 ksamples/s	60 ksamples/s
From 0 to 100mV	200 ksamples/s	250 ksamples/s	250 ksamples/s	60 ksamples/s
From 0 to 20mV	50 ksamples/s	60 ksamples/s	60 ksamples/s	60 ksamples/s

If you have a KPCI-1802HC board and are changing gains between channels, the maximum throughputs are as listed in Table 2-7 for bipolar mode and in Table 2-8 for unipolar mode. In both cases, a 1 LSB (Least Significant Bit) maximum error applies, assuming an ideal voltage source.

Table 2-7
Maximum KPCI-1802HC throughput when changing gain between channels: bipolar mode

When changing range...	Maximum throughput			
	To ±10.0V	**To ±5.0V**	**To ±2.50V**	**To ±1.25V**
From ±10.0V	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s
From ±5.0V	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s
From ±2.50V	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s
From ±1.25V	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s	312.5 ksamples/s

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Table 2-8
Maximum KPCI-1802HC throughput when changing gain between channels: unipolar mode

When changing range...	Maximum throughput			
	To 0 to 10.0V	**To 0 to 5.0V**	**To 0 to 2.5V**	**To 0 to 1.25V**
From 0 to 10.0V	312.5 ksamples/s	312.5 ksamples/s	250 ksamples/s	200 ksamples/s
From 0 to 5.0V	312.5 ksamples/s	312.5 ksamples/s	250 ksamples/s	200 ksamples/s
From 0 to 2.5V	250 ksamples/s	250 ksamples/s	312.5 ksamples/s	200 ksamples/s
From 0 to 1.25V	200 ksamples/s	200 ksamples/s	200 ksamples/s	312.5 ksamples/s

Data conversion modes

KPCI-1800HC Series boards support two data-conversion modes: paced mode and burst mode. The conversion rate for each mode is controlled by an independent clock: the pacer clock for paced mode and the burst-mode conversion clock for burst mode.

Paced conversion mode

The paced mode, which is the default data-conversion mode, is the best mode for continuous, constant-rate scanning of each channel in a queue of channels. In the paced mode, one channel in the channel-gain queue is sampled and converted each time the pacer clock emits a pulse. The entire channel-gain queue is scanned at a rate equal to the pacer clock rate divided by the number of channels in the queue. Therefore, the sample rate — the rate at which an individual channel in the queue is repetitively sampled — is also equal to the pacer clock rate, divided by the number of channels in the queue. See Figure 2-5. The internal pacer clock is programmable from 0.0012Hz to 333kHz.

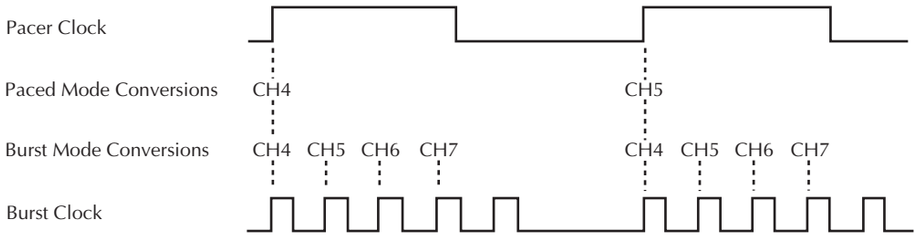
Burst conversion mode

The burst conversion mode is the best mode to use if you need to complete scans of the entire channel-gain queue quickly — close to simultaneously — and initiate scans of the entire queue at a significantly lower rate. For example, you would use the burst mode if you wish to complete scans of the entire queue at 1000 conversions/sec but wish to initiate scans of the entire queue only every second.

In the burst mode, each pulse from the pacer clock initiates a burst of pulses from the burst clock which are emitted at the burst clock rate. Each pulse from the burst clock causes one channel in the queue to be sampled and converted, and burst clock pulses continue until the entire queue is scanned. In summary, scans of the channel-gain queue are repetitively initiated at a rate equal to the pacer clock rate, and scans of the queue are completed at a rate equal to the burst clock rate. Therefore, the sample rate — the rate at which an individual channel in the queue is repetitively sampled — is also equal to the pacer clock rate. See Figure 2-5.

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Figure 2-5
Paced mode and burst mode timing for a queue of channels 4 to 7



Clock sources

KPCI-1800HC Series boards provide two conversion clocks: a pacer clock and a burst mode clock. The use of these clocks in the paced and burst conversion modes is described in *Data conversion modes* and summarized in Figure 2-5. The clock sources themselves are described in the following subsections.

Pacer clock sources

The following clock sources may be used for paced mode conversions on KPCI-1800HC Series boards:

- **Software clock source**

  KPCI-1800HC Series boards allow you to acquire single samples under program control. In other words, conversions are controlled through the Windows interface rather than by hardware signals. When using a software conversion clock, the host computer issues a command to initiate a conversion. The host polls the board to determine if the conversion is complete. When the conversion is complete, the host reads the data from the A/D converter and returns the value.

  Software-initiated conversions are suitable for measuring DC voltages. However, in applications where you must accurately control the sampling rate (as when measuring time-varying signals), using either an internal or external hardware clock source is recommended, as described below.

- **Hardware clock source, internal (Internal pacer clock source)**

  The internal, onboard pacer clock source uses counters of the onboard 82C54 counter/timer, in combination with a crystal-controlled time base running at 5MHz (a crystal output of 10MHz, immediately divided by 2). You can program the internal pacer clock rate from 0.0012Hz to 333kHz.

  You can use the internal pacer clock source to pace events other than analog-to-digital conversions. However, all events timed by the internal pacer clock source are paced at the same rate.

- **Hardware clock source, external (External pacer clock source)**

  An external pacer clock source is an externally applied TTL-compatible signal attached to the DI0/XPCLK pin (B39) of the main I/O connector, J1.The active edge of the signal that is recognized as a clock pulse — either a positive, rising edge or a negative, falling edge — is software selectable.

  By using an external pacer clock source, you can sample at rates unavailable from the 82C54 counter/timer, at uneven intervals, or in response to external events. An external pacer clock source also allows you to synchronize multiple boards via a common timing signal.

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You can use the external pacer clock source in the paced conversion mode to pace individual analog-to-digital conversions. You can use the external pacer clock source in the burst conversion mode to pace space bursts of conversions. Refer to Figure 2-5.

NOTE *The A/D converter converts samples at a maximum of 333 ksamples/s (one sample every 3.0µs), and the practical throughput is generally lower. Refer to the previous section entitled "Throughput". If you use an external clock, ensure that it does not initiate conversions more frequently than the maximum throughput for your data acquisition setup.*

Keep in mind that the maximum sample rate for an individual channel equals the maximum throughput divided by the number of channels in the channel-gain queue.

You cannot simultaneously use an external pacer clock source and the internal pacer clock source. However, you can simultaneously use a software trigger source to start analog input conversions while simultaneously using either an internal or external pacer clock source for other I/O operations.

Burst clock source

In the burst mode, the burst clock sets the rate at which burst pulses are emitted and individual channels in the channel-gain queue are converted. The burst clock works with the pacer clock, which sets the rate at which groups of burst pulses are initiated. See Figure 2-5.

Burst clock and pacer clock frequencies are programmable, as follows:

- The burst clock rate can be set from 3921.6Hz to 333kHz. The maximum burst mode conversion clock rate is gain-sensitive, as explained in *Throughput*.
- The pacer clock rate should be set no higher than the burst clock rate divided by the number of channels in the channel-gain queue.

Triggers

Triggers are external digital signals or, in some cases, threshold crossings of analog signals. Triggers act at a single instant in time, in contrast to gates, which start analog input operations when the gate is turned on and stop the input operations when the gate is turned off. (Refer also to *Gates* in this section.)

Trigger sources

Trigger sources may be internal or external, as follows:

- **Internal triggers**

  An internal trigger is a software command that starts or stops data acquisition.
- **External digital triggers**

  An external digital trigger is the rising or falling edge of a TTL-compatible signal that is connected to digital input DI1/TGIN, pin B40 on the I/O.

  Use software to configure the DI1/TGIN input as a trigger (instead of as a gate or as a general-purpose digital input). Also use software to program whether analog input operations start on either positive or negative triggers, which are defined as follows:
  - *Positive-edge trigger* — Triggering occurs on the rising edge of the trigger signal.
  - *Negative-edge trigger* — Triggering occurs on the falling edge of the trigger signal.

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- **External analog triggers**

  An external analog trigger is an event that occurs at a user-selected point on an analog input signal, such as a specified rising or falling voltage level. An analog trigger is not provided on the KPCI-1800HC Series boards.

Trigger operation and clock source effects

The actual point at which conversions begin depends on whether the clock source is internal or external, as follows:

- **Internal trigger operation with internal clock source**

  If conversions are triggered with an internal trigger and timed via an internal pacer clock source, then conversions begin virtually immediately after the trigger, as follows:

  1. The 82C54 counter/timer is idle until the internal trigger occurs; after the trigger occurs, the first conversion begins virtually immediately.
  2. Subsequent conversions are synchronized to the internal clock.

  See Figure 2-6.

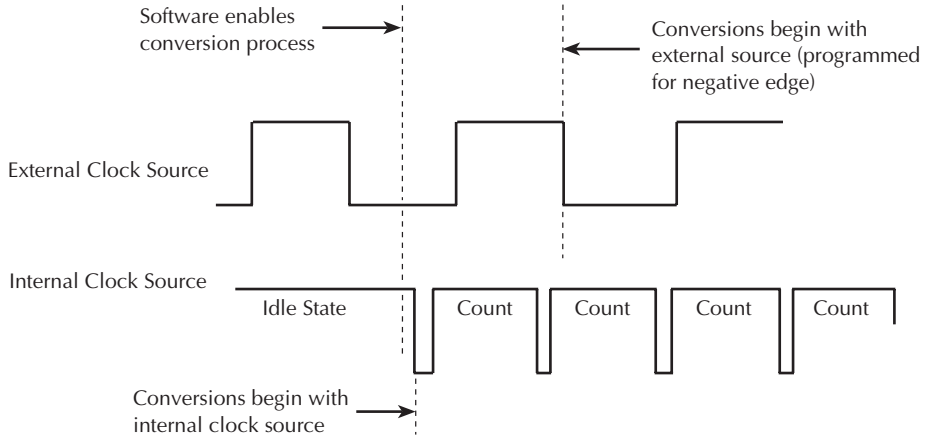
- **Internal trigger operation with external clock source**

  If conversions are triggered with an internal trigger and timed via an external clock source, then analog input operations are triggered as follows:

  1. Conversions are armed when the trigger occurs.
  2. Conversions begin with the next active edge of the external clock source.
  3. Conversions continue with subsequent active edges of the external clock source.

  See Figure 2-6.

Figure 2-6
Enabling conversions with software triggers



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- **External trigger operation with internal clock source**

  If conversions are triggered with an internal trigger and timed via an internal pacer clock source, then analog input operations are triggered as follows:

  1. Conversions begin virtually immediately after the internal trigger:
  2. The 82C54 counter/timer is idle until the internal trigger occurs. However, after the trigger occurs, the first conversion begins within 400ns.
  3. Subsequent conversions are synchronized to the internal clock.

  See Figure 2-7.

- **External trigger operation with external clock source**

  If conversions are triggered with an internal trigger and timed via an external clock source, then analog input operations are triggered as follows:

  1. Conversions are armed when the trigger occurs.
  2. Conversions begin with the next active edge of the external clock source.
  3. Conversions continue with subsequent active edges of the conversion clock.

  See Figure 2-7.

Figure 2-7
Enabling conversions with hardware triggers

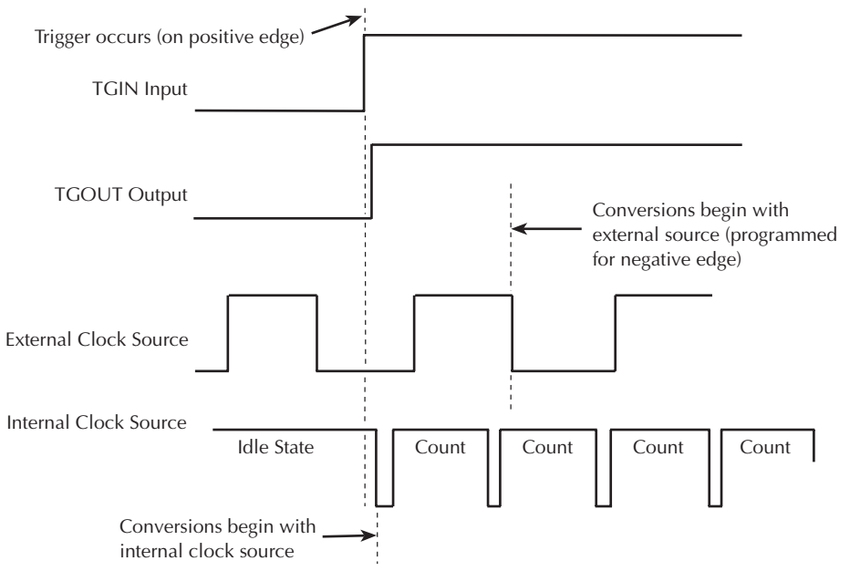


Figure 2-7 also shows that a pulse is initiated at the trigger out (TGOUT digital output just following the external trigger pulse at DI1/TGIN. For more information about TGOUT, refer to the section *Trigger-out (TGOUT) digital control output.*

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Trigger acquisition modes

Depending on your application, you may wish to use a trigger event to do one of the following: to start data collection, to halt data collection after a specified amount of additional data is collected, or to halt data collection abruptly. Three trigger modes are available in the KPCI-1800HC to accomplish these objectives.

- **Post-trigger acquisition mode**

  In post-trigger acquisition, the data to be acquired appears after the trigger event. Post-trigger acquisition, starts after an internal or external trigger event and continues until a specified number of samples has been acquired or until the operation is stopped by software. See Figure 2-8a. Post-trigger, the most common trigger acquisition mode, has many obvious applications.

- **About-trigger acquisition mode**

  In about-trigger acquisition, the data to be acquired appears before and after the trigger event. About-trigger acquisition is started by an internal or external trigger and continues after an external trigger event until a specified number of samples has been acquired. See Figure 2-8b. For example, if you were performing a car crash safety test, you might wish to do the following:

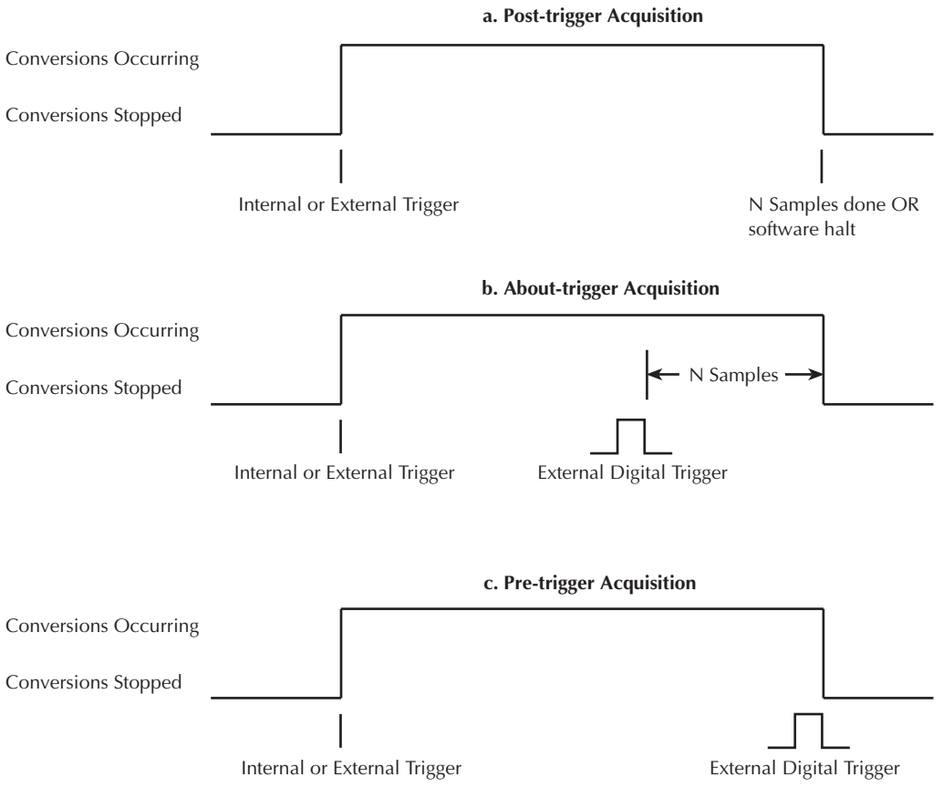
  1. Monitor speed and acceleration up to the point of impact.
  2. Emit an accelerometer-based trigger pulse at impact.
  3. Monitor crash-dummy impact forces and movement for a fixed number of samples after impact.

- **Pre-trigger acquisition mode**

  In the pre-trigger acquisition mode, the data to be acquired appears before the trigger event. A pre-trigger acquisition is started by an internal or external trigger and continues until an external trigger event occurs. See Figure 2-8c. For example, if you were monitoring an experimental process, you might wish to trigger process data acquisition to stop automatically at completion of the process.

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Figure 2-8
Trigger acquisition modes



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Gates

A gate is a digital input that allows conversions to proceed as long as it is active and causes conversions to be halted as long as it is inactive. In other words, conversions can be started and stopped at will by turning the gate input on and off. (By contrast, a trigger acts at a single instant in time. Refer also to *Triggers* in this section.)

An external gate signal is connected to digital input DI1/TGIN, pin B40 on the I/O connector. This is the same input as used for an external trigger. Software is used to configure the DI1/TGIN input as a gate (instead of as a trigger or as a general-purpose digital input).

The way conversions are synchronized with a gate signal depends on whether you are using an internal clock or external clock source, as follows:

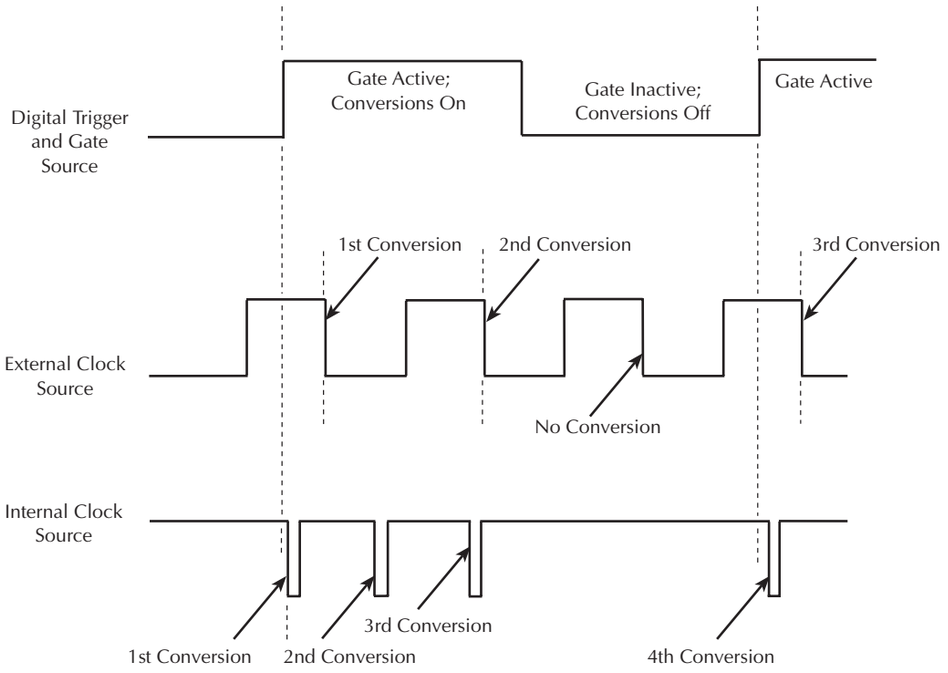
- **Gate operation with internal clock source**

  When using the gate input with an internal clock, conversions are synchronized with the internal gate signal. When the gate signal becomes active, the 82C54 counter is loaded (or reloaded) with an initial count value and starts counting, and data conversion starts (or resumes). When the gate signal becomes inactive, the 82C54 counter stops and data conversion stops. See Figure 2-9.

- **Gate operation with external clock source**

  When using the gate input with an external clock signal, conversions are synchronized with the external gate signal. When the gate signal becomes inactive, the signal from the external clock continues uninterrupted. See Figure 2-9.

Figure 2-9
Enabling conversions with gates



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Analog output features

The analog output section of KPCI-1800HC Series boards consists of two 12-bit DACs (digital-to-analog converters). Each DAC has a fixed voltage range of ±10V and a voltage resolution of 2.4mV [(10V range × 1000mV/V) /2^{12}]. The DAC output always initiates to 0V at power-up or reset. The two DACs have output current ratings of ±5mA maximum and can drive capacitive loads of up to 100µF.

An analog output voltage changes on command, when an individual voltage value is written to a DAC by software. This method is sometimes referred to as "level control."

Digital input and output features

KPCI-1800HC Series boards have eight general-purpose digital outputs, two digital control outputs, two general-purpose digital inputs, and two dual-function digital inputs that can be configured either as general purpose inputs or as control inputs.

Logic 1 on an I/O line indicates that the input/output is high (greater than 2.0V); logic 0 on an I/O line indicates that the input/output is low (less than 0.8V). The digital inputs are compatible with TTL-level signals. These inputs are provided with 10kΩ pull-up resistors connected to +5V; therefore, the inputs appear high (logic 1) if no signal is connected.

General purpose digital inputs and outputs

The digital outputs DO0 through DO7 are fixed as general-purpose digital outputs. Likewise, digital inputs DI2 and DI3 are fixed as general-purpose digital inputs.

The two remaining digital inputs, DI0/XPCLK and DI1/TGIN are dual-purpose inputs. You can configure them to be general-purpose inputs DI0 and DI1. Alternatively, you can configure DI0/XPCLK to be an external pacer clock input (XPCLK), and/or you can configure DI1/TGIN to be an external trigger input (TGIN). (The XPCLK and TGIN control inputs are discussed in the next two sections.)

External pacer clock (XPCLK) digital control input

You can configure digital input DI0/XPCLK as an external pacer-clock input (XPCLK). Then you can connect DI0/XPCLK to an external hardware-clock source to time analog inputs. However, when DI0/XPCLK is configured as an external pacer-clock input, you cannot use it as a general-purpose digital input.

You cannot use the external pacer-clock source and the internal pacer-clock source simultaneously. However, you can simultaneously use the software-clock source to start analog input conversions while simultaneously using either an internal or external hardware-clock source for other I/O operations.

Trigger in (TGIN) digital control input

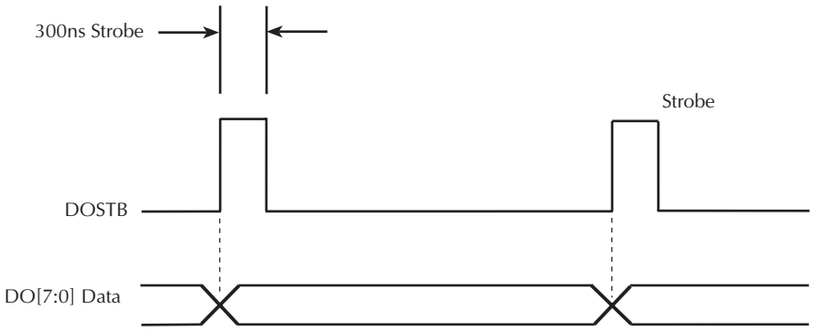
You can configure digital input line DI1/TGIN as an external digital trigger input or gate input and connect DI1/TGIN to a trigger or gate signal. When DI1/TGIN is configured as a trigger or gate input, you cannot use it as a general-purpose digital input.

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Strobe (DOSTB) digital control output

At pin A42 of the I/O connector, each KPCI-1800HC Series board provides a strobe output signal, DOSTB, that can be used to coordinate moving data out of digital outputs and latching this data into registers of other equipment. Use the positive (rising) edge of the strobe signal to move data out of a KPCI-1800HC Series board, and use the negative edge of the strobe signal to latch this data into the other equipment. The strobe pulse is 300ns wide, and using the negative edge of the pulse provides a 300ns lag to allow for delays. Data is valid until the next strobe pulse occurs. See Figure 2-10.

Figure 2-10
Timing relationship between data from DO0 to DO7 and latch strobe DOSTB



Trigger-out (TGOUT) digital control output

At pin A41 of the I/O connector, each KPCI-1800HC Series board provides a trigger/gate output signal, TGOUT, that is synchronized with internal and external gate signals. If you use only the internal pacer clock to trigger analog I/O operations, you can use the TGOUT signal to synchronize analog I/O operations at multiple KPCI-1800HC Series boards. Alternatively, you can use the TGOUT signal to trigger or gate user-specific events. The TGOUT signal has the following properties:

- **TGOUT signal with an external trigger input signal**

  When you start an analog input operation with an external trigger signal at DI1/TGIN, there is a delay of about 200ns between the active edge of the TGIN signal and the positive, rising edge of the TGOUT signal. See Figure 2-11a.

NOTE *TGOUT cannot be used with about-trigger acquisitions.*

- **TGOUT signal with an external gate input signal**

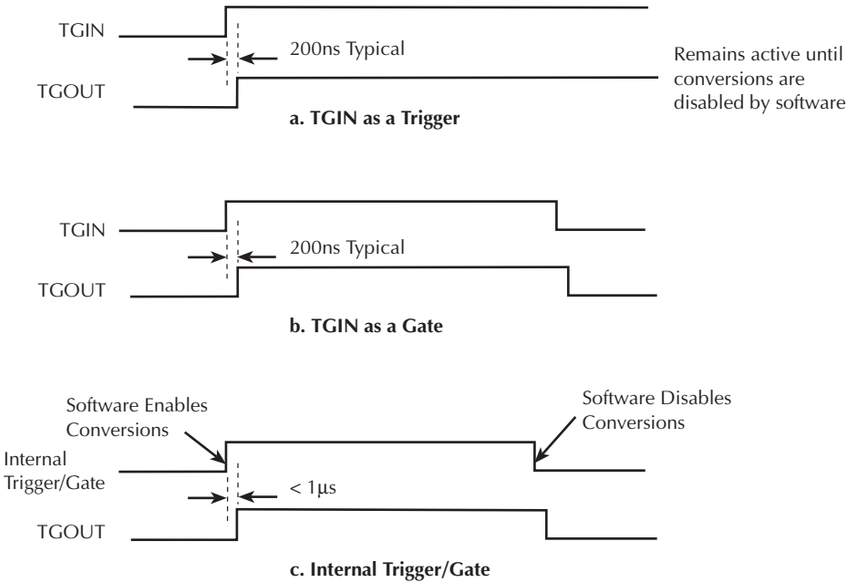
  When you start an analog input operation via an external gate signal at DI1/TGIN, there is a delay of about 200ns between the active edge at TGIN and the positive, rising edge of TGOUT. See Figure 2-11b.

- **TGOUT signal with an internal trigger or gate signal**

  When you start an analog input operation via an internal trigger/gate, there is a delay of less than 1µs between the active edge of the internal trigger/gate and the positive, rising edge of TGOUT. See Figure 2-11c.

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Figure 2-11
Timing for the generation of TGOUT



Power

A KPCI-1800HC Series board requires 10W of +5V power from the host computer power bus and 6W of +12V power from this power bus to operate onboard circuits.

Additional power for light duty external circuits may be drawn directly or indirectly from the host computer power bus at the KPCI-1800HC Series I/O connector. The +5V power from the computer bus is available for external use, at a maximum **total** current draw of 1A, at pins A47, B47, A48, and B48 of the I/O connector. Part of the ±15V board power, which is developed from the +12V computer bus power by an onboard DC/DC converter, is available for external use at a maximum current draw of ±30mA. The -15V power is available at pin A37 of the I/O connector and the +15V power is available at pin B37 of the I/O connector.

CAUTION **Do not connect the +5V outputs or the ±15V outputs to external power supplies. Connecting these outputs to external power supplies may damage the external supplies, the board, and the computer.**

Do not draw more than 1.0A, total, from all +5V outputs combined. Drawing more than 1.0A, total, may damage the board. However, keep in mind that the 5V output comes from the computer power bus. Know the limits of the computer 5V power bus and the current drawn from it by other boards and devices. Other demands on the 5V power bus may limit the current drawn from your board to less than 1.0A.

Do not draw more than 30mA from either the +15V output or the -15V output. Drawing more than 30mA may damage the board.

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3
Installation

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This section describes system installation, in the following order:

- Software options and installation guidelines. (Note: install the software before installing the hardware.)
- Hardware installation, including the following:
  - Unwrapping and inspecting the board
  - Physically installing the board
  - Checking the combined board and DriverLINX installation
  - Identifying the I/O connector pins
  - Wiring your circuits to the I/O connector pins (via the wiring accessories)
  - Synchronizing multiple boards
  - Powering your circuits from the from the board

Installing the software

NOTE *Install the DriverLINX software before installing the KPCI-1800HC Series board. Otherwise, the device drivers will be more difficult to install.*

Software options

Users of KPCI-1800HC Series boards have the following two software options. In both cases, the software interfaces with your system via the DriverLINX software provided with your board:

- The user can run a fully integrated data-acquisition software package such as TestPoint or LabVIEW.
- The user can write and run a custom program in Visual C/C++, Visual Basic, or Delphi, using the programming support provided in the DriverLINX software.

A summary of the pros and cons of using integrated packages or writing custom programs is provided in the Keithley Full Line Catalog.

The KPCI-1800HC Series has fully functional driver support for use under Windows 95/98/NT.

DriverLINX driver software for Windows 95/98/NT

DriverLINX software, supplied by Keithley with the KPCI-1800HC Series board, provides convenient interfaces to configure analog and digital I/O modes without register-level programming.

Most importantly, however, DriverLINX supports those programmers who wish to create custom applications using Visual C/C++, Visual Basic, or Delphi. DriverLINX accomplishes foreground and background tasks to perform data acquisition. The software includes memory and data buffer management, event triggering, extensive error checking, and context sensitive online help.

DriverLINX provides application developers a standardized interface to over 100 services for creating foreground and background tasks for the following:

- Analog input and output
- Digital input and output
- Time and frequency measurement
- Event counting
- Pulse output
- Period measurement

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In addition to basic I/O support, DriverLINX also provides:

- Built-in capabilities to handle memory and data buffer management.
- A selection of starting and stopping trigger events, including pre-triggering, mid-point triggering and post-triggering protocols.
- Extensive error checking.
- Context-sensitive on-line help system DriverLINX is essentially hardware independent, because its portable APIs (Application Programming Interfaces) work across various operating systems. This capability eliminates unnecessary programming when changing operating system platforms.

TestPoint™

TestPoint is a fully featured, integrated application package that incorporates many commonly used math, analysis, report generation, and graphics functions. The TestPoint graphical drag-and-drop interface can be used to create data acquisition applications, without programming, for IEEE-488 instruments, data acquisition boards, and RS232-485 instruments and devices.

TestPoint includes features for controlling external devices, responding to events, processing data, creating report files, and exchanging information with other Windows programs. It provides libraries for controlling most popular GPIB instruments. OCX and ActiveX controls plug directly into TestPoint, allowing additional features from third party suppliers.

TestPoint interfaces with your KPCI-1800 Series board through DriverLINX, using a driver that is provided by the manufacturer.

LabVIEW™

LabVIEW is a fully featured graphical programming language used to create virtual instrumentation. It consists of an interactive user interface, complete with knobs, slide switches, graphs, strip charts, and other instrument panel controls. Its data-driven environment uses function blocks that are virtually wired together and pass data to each other. The function blocks, which are selected from palette menus, range from arithmetic functions to advanced acquisition, control, and analysis routines. Also included are debugging tools, help windows, execution highlighting, single stepping, probes, and breakpoints to trace and monitor the data flow execution. LabVIEW can be used to create professional applications with minimal programming.

A Keithley VI palette provides standard virtual instruments (VIs) for LabVIEW that interface with your KPCI-1800 Series board through DriverLINX. The needed driver is provided on your DriverLINX CD-ROM.

Installing DriverLINX

Refer to the instructions on the *Read this first* sheet and the manuals on the DriverLINX CD-ROM, both shipped with your board, for information on installing and using DriverLINX.

Installing application software and drivers

Installing the TestPoint software and driver

The DriverLINX driver for TestPoint is provided as part of the TestPoint software. The driver therefore installs automatically when you install TestPoint.

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You can install TestPoint application software, made by Capital Equipment Corporation (CEC), at any time — before or after installing DriverLINX and the KPCI-1800HC board. For TestPoint installation instructions, consult the manual provided by CEC.

NOTE *Before using TestPoint with the KPCI-1800 version of DriverLINX, check with CEC to ensure that your version of TestPoint is compatible with DriverLINX.*

Installing the LabVIEW software and driver

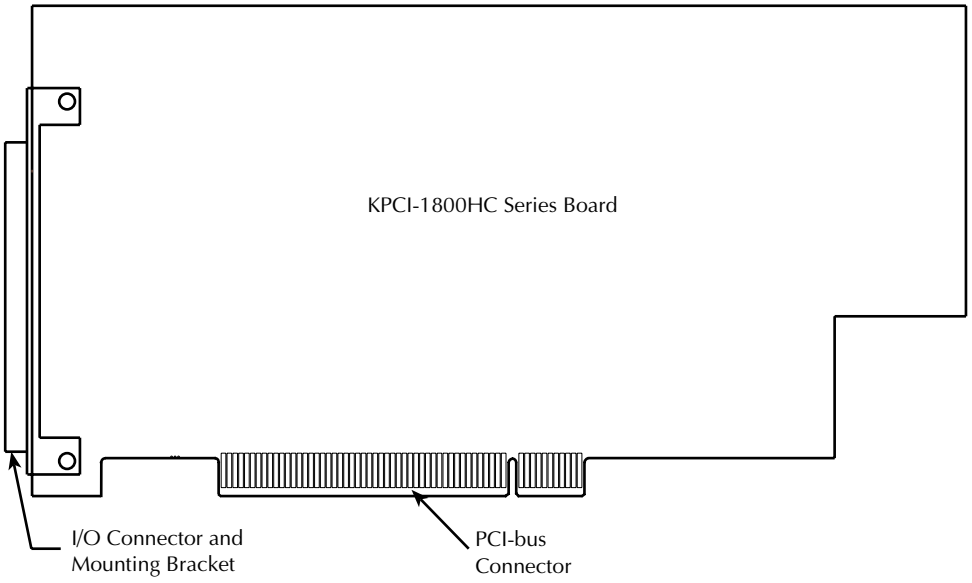
A DriverLINX driver for LabVIEW is provided on your DriverLINX CD-ROM. The LabVIEW driver does not install automatically when you install DriverLINX and your board. You must first install the LabVIEW application program, then install the DriverLINX driver. Access the LabVIEW driver installation routine by starting setup.exe on the DriverLINX CD-ROM, then selecting LabVIEW™ Support from the Install These DriverLINX components screen.

Consult the manual provided by National Instruments for LabVIEW installation instructions.

Installing and wiring to the KPCI-1800HC Series board

The remainder of this section describes physically installing the KPCI-1800HC Series board, connecting interfaces to the board, and wiring circuits to the interfaces. KPCI-1800HC Series board connectors involved in these operations are labeled in Figure 3-1.

Figure 3-1
Connectors on the KPCI-1800HC Series board



The remainder of this section is ordered according to the following recommended installation sequence:

1. Install the board in your computer, as described in *Installing the board.*
2. Check the installation as described in *Checking the combined board and DriverLINX installations*.

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3. Review the I/O connections for each pin on the 100-pin I/O connector of your board. Connector pin assignments for the KPCI-1800HC Series boards are identified and described under *Identifying I/O connector pin assignments for KPCI-1800HC series*.
4. Connect the appropriate screw terminal other interface accessory(s) to your board, using an appropriate cable assembly. An interface accessory is required to wire the board to your circuits. These accessories range from a basic screw terminal connector (STA-100) to signal conditioning accessories. Use of interface accessories and cables is described under *Connecting interface accessories to a KPCI-1800HC Series board.*
5. Wire your circuits to the interface accessories that you connected to the board in step 3. Refer to the sections *Wiring analog input signals*, *Wiring analog output signals*, and *Wiring digital input and output signals*.
6. If you wish to synchronize multiple KPCI-1800HC Series boards, interconnect the trigger or gate signals as described under *Synchronizing multiple boards*.
7. If you desire to use KPCI-1800HC Series board power for any of your circuits, be sure to read *Wiring +5V and ±15V power to external circuits* before proceeding.

Installing the board

CAUTION **Ensure that the computer is turned OFF before installing or removing a board. Installing or removing a board while power is ON can damage your computer, the board, or both.**

Handle the board in a static-controlled workstation; wear a grounded wrist strap. Discharge static voltage differences between the wrapped board and the handling environment before removing the board from its protective wrapper. Failure to discharge static electricity before and during handling may damage semiconductor circuits on the board.

Handle the board using the mounting bracket. Do not touch the circuit traces or connector contacts when handling the board.

Checking resources for the board

Ensure that your computer has sufficient resources, particularly power resources, to run your KPCI-1800HC board. Check the capacity of the computer power supply and the power requirements of your computer and presently installed boards. Adding a KPCI-1800 Series board requires an additional 870mA at +5V, maximum, and an additional 550mA at +12V, maximum. If necessary, free resources by uninstalling other boards.

Unwrapping and inspecting the KPCI-1800HC Series board

NOTE *Install the DriverLINX software before installing the KPCI-1800HC board. Otherwise, the device drivers will be more difficult to install.*

After you remove the wrapped board from its outer shipping carton, unwrap and inspect it as follows:

1. Your board is packaged at the factory in an anti-static wrapper. Do not remove the anti-static wrapper until you have discharged any static electricity voltage differences between the wrapped board and the environment. Wear a grounded wrist strap. A grounded wrist strap

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discharges static electricity from the wrapped board as soon as you hold it. Keep the wrist strap on until you have finished installing the board.

2. Remove the KPCI-1800HC Series board from its anti-static wrapping material. (You may wish to store the wrapping material for future use.)
3. Inspect the board for damage. If damage is apparent, arrange to return the board to the factory. Refer to Section 6, *Technical support*.
4. Check the remaining contents of your package against the packing list and report any missing items immediately.
5. If the inspection is satisfactory, proceed to *Installing the KPCI-1800HC Series board*.

Installing the KPCI-1800HC Series board

Install a KPCI-1800HC Series board in a PCI expansion slot on your computer as follows:

1. Turn power OFF to the computer and to any external circuits attached to the board.
2. Remove the computer chassis cover.
3. Select an unoccupied PCI expansion slot in the rear panel, and remove the corresponding dummy mounting plate.
4. Insert the PCI connector of the board into the selected PCI slot of the computer. Take care not to interfere with neighboring boards. Ensure that the board is properly seated in the slot.
5. Secure the mounting bracket of the board to the chassis, using the retaining screw that you removed when you removed the dummy mounting plate.

Configuring the board to work with DriverLINX

After physically installing the board, turn on and reboot the computer. The DriverLINX Plug and Play Wizard screen appears. Run the Wizard immediately by following the progressive instructions on the screen.

If you do not run the Wizard immediately, it will not appear the next time you reboot. You must then start the Wizard from a batch file, as follows:

1. Open the Windows Explorer.
2. Double click on X:\DrvLINX4\Help\kpci1800.bat, where X = the letter of the drive on which you installed DriverLINX.

   The Wizard appears.

NOTE *You can also start this batch file directly from the CD-ROM by double clicking on Y:\DrvLINX4\Help\kpci1800.bat, where Y = the drive letter of your CD-ROM drive.*

Checking the combined board and DriverLINX installations

Before making any connections to the board, check whether DriverLINX and your board are installed correctly and working together properly. Do this using the first two steps of *Problem isolation scheme B: installation* in Section 6. The first two steps evaluate whether the DriverLINX Analog I/O Panel utility starts properly. If the Panel does not start properly at first, remaining steps lead you through diagnostic and remedial efforts. If necessary, steps lead you to deinstall, then reinstall DriverLINX and the board.

Do the following:

1. Turn ON your computer and boot Windows 95, 98, or NT.
2. Perform the first two steps of *Problem isolation scheme B: installation* in Section 6.

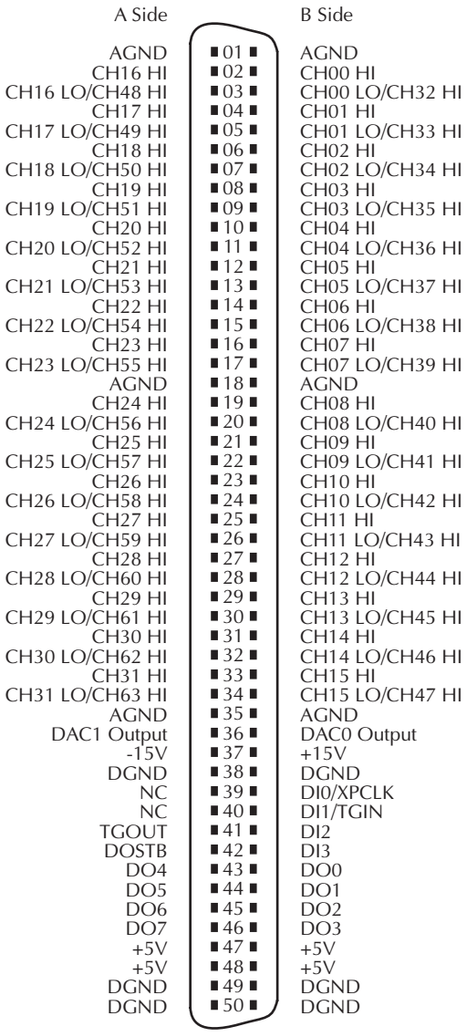
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3. If you cannot initially run the Analog I/O Panel, perform additional steps of *Problem isolation scheme B: installation* as directed.
4. After DriverLINX and your board are installed properly and working together, continue with, *Identifying I/O connector pin assignments for KPCI-1800HC Series* below.

Identifying I/O connector pin assignments for KPCI-1800HC series

Figure 3-2 and Tables 3-1 and 3-2 show and describe the pin assignments for the I/O connector, a 100-pin D-type connector, which is located at the rear of the board.

Figure 3-2
Pin assignments for the I/O connector of the KPCI-1800HC Series boards



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Table 3-1
Descriptions for A side pins

Pin No.	Pin label	Description	
A1	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
A2 A4 A6 : A16	CH16 HI CH17 HI CH18 HI : CH23 HI	Channel 16 high level input Channel 17 high level input Channel 18 high level input : Channel 23 high level input	
		If analog inputs are configured as differential:	If analog inputs are configured as single-ended:
A3 A5 A7 : A17	CH16 LO/CH48 HI CH17 LO/CH49 HI CH18 LO/CH50 HI : CH23 LO/CH55 HI	Channel 16 low level input Channel 17 low level input Channel 18 low level input : Channel 23 low level input	Channel 48 high level input Channel 49 high level input Channel 50 high level input : Channel 55 high level input
A18	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
A19 A21 A23 : A33	CH24 HI CH25 HI CH26 HI : CH31 HI	Channel 24 high level input Channel 25 high level input Channel 26 high level input : Channel 31 high level input	
		If analog inputs are configured as differential:	If analog inputs are configured as single-ended:
A20 A22 A24 : A34	CH24 LO/CH56 HI CH25 LO/CH57 HI CH26 LO/CH58 HI : CH31 LO/CH63 HI	Channel 24 low level input Channel 25 low level input Channel 26 low level input : Channel 31 low level input	Channel 56 high level input Channel 57 high level input Channel 58 high level input : Channel 63 high level input
A35	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
A36	DAC1 OUT	Output from digital-to-analog converter number 1.	
A37	-15V	-15VDC at 30mA max. (Refer to *Wiring ±15V power*.)	
A38	DGND	Digital ground. (Refer to *Wiring digital input and output signals*.)	
A39	NC	No connection is to be made to this terminal.	
A40	NC	No connection is to be made to this terminal.	
A41	TGOUT	Trigger/gate output. (Refer to *Wiring digital control signals*.)	
A42	DOSTB	Digital output strobe. (Refer to *Wiring digital control signals*.)	
A43 to A46	DO4, DO5, DO6, DO7	Digital outputs 4, 5, 6, and 7.	
B47, B48	+5V	+5VDC from computer-bus. (Refer to *Wiring +5V power*.)	
A49, A50	DGND	Digital ground. Refer to *Wiring digital input and output signals*.	

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Table 3-2
Descriptions for B side pins

Pin No.	Pin label	Description	
B1	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
B2 B4 B6 : B16	CH00 HI CH01 HI CH02 HI : CH07 HI	Channel 0 high level input Channel 1 high level input Channel 2 high level input : Channel 7 high level input	
  B3 B5 B7 : B17	 CH00 LO/CH48 HI CH01 LO/CH49 HI CH02 LO/CH50 HI : CH07 LO/CH55 HI	If analog inputs are configured as differential: Channel 0 low level input Channel 1 low level input Channel 2 low level input : Channel 7 low level input	If analog inputs are configured as single-ended: Channel 32 high level input Channel 33 high level input Channel 34 high level input : Channel 39 high level input
B18	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
B19 B21 B23 : B33	CH8 HI CH9 HI CH10 HI : CH15 HI	Channel 8 high level input Channel 9 high level input Channel 10 high level input : Channel 15 high level input	
  B20 B22 B24 : B34	 CH08 LO/CH40 HI CH09 LO/CH41 HI CH10 LO/CH42 HI : CH15 LO/CH47 HI	If analog inputs are configured as differential: Channel 8 low level input Channel 9 low level input Channel 10 low level input : Channel 15 low level input	If analog inputs are configured as single-ended: Channel 40 high level input Channel 41 high level input Channel 42 high level input : Channel 47 high level input
B35	AGND	Analog ground. (Refer to *Wiring analog input signals*.)	
B36	DAC0 OUT	Output from digital-to-analog converter number 0.	
B37	+15V	+15VDC at 30mA max. (Refer to *Wiring ±15V power*.)	
B38	DGND	Digital ground. (Refer to *Wiring digital input and output signals*.)	
B39	DI0/XPCLK	Digital input number 0, if configured as a general purpose digital input.	External pacer clock input, if configured as a clock input (Refer to *Wiring digital control signals*.)
B40	DI1/TGIN	Digital input number 1, if configured as a general purpose digital input.	Trigger/gate input, if configured as a trigger/gate input (Refer to *Wiring digital control signals*.)
B41, B42	DI2, DI3	Digital inputs 2 and 3.	
B43 to B46	DO0, DO1, DO2, DO3	Digital outputs 0, 1, 2, and 3.	
B47, B48	+5V	+5VDC from computer-bus (Refer to *Wiring +5V power*.)	
B49, B50	DGND	Digital ground. (Refer to *Wiring digital input and output signals*.)	

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Connecting interface accessories to a KPCI-1800HC Series board

Before you can wire your circuits to a KPCI-1800HC Series board, you must first interface screw terminals to the I/O connector pins of the board. The required screw terminals can be provided by a single accessory or via secondary interface accessories, such as signal conditioning modules. Use of appropriate interface accessories and connecting cables, all available from Keithley, are described in the following subsections. Table 3-3 summarizes the characteristics of the available interface accessories.

Table 3-3
Interface accessories for KPCI-1800HC Series boards

STP-100	Basic screw-terminal accessory. Interfaces each KPCI-1800HC Series I/O connector-pin to a corresponding screw terminal*.
STA-1800HC	Screw-terminal accessory and secondary connector interface. Interfaces KPCI-1800HC Series I/O connector-pins both to screw terminals and to four secondary connectors*. Secondary connectors interface signal conditioning modules with a KPCI-1800HC Series board. Also provides a breadboarding area for user circuits and an onboard temperature measurement circuit that facilitates thermocouple Cold-Junction Compensation (CJC).
CONN-1800HC	Secondary connector interface, only. Effectively an STA-1800HC without the screw terminals, the breadboarding area, or the CJC temperature measurement circuit. Interfaces signal conditioning modules to a KPCI-1800HC Series board*.

*This accessory connects to the 1800HC Series I/O connector via a CAB-1800 series cable.

The contents of this section are:

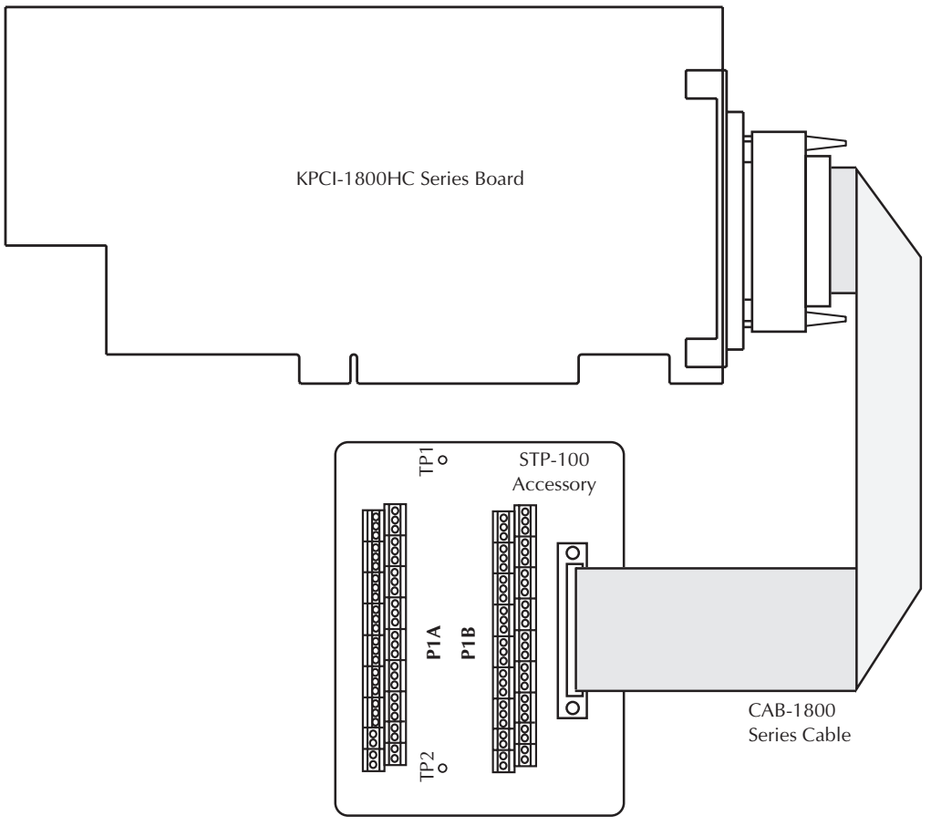
- The first subsection below describes connecting an STP-100 accessory to a KPCI-1800HC Series board.
- The second and third subsections describe connecting an STA-1800HC accessory to a KPCI-1800HC Series board and using the CJC temperature measurement circuit of the STA-1800HC.
- The fourth subsection describes connection of the CONN-1800HC accessory to a KPCI-1800HC Series board.
- The last subsection describes using an STA-1800HC or a CONN-1800HC accessory to connect an MB01 signal conditioning rack to a KPCI-1800HC Series board.

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Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board

The STP-100 accessory provides basic screw terminal wiring to the I/O connector of a KPCI-1800HC Series board. Figure 3-3 shows how the STP-100 interfaces with the board.

Figure 3-3
Connecting an STP-100 screw terminal accessory



As shown in Figure 3-3, use a CAB-1800 Series cable to connect an STP-100 and a KPCI-1800HC. Available CAB-1800 Series cables are listed in Table 3-4.

Table 3-4
CAB-1800 Series cables

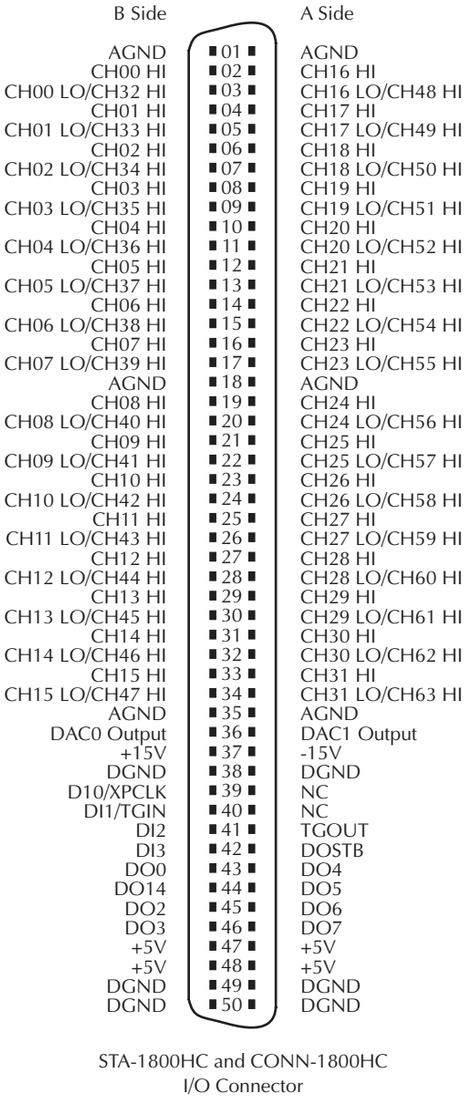
Cable	Description
CAB-1800	18-inch, 100-wire ribbon cable
CAB-1801	36-inch, 100-wire ribbon cable
CAB-1800/S	18-inch, 100-wire, shielded, ribbon cable
CAB-1801/S	36-inch, 100-wire, shielded, ribbon cable

The red wire on CAB-1800 Series cables runs to pin 1 of each cable connector. Be sure to mate pin 1 of each cable connector to pin 1 of a board connector.

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Pin assignments for screw terminals of the STP-100 I/O connector are shown in Figure 3-4. (Note that the I/O connector is physically a mirror image of the pin assignments for the KPCI-1800HC Series I/O connector). Refer to Tables 3-1 and 3-2 under *Identifying I/O connector pin assignments for KPCI-1800HC series* for descriptions of the pin assignments.

Figure 3-4
Pin assignments for the I/O connector of the STP-100 accessory and the main I/O connectors of the STA-1800HC and CONN-1800HC accessories



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Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board

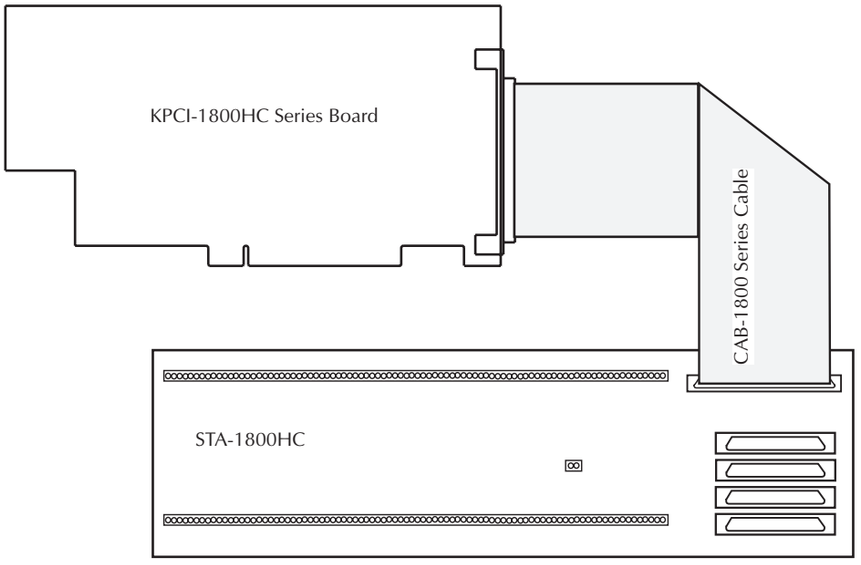
In addition to interfacing screw terminals to the KPCI-1800HC Series I/O connector, the STA-1800HC provides secondary I/O connectors and on-board circuit capabilities. Its features are as follows:

- A 100-pin female connector for cabling to the I/O connector of a KPCI-1800HC Series board.
- 120 labeled screw terminals for connecting sensor outputs and test equipment to the I/O connector of a KPCI-1800HC Series board. Thirty-two separate analog-ground terminals facilitate grounding, especially for differential measurements.
- A CJC (Cold Junction Compensation) circuit that provides an analog board-temperature signal. The CJC signal can be used as an input to KPCI-1800HC, and cold-junction correction values can be calculated for thermocouple inputs.
- Four 37-pin male connectors for cabling to MB01 backplanes.
- A breadboard area for user-installed circuitry.

To connect an STA-1800HC to a KPCI-1800HC Series board, use a CAB-1800 Series cable as shown in Figure 3-5.

Pin assignments for the 100-pin I/O connector of an STA-1800HC are shown in Figure 3-4 which is found in the section *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*. (Note that the I/O connector is physically a mirror image of the pin assignments for the KPCI-1800HC Series I/O connector). Refer to Tables 3-1 and 3-2 under *Identifying I/O connector pin assignments for KPCI-1800HC series* for descriptions of the pin assignments.

Figure 3-5
Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board



Available CAB-1800 Series cables are listed in Table 3-4. The red wire on the CAB-1800 Series cables runs to pin 1 of each cable connector. Be sure to mate pin 1 of each cable connector to pin 1 of a board connector.

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Use the auxiliary 37-pin connectors of the STA-1800HC to connect MB Series modules to a KPCI-1800HC series board. For more information about using the auxiliary 37-pin connectors, refer to the section *Connecting an MB01 module rack (backplane) to a KPCI-1800HC Series board*. Pin assignments for the STA-1800HC auxiliary 37-pin connectors are shown in Figures B-3 through B-6 of Appendix B.

Using the CJC (Cold Junction Compensation) temperature circuit of an STA-1800HC accessory

A temperature-dependent voltage, called the reference junction voltage (or cold junction voltage), is always generated between a thermocouple and the terminals to which the thermocouple is connected. Therefore, if you connect a thermocouple to a KPCI-1800HC Series board via an STA-1800HC accessory, a reference-junction voltage is generated between the thermocouple leads and the STA-1800HC connection terminals.

The reference junction voltage is defined as follows:

Reference junction voltage	=	(voltage generated by your thermocouple at temperature of the STA-1800HC terminals)	-	(Voltage generated by your thermocouple at 0˚C)

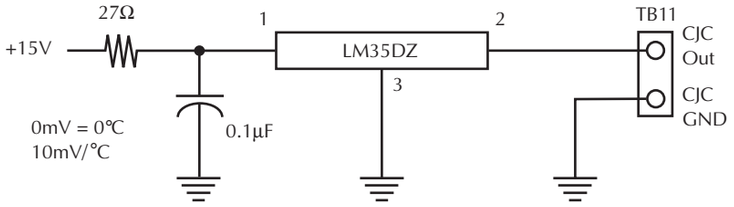
The reference junction voltage can be determined from an equation or a lookup table for your thermocouple type. It must be added to the thermocouple voltage "seen" by your KPCI-1800HC before converting it to an accurate temperature reading.

To facilitate cold junction compensation, the STA-1800HC provides a CJC (Cold Junction Compensation) temperature measurement circuit to monitor the temperature at its screw terminals. The CJC temperature circuit outputs a voltage that is 0V at 0˚C and linearly proportional to the screw terminal temperature at all other temperatures, as follows:

CJC circuit output voltage, mV = (connection terminal temperature, ˚C) × (10mV/˚C)

The schematic for the CJC temperature circuit is shown in Figure 3-6.

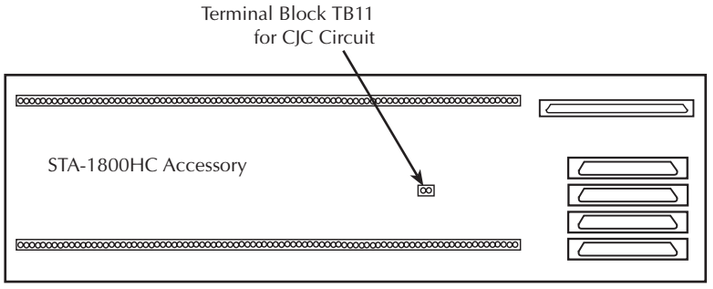
Figure 3-6
CJC temperature circuit



The CJC output signal appears across screw terminals TB11. The location of terminals TB11on the accessory is shown in Figure 3-7.

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Figure 3-7
Location of CJC circuit screw terminals (TB11) on STA-1800HC accessory



Use the following procedure to convert a thermocouple reading to an accurate temperature value:

1. Wire TB11 of the CJC circuit to the screw terminals of an unused KPCI-1800HC analog input channel.
2. Read the CJC circuit voltage from TB11.
3. Perform the following data manipulations in the host computer:
   a. Convert the CJC circuit voltage to the connection terminal temperature.
   b. Convert the connection terminal temperature to the reference junction voltage, using the correct equation or lookup table for your thermocouple type.
   c. Add the reference junction voltage to the thermocouple readings at the STA-1800HC screw terminals.
   d. Convert the corrected thermocouple readings to temperatures, using the correct equation or lookup table for your thermocouple type.

Connecting a CONN-1800HC accessory to a KPCI-1800HC Series board

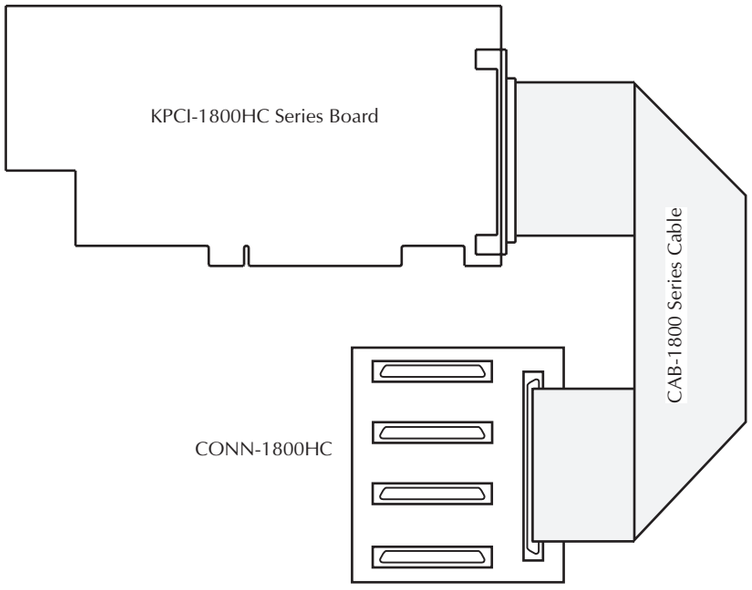
The CONN-1800HC connector panel is an interface for cabling MB-series signal conditioning modules to KPCI-1800HC Series boards. You can also use CONN-1800HC for custom hookups. The CONN-1800HC is essentially an STA-1800HC without screw terminals or a CJC (Cold Junction Compensation) thermometer circuit. The components of the CONN-1800HC are:

- A 100-pin female connector for cabling to the I/O connector of a KPCI-1800HC Series board
- Four 37-pin male connectors for cabling to MB01 backplanes or custom hookups

Connect a CONN-1800HC cable to a KPCI-1800HC Series board using a CAB-1800 Series cable, as shown in Figure 3-8. Available CAB-1800 Series cables are listed in Table 3-4 under *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board.*

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Figure 3-8
Connecting a CONN-1800HC accessory to a KPCI-1800HC Series board



Pin assignments for the 100-pin I/O connector of a CONN-1800HC are shown in Figure 3-4, which is found in *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*. (Note that the I/O connector is physically a mirror image of the pin assignments for the KPCI-1800HC Series I/O connector). Refer to Tables 3-1 and 3-2 under *Identifying I/O connector pin assignments for KPCI-1800HC series* for descriptions of the pin assignments.

Use the auxiliary 37-pin connectors of the CONN-1800HC to connect MB Series modules to a KPCI-1800HC series board. For more information about using the auxiliary 37-pin connectors, refer to *Connecting an MB01 module rack (backplane) to a KPCI-1800HC Series board*. Pin assignments for the CONN-1800HC auxiliary 37-pin I/O connectors are shown in Figures B-3 through B-6 of Appendix B.

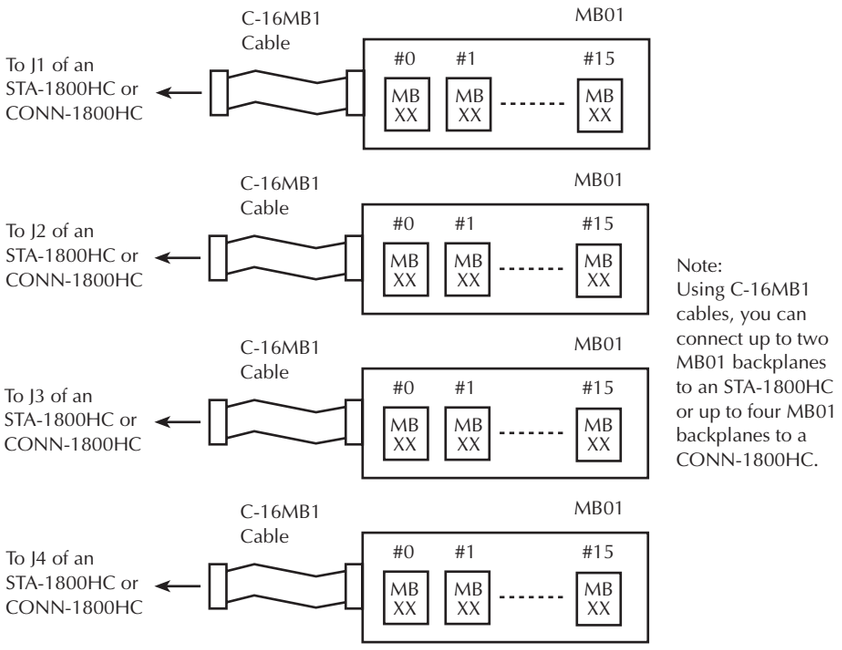
Connecting an MB01 module rack (backplane) to a KPCI-1800HC Series board

MB Series modules provide front-end signal conditioning for a KPCI-1800HC Series board when connected through an MB01 module rack (backplane) and an STA-1800HC or a CONN-1800HC accessory. Figure 3-9 shows the connections to an STA-1800HC or a CONN-1800HC accessory. The previous sections *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* or *Connecting a CONN-1800HC accessory to a KPCI-1800HC Series board* describe how to connect the STA-1800HC or a CONN-1800HC accessory to a KPCI-1800HC Series board.

For details about MB Series modules, refer to the MB Series User's Guide.

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Figure 3-9
Connecting MB01 module racks (backplanes) to an STA-1800HC or a CONN-1800HC



NOTE *If you are programming an application that requires references to channel numbering on connectors J1 to J4 of an STA-1800HC or CONN-1800HC, you can obtain the correct channel numbering from the pin assignments for these connectors. Refer to Appendix B.*

Wiring analog input signals

This section provides general guidance on wiring your circuits to single-ended and differential inputs, as well as special precautions to avoid problems when wiring signals to a KPCI-1800HC set for high gains.

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WARNING **Do NOT connect data acquisition inputs to the AC line. Keep data acquisition cables and connections away from any AC line connections. Interconnections or shorting between data and power lines can result in personal injury or death or extensive damage to your computer. To prevent this problem, do the following:**

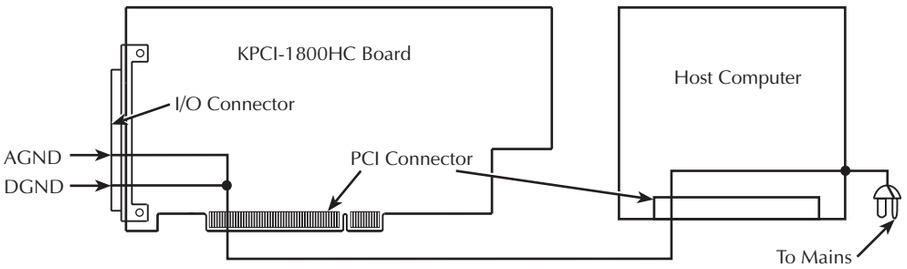
- **Avoid direct connections to the AC line by using safety approved isolation transformers, isolation amplifiers, or both.**
- **Ensure that all connections are tight and sound, so that signal wires are unlikely to come loose and short to hazardous voltages.**

CAUTION **Ensure that both the computer and the external circuits are turned OFF before making any connections. Making connections while the computer and external circuits are powered can damage the computer, the board, and the external circuit.**

Ensure that no analog-input signal exceeds ±15V, which is the maximum allowable rating for the board. Exceeding ±15V will damage the board.

NOTE *KPCI-1800HC Series boards contain separate ground connections for analog and digital signals. Use the analog ground (AGND) for analog signals and analog power; use the digital ground (DGND) for digital signals and other power-supply returns. Do this to avoid interference from digital switching noise currents on sensitive analog signals. However, be aware that both analog and digital grounds are tied together at the board PCI connector and are ultimately connected to the building system ground via the mains. See Figure 3-10. I/O connector pin assignments and descriptions for AGND and DGND are provided in Figure 3-1 and Tables 3-1 and 3-2.*

Figure 3-10
Analog and digital ground path



NOTE *Though the circuit diagrams show direct connections to channel input pins of the main I/O connector, you must make actual connections through corresponding screw terminals of an STA-1800HC or STP-100 accessory. Refer to Appendix B for a list of these inputs and their descriptions.*

The circuit diagrams in this section represent wiring of a single signal source to a single channel (typically designated as "channel n"). Differential analog circuits can be used with any of 32 separate signal sources connected to 32 differential inputs; single-ended analog circuits can be used with any of 64 separate signal sources connected to 64 single-ended inputs.

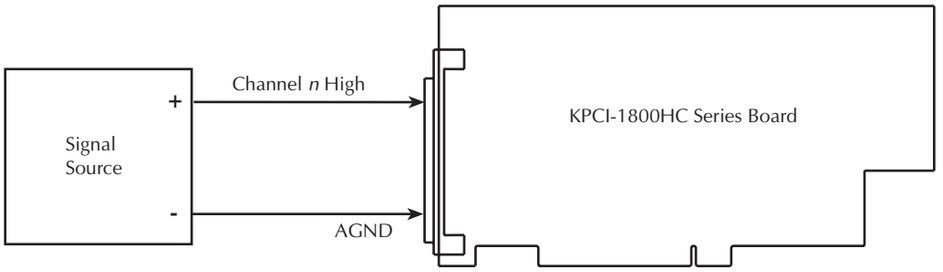
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Wiring a signal to a single-ended analog input

NOTE *Before wiring your signals to single-ended inputs, ensure that you understand the limitations of single-ended inputs. Refer to Section 2, "Choosing between the differential and single-ended input modes."*

Figure 3-11 shows the connections between a signal source and one channel of a KPCI-1800HC Series board configured for single-ended input mode.

Figure 3-11
Wiring a signal source to a board configured for single-ended inputs



Wiring a floating signal source to a differential analog input

NOTE *If you are unclear about whether to use differential or single-ended input mode, refer to Section 2, "Choosing between the differential and single-ended input modes."*

Figure 3-12 shows three connection schemes for wiring a signal source to a KPCI-1800HC Series channel when the board is configured for differential input and the input signal source is floating. Floating signal sources are ideally either totally ungrounded (a battery, for example) or are otherwise not connected either directly or indirectly to the building ground or analog signal ground. (Real floating signal sources do have finite, though small, coupling to ground due to finite insulation resistance and other sources of current leakage, such as capacitive coupling in a transformer.) Examples of floating signal sources include devices powered by batteries, devices powered through isolation transformers, ungrounded thermocouples, and outputs of isolation amplifiers. Using floating signal source intrinsically avoids ground loops.

However, when your KPCI-1800HC Series board is used in the differential input mode, a current path must be connected to the analog ground terminal. When the signal source floats, the lack of a ground reference point allows instrumentation amplifier bias currents to raise the common-mode voltage of the signal to high values. Excessive common mode voltages result in excessive signal errors or, worse, amplifier saturation and unusable data.

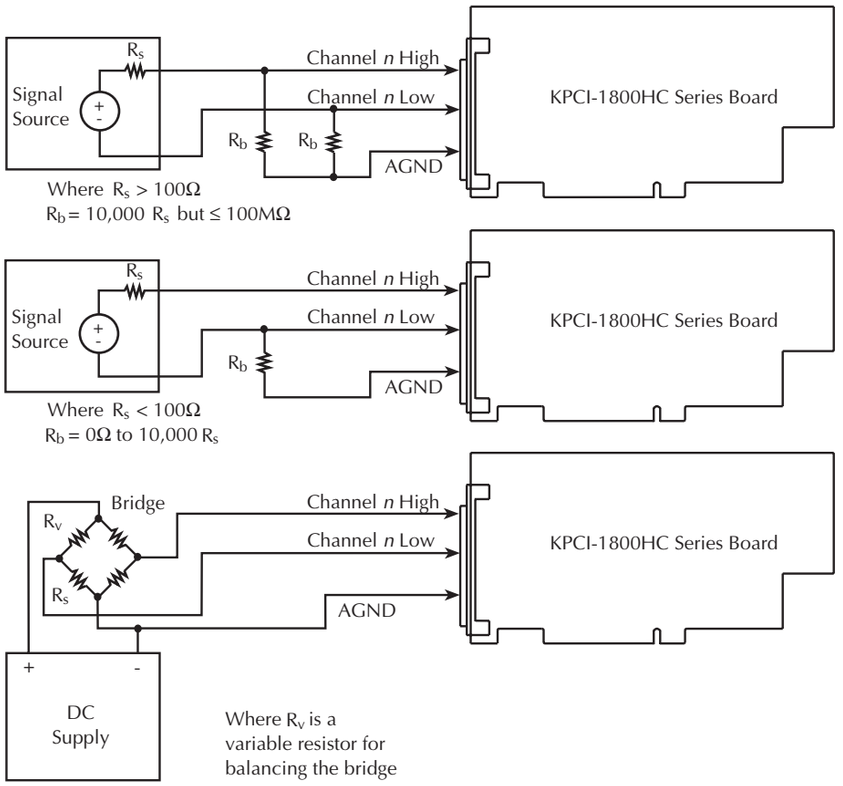
NOTE *The bias current of the input instrumentation amplifier is a very small but finite current drawn from an input terminal to the amplifier. The magnitude of the bias current depends on the amplifier design and may range from a few femtoamperes to a few microamperes.*

The common-mode voltage (V_{cm}) is a voltage that is common to both the input-high and input-low terminals of a differential input: it appears between each terminal and ground.

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If your signal source is floating, you must provide the path to the analog ground. Use one or two bias return resistors, as discussed below and illustrated in Figure 3-12.

Figure 3-12
Wiring a floating signal source to differential inputs: three common examples



The minimum bias return resistance and the number of bias resistors (one or two) are determined by noise considerations. The maximum bias return resistance (R_b) is limited by the maximum acceptable common-mode voltage due to the bias current, as follows:

Common-mode voltage due to bias current = (Bias current) * (Bias return resistance, R_b)

The remaining discussions of this section guide you in selecting bias return resistors.

Using a single bias return resistor (middle circuit of Figure 3-12). If the signal source resistance (R_S) is low, one bias return resistor connected between the input-low terminal and the analog ground is adequate.

The minimum bias return resistance is determined by the signal source resistance and the susceptibility and exposure of your circuit to noise pickup from the environment. If the source resistance (R_S) is low, the bias resistance can generally be low. In some cases, the bias resistance (R_b) can be zero. That is, you can connect a lead directly between the analog ground and the negative terminal of the signal source. However, the following then occurs:

- Electrostatically-coupled noise in the negative signal lead is shunted directly to ground and does not affect the negative signal input.
- Electrostatically-coupled noise in the positive signal lead is not shunted directly to ground and causes a net noise voltage at the positive signal input.

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The net voltage at the positive signal input cannot be rejected by the common-mode rejection capabilities of the KPCI-1800HC.

Therefore, depending on the source resistance (R_S) and/or the electrostatic noise pickup, it is frequently better to use a larger bias resistance (R_b) to help balance the ground return paths of the positive and negative signals. The higher resistance makes the ground paths and noise coupling in the positive and negative signals more similar. The noise that is common to both positive and negative signals can then be rejected as part of the common mode voltage. If the source resistance is less than 100 ohms, you may select the bias return resistance as follows:

Bias return resistance, R_b = 10,000 * (Source resistance, R_S) if $R_S < 100\Omega$

Using two bias return resistors (top circuit of Figure 3-12). You can slightly improve noise rejection by connecting identical bias return resistors to both the positive and negative signals. This balances the ground return paths. Use the following resistance value:

Bias return resistance, R_b = 10,000 * (Source resistance, R_S), 100MΩ max, if $R_S > 100\Omega$

However, be aware that the bias return resistor connected to the input-high terminal loads the signal, causing a proportional error.

Using no bias return resistors with a bridge circuit (bottom circuit of Figure 3-12). In the lower circuit of Figure 3-12, added bias return resistors are not needed. The bridge resistors at the signal source inherently provide the bias current return path. The common mode voltage at the input terminals is the voltage drop across R_S of the bridge.

Wiring a ground-referenced signal source to a differential analog input

NOTE *If you are unclear about whether to use differential or single-ended input mode, refer to Section 2, "Choosing between the differential and single-ended input modes."*

A ground-referenced signal source is a signal source that is connected directly or indirectly to the building system ground. The analog signal ground of the KPCI-1800HC is ultimately connected to the building system ground via the power mains, as shown in Figure 3-10. Therefore, the ground-referenced signal source is also indirectly connected to the analog ground.

However, the quality of the ground connection between the signal source and analog ground of the KPCI-1800HC may be poor. The signal-source ground and the KPCI-1800HC Series board analog ground are typically not at the same voltage level. This voltage difference is due to the wiring between the data acquisition equipment and the building system ground, to which power-using and noise-generating equipment is typically also connected. The voltage difference is seen at the KPCI-1800HC differential input terminals as a common-mode voltage (V_{cm}); so called because it is effectively common to both the input-high and input-low terminals. An ideal, properly connected differential input responds only to the difference in the signals at the input-high and input-low terminals. The common-mode voltage is rejected, leaving only the desired signal. Practically, the common-mode voltage always causes an error, typically small, that is limited by the common-mode rejection ratio (CMRR) of the differential input.

Figure 3-13 illustrates how to satisfactorily connect a ground-referenced signal source to a differential input. In the upper circuit of Figure 3-13, a separate ground return line is connected between the negative-terminal ground of the signal source and the analog ground of the KPCI-1800HC Series board. Because both the input-high and input-low terminals of the KPCI-1800HC have high input impedance, effectively all ground currents due to ground voltages flow through the separate ground-return line. Because the separate ground return line is common to both the input-high and input-low terminals, the voltage drop across it is rejected as a common-mode voltage.

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In the lower circuit of Figure 3-13, the grounding connection for a bridge circuit powered by a ground-referenced power supply is the same as for a floating bridge. When the bridge has a ground-referenced power supply, the common mode voltage is the sum of the voltage drop across the ground line and the voltage drop across R_S of the bridge.

Figure 3-13
Satisfactory differential input connections for ground-referenced signals that avoid a ground loop

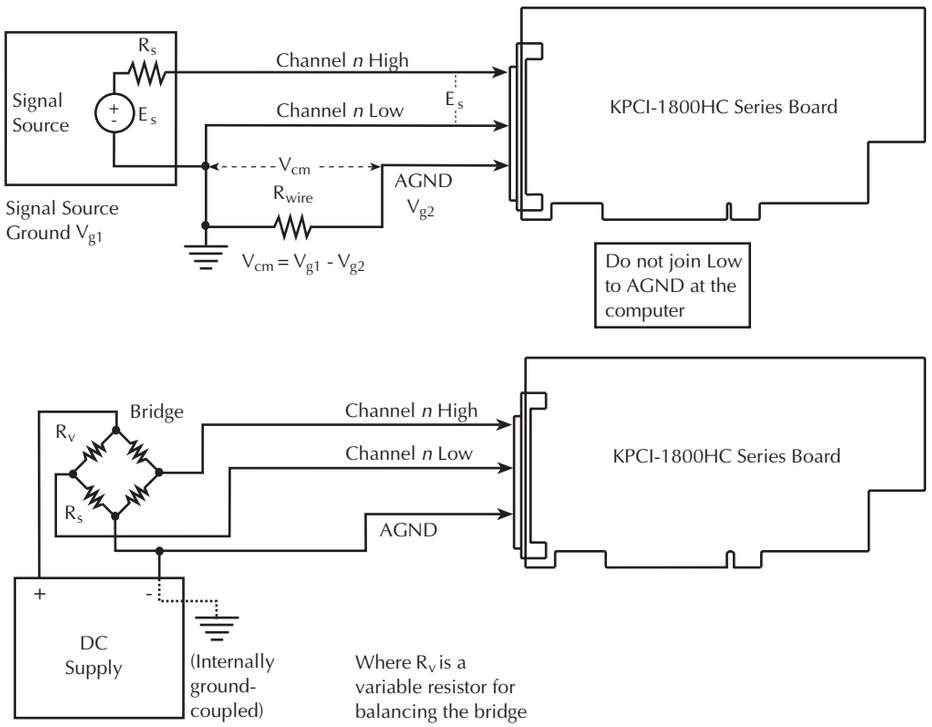
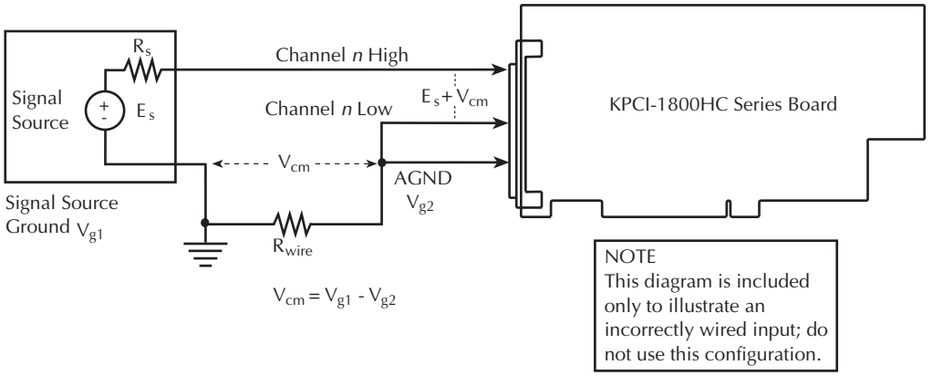


Figure 3-14 illustrates how NOT to connect a differential input. If the analog ground and input-low terminal of the KPCI-1800HC Series board are joined near the board, a ground loop current flows in the negative signal lead. The voltage difference across this signal lead is then a component of the measured signal, not a common-mode voltage. A differential amplifier cannot reject this unwanted signal component.

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Figure 3-14
Improper differential input connection, which creates a ground loop error



Avoiding wiring problems at high gains

Operating a KPCI-1801HC at a gain of 250 can lead to problems if your application is unable to cope with noise. At a gain of 250, each bit of A/D output corresponds to 10µV of analog input. If special precautions are not taken, the high gain, high speed, and large bandwidth of this board allow thermal emfs and noise to easily degrade performance. The following suggestions are provided to help you to minimize problems at high gain.

- Operate the KPCI-1801HC in 32-channel differential mode. Using the board in 64-channel, single-ended mode at high gains introduces enough ground-loop noise to produce large fluctuations in readings.
- Minimize noise from crosstalk and induced-voltage pickup in the flat cables and screw-terminal accessories by using shielded cable (for example, a CAB-1800/S is preferred over a CAB-1800 cable and an S1800 cable is preferred over a C1800 cable.) Connect the shield to the analog ground (AGND) and the inner conductors to the input low (LO) and input-high (HI) terminals. Channel LO and AGND should have a common DC return (or connection) at some point; this return should be as close to the signal source as possible. (See Figures 3-12 and 3-13.) Induced noise from radio frequency (RF) and magnetic fields can easily exceed tens of microvolts, even on one-foot or two-foot long cables. Shielded cable helps to avoid this problem.
- Avoid bimetallic junctions in the input circuitry. For example, the thermal emf of a Kovar-to-copper junction, such as at the Kovar leads of reed relay, is typically 40µV/°C. Thermal emfs at bimetallic junctions, combined with air currents and other sources of temperature variation, can introduce strange random signal variations.
- Consider filtering, which can be accomplished with hardware (resistors, capacitors, and so on) but is often accomplished more easily with software. Instead of reading the channel once, read it 10 or more times in quick succession and average the readings. If the noise is random and Gaussian, it will be reduced by the square root of the number of readings.

Refer also to Section 2, *Optimizing throughput,* for additional precautions about assigning high gains to channels in the channel-gain queue.

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Wiring analog output signals

This section provides a few guidelines on wiring the analog outputs from the two 12-bit DACs (digital-to-analog converters) on your KPCI-1800HC Series board. Each DAC outputs a range of ±10V. Performance characteristics and drive capabilities for these DACs are listed in Appendix A.

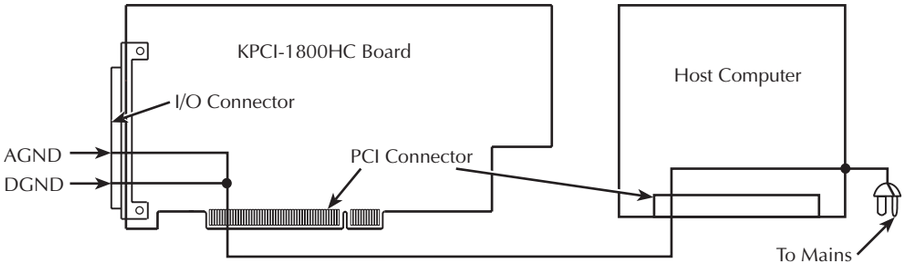
WARNING **Do NOT intersperse data acquisition connections with AC line connections. Keep data acquisition cables and connections away from any AC line connections. Interconnections or shorting between data and power lines can result in personal injury or death or extensive damage to your computer. To prevent this problem, ensure that all connections are tight and sound, so that signal wires are unlikely to come loose and short to hazardous voltages.**

CAUTION **Ensure that both the computer and the external circuit are turned OFF before making any connections. Making connections while the computer and external circuits are powered can damage the computer, the board, and the external circuit.**

NOTE *Avoid large capacitive loads at the analog outputs. Capacitive loads higher than 100µF will destabilize the analog outputs and make them susceptible to ringing (transient oscillations).*

KPCI-1800HC Series boards contain separate ground connections for analog and digital signals. Use the analog ground (AGND) for analog signals and analog power; use the digital ground (DGND) for digital signals and other power-supply returns. Do this to avoid interference from digital switching noise currents on sensitive analog signals. However, be aware that both analog and digital grounds are tied together at the board PCI connector and are ultimately connected to the building system ground via the mains. See Figure 3-15. I/O connector pin assignments and descriptions for AGND and DGND are provided in Figure 3-1 and Tables 3-1 and 3-2.

Figure 3-15
Analog and digital ground path



Though this section describes connections to analog output pins of the main I/O connector, you must make the analog output connections through the corresponding screw terminals of an STA-1800HC or STP-100 accessory.

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The DAC0 output is available at pin B36 of the KPCI-1800HC Series I/O connector, and the DAC1 output is available at pin A36. The corresponding screw terminals of an STA-1800HC or STP-100 accessory are listed in Table 3-5.

Table 3-5
Analog output terminals on STA-1800HC and STP-100 accessories

Label on screw terminal accessory		Corresponding I/O connector pin number	Description
On STA-1800HC	On STP-100		
DAC0OUT	P1B-36	B36	The output of digital-to-analog converter 0
DAC1OUT	P1A-36	A36	The output of digital-to-analog converter 1
A GND terminals, two of which are next to DAC0OUT and DAC1OUT	P1A-01 P1B-01 P1A-18 P1B-18 P1A-35 P1B-35	A01, B01, A18, B18, A35, B35	Analog ground terminals

To connect an STA-1800HC or STP-100 accessory to your board, refer to *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* or *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board.*

Wiring digital input and output signals

WARNING **Do NOT connect data acquisition inputs to the AC line. Keep data acquisition cables and connections away from any AC line connections. Interconnections or shorting between data and power lines can result in personal injury or death or extensive damage to your computer. To prevent this problem, do the following:**

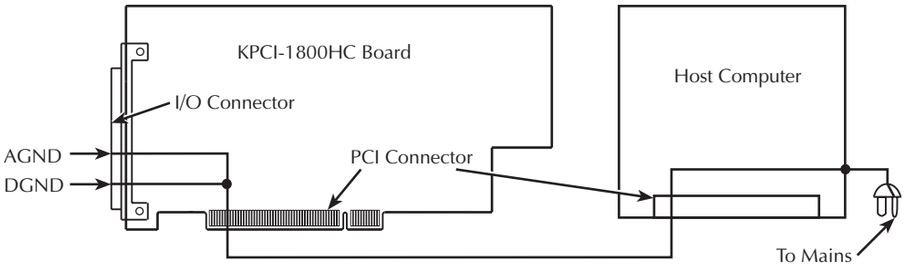
- **Avoid direct connections to the AC line by using safety approved isolation transformers, isolation amplifiers, or both.**
- **Ensure that all connections are tight and sound, so that signal wires are unlikely to come loose and short to hazardous voltages.**

CAUTION **Ensure that both the computer and the external circuit are turned OFF before making any connections. Making connections while the computer and external circuits are powered can damage the computer, the board, and the external circuit.**

NOTE *KPCI-1800HC Series boards contain separate ground connections for analog and digital signals. Use the analog ground (AGND) for analog signals and analog power; use the digital ground (DGND) for digital signals and other power-supply returns. Do this to avoid interference from digital switching noise currents on sensitive analog signals. However, be aware that both analog and digital grounds are tied together at the board PCI connector and are ultimately connected to the building system ground via the mains. See Figure 3-16. I/O connector pin assignments and descriptions for AGND and DGND are provided in Figure 3-1 and Tables 3-1 and 3-2.*

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Figure 3-16
Analog and digital ground path

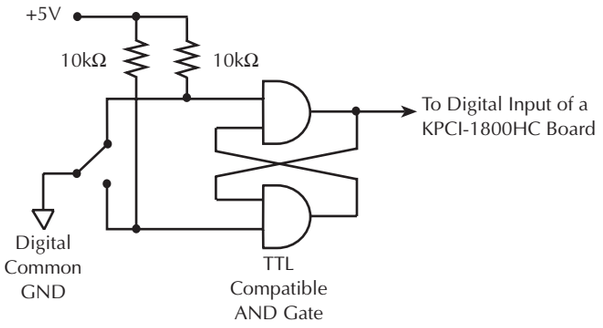


Though the circuit diagrams in this section show direct connections to digital input pins of the main I/O connector, you must make actual digital I/O connections through corresponding screw terminals of an STA-1800HC or STP-100 accessory.

Digital input signal conditioning

External circuits must properly match the input requirements of the board. The digital inputs of your KPCI-1800HC Series board are already equipped with 10kΩ pull-up resistors connected to the +5V power supply. However, some applications may require you to eliminate contact bounce at the input. The effects of contact bounce may be eliminated by programming in your application software. However, it is often desirable to eliminate contact bounce from the signal, using a de-bounce circuit between the contacts and the KPCI-1800HC Series input. Figure 3-17 shows a typical de-bounce circuit that can be used with Form C contacts.

Figure 3-17
Contact de-bounce circuit



Wiring general-purpose digital I/O signals

KPCI-1800HC Series boards have eight general-purpose digital outputs, two general-purpose digital inputs, and two dual-function digital inputs that can be configured either as general purpose inputs or as control inputs XPCLK and TGIN. For more information about digital inputs, refer to Section 2, *Digital input and output features*.

Wire a general-purpose I/O signal between the appropriate digital I/O pin and a digital ground pin on your KPCI-1800HC Series board. Make the connections using the screw terminals of an

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STA-1800HC or STP-100 accessory. The screw terminal labels for these connections are identified in Table 3-6.

Table 3-6
General purpose and control digital I/O terminals for STA-1800HC and STP-100 accessories

Label on screw terminal accessory		Corresponding I/O connector pin number	Description
On STA-1800HC	On STP-100		
DI0/XPCLK	P1B-39	B39	Depending on configuration, general purpose digital input number 0 or external pacer clock input
DI1/TGIN	P1B-40	B40	Depending on configuration, general purpose digital input number 1 or trigger/gate input
DI2, DI3	P1B-41 P1B-42	B41, B42	Digital inputs 2 and 3
DO0 to DO3	P1B-43 to P1B-46	B43 to B46	Digital outputs 0 to 3
DO4 to DO7	P1A-43 to P1A-46	A43 to A46	Digital outputs 4 to 7
TGOUT	P1A-41	A41	Trigger/gate output
DOSTB	P1A-42	A42	Digital output strobe
Any terminal labeled D GND	P1A-38 P1B-38 P1A-49 P1B-49 P1A-50 P1B-50	A38, B38, A49, B49, A50, B50	Digital ground

For more information about using the recommended screw terminal accessories, refer to *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* and *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*.

Wiring digital control signals

KPCI-1800HC Series boards provide two digital control inputs and two digital control outputs. The digital control inputs, XPCLK and TGIN, are alternately configurable as general-purpose digital inputs, as noted in the previous section. For more information about digital control signals, refer to Section 2, *Digital input and output features*.

Wire a digital control signal between the appropriate digital I/O pin and a digital ground pin on your KPCI-1800HC Series board. Make the connections using the screw terminals of an STA-1800HC or STP-100 accessory. The screw terminal labels for these connections are identified in Table 3-6. For more information about using the recommended screw terminal accessories, refer to *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* and *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*.

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The four digital control terminals are summarized below:

- The DI0/XPCLK terminal inputs an external pacer clock signal to the KPCI 1800HC Series board when, and only when, the DI0/ XPCLK input is configured for the XPCLK mode. The nature and use of the XPCLK signal is described more fully in Section 2 in the following sections: *Pacer clock sources*, *The external pacer clock (XPCLK) digital control input*, and, in context, *Triggers* and *Gates*.
- The DI1/TGIN terminal inputs an external trigger or gate signal to the KPCI 1800HC Series board when, and only when, the DI1/TGIN input is configured for the TGIN mode.
- The nature and use of the TGIN signal is described more fully in Section 2 under *Triggers*, *Gates*, and *Trigger in (TGIN) digital control input*. Use of TGIN for multiple-board synchronization is described, in context, in the next section *Synchronizing multiple boards*.
- The TGOUT terminal outputs a trigger signal from the KPCI 1800HC Series board that can be used to synchronize analog I/O operations at multiple KPCI 1800HC series boards. The TGOUT signal is described in more detail in Section 2, *Trigger-out (TGOUT) digital control output* and, in context, in the next section *Synchronizing multiple boards*.
- The DOSTB terminal outputs a strobe signal from the KPCI 1800HC Series board, which is used to coordinate moving data out of digital outputs and latching data into registers in other equipment. The TGOUT control output is described more fully in Section 2, *Strobe (DOSTB) digital control output*.

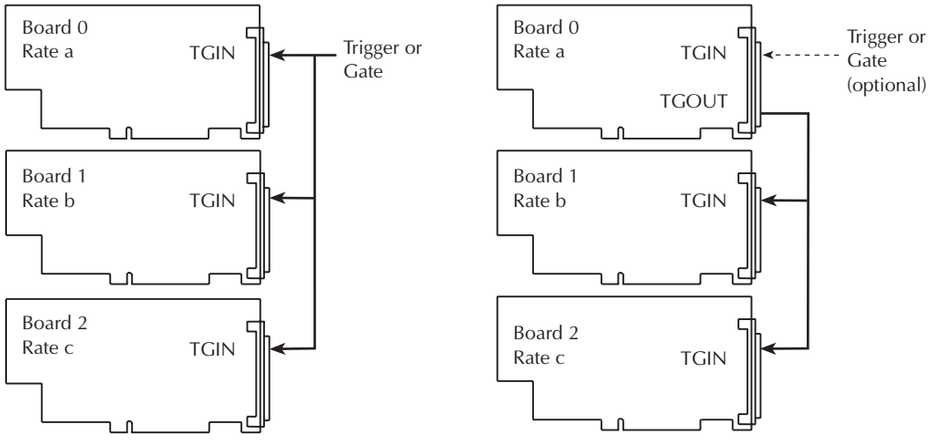
Synchronizing multiple boards

You can synchronize up to three KPCI-1800HC Series boards using trigger and gate signals from the main I/O connectors. A/D (analog-to-digital) conversions at synchronized boards can be started simultaneously by a single event, regardless of whether the boards have been programmed for the same conversion rate or for different conversion rates.

The onboard pacer clock of each board is designed to be tightly coupled with trigger or gate events. Within a short, defined time lag, each synchronized board begins the first analog conversion when the board receives a trigger or gate signal. (Refer to Section 2 *Triggers* and *Gates*.) Each board then continues analog conversions at the rate previously set for that board via DriverLINX.

Figure 3-18 shows two connection schemes for synchronizing multiple boards. In both schemes, the conversion rate for each board is timed by the internal pacer clock for that board.

Figure 3-18
Two connection schemes for synchronizing multiple boards



a. Scheme 1 **b. Scheme 2**

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Board synchronization scheme 1

In Scheme 1, start conversions at synchronized boards with one external trigger/gate signal. Connect the trigger/gate inputs of the boards together such that each board receives the trigger or gate input simultaneously.

A/D conversions at each board start 400 ±100ns after the active edge of a trigger or gate input. Therefore, boards can be synchronized within 100 ±100ns. For example, one board could start conversions as soon as 300ns after the active edge of the trigger input, while another board could start conversions as late as 500ns after the active edge of the trigger input.

When using scheme 1, you can time subsequent A/D conversions using either the onboard pacer clock or an external pacer clock.

Board synchronization scheme 2

In Scheme 2, start conversions in either of two ways: by an external trigger/gate signal or by software. The board connections are in a master/slave relationship; board 0 is the master, and the other boards are the slaves.

If using a hardware trigger for board 0 of scheme 2, board 0 triggers conversions in all boards immediately. Note that TGOUT is an active, high-going signal. Therefore, you must program the TGIN input of each slave board to respond to the positive (rising) edge of the TGOUT signal.

If you use software to enable board 0, the following sequence occurs:

1. The board-0 pacer clock first triggers conversions in the slave boards.
2. Then, conversions start in board 0.

Conversions in board 0 are delayed by a protection feature, which is built into the register that creates software-triggered conversions. This protection feature prevents false conversions.

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Wiring +5V and ±15V power to external circuits

CAUTION **Ensure that both the computer and the external circuit are turned OFF before making any connections. Making connections while the computer and external circuits are powered can damage the computer, the board, and the external circuit.**

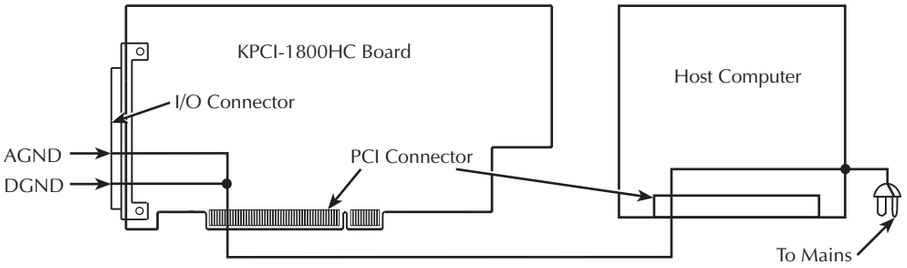
Do not connect the +5V outputs or the ±15V outputs to external power supplies. Connecting these outputs to external power supplies may damage the external supplies, the board, and the computer.

Do not draw more than 1.0A, total, from all +5V outputs combined. Drawing more than 1.0A, total, may damage the board. Also, keep in mind that the 5V output comes from the computer power bus. Know the limits of the computer 5V power bus and the current drawn from it by other boards and devices. Other demands on the 5V power bus may limit the current drawn from your board to less than 1.0A.

Do not draw more than 30mA from either the +15V output or the -15V output. Drawing more than 30mA may damage the board.

NOTE *KPCI-1800HC Series boards contain separate ground connections for analog and digital signals. Use the analog ground (AGND) for analog signals and analog power; use the digital ground (DGND) for digital signals and other power-supply returns. Do this to avoid interference from digital switching noise currents on sensitive analog signals. However, be aware that both analog and digital grounds are tied together at the board PCI connector and are ultimately connected to the building system ground via the mains. See Figure 3-19. I/O connector pin assignments and descriptions for AGND and DGND are provided in Figure 3-1 and Tables 3-1 and 3-2.*

Figure 3-19
Analog and digital ground path



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Wiring +5V power

Power at +5V for light external circuits, such as pull-up resistors, may be drawn indirectly from the host computer power bus via the KPCI-1800HC Series I/O connector. If you ensure that the following conditions are maintained, this power may also be used to energize external accessories:

- The total current drawn to power the board and all external circuits must not overload the computer power bus.
- The maximum **total** current drawn from all +5V pins on the I/O connector — A47, B47, A48, and B48 combined — must be less than 1.0A.

The +5V power is available through the terminals of screw terminal accessories as listed in Table 3-7.

Table 3-7
Power output terminals for STA-1800HC and STP-100 accessories

Label on screw terminal accessory		Corresponding I/O connector pin number	Description
On STA-1800HC	On STP-100		
+5V	P1A-47 P1B-47 P1A-48 P1B-48	A47, B47, A48, B48	+5VDC output
+15V	P1B-37	B37	+15VDC output
-15V	P1A-37	A37	-15VDC output
A GND	P1A-01 P1B-01 P1A-18 P1B-18 P1A-35 P1B-35	A01, B01 A18, B18, A35, B35	Analog ground terminals
Any terminal labeled D GND	P1A-38 P1B-38 P1A-49 P1B-49 P1A-50 P1B-50	A38, B38, A49, B49, A50, B50	Digital ground

For more information about the screw terminal accessories, refer to *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* and *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*.

Wiring ±15V power

Part of the ±15V developed by a DC/DC converter on the KPCI-1800HC Series boardis available for external use. The ±15V power is convenient for use with light external circuits, such as operational amplifiers. However, do not draw more than 30mA, total, from either the +15V output or the -15V output.

The ±15V power is available through the terminals of screw terminal accessories as listed above in Table 3-7. For more information about the STA-1800HC or STP-100 accessories, refer to *Connecting an STA-1800HC screw terminal accessory to a KPCI-1800HC Series board* and *Connecting an STP-100 screw terminal accessory to a KPCI-1800HC Series board*.

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4
DriverLINX Test Panels

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The test panels are small applications programs within DriverLINX that allow you to perform limited data acquisition functions. You can use the panels to do tasks such as:

- Monitor one or two analog input channels on-screen.
- Set the levels of one or two analog output channels.
- Monitor and set digital input and output bits.

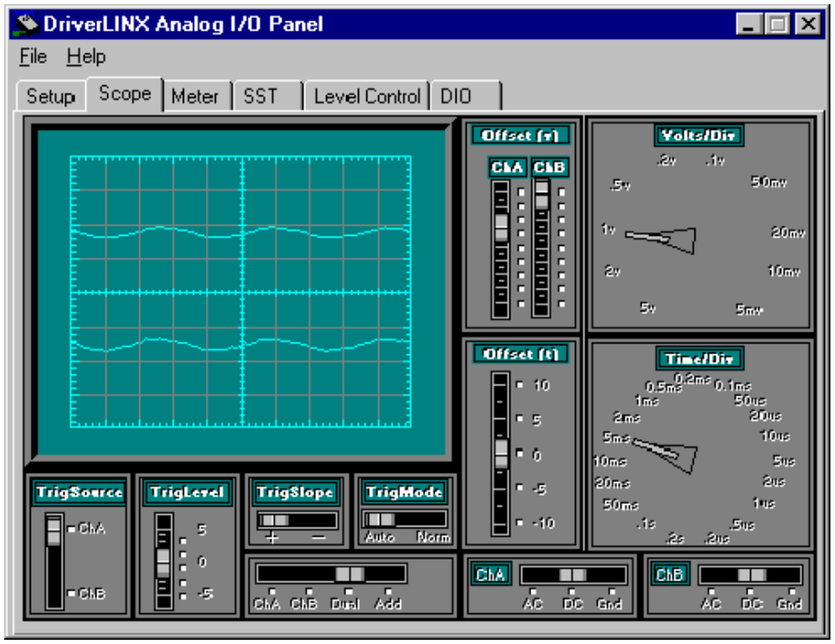
Test panels are designed primarily for testing the functions of your board. However, one panel in particular — the Analog I/O panel — can be useful for limited routine tasks.

DriverLINX Analog I/O Panel

The Analog I/O panel allows you to perform any one of the following five functions at any given time:

- To read voltages from two analog input channels on a digitizing oscilloscope screen. See Figure 4-1.
- To display a DC voltage from one analog input channel on a digital voltmeter screen. See Figure 4-2.
- To send a user-configurable sine-wave, square-wave, or triangular-wave signal from one or two analog output channels (the signal from two channels being identical). See Figure 4-3.
- To control the DC output voltages of two analog output channels. See Figure 4-4.
- To set and read all digital input and output bits on your board. See Figure 4-5.

Figure 4-1
Analog I/O Panel oscilloscope utility



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Figure 4-2
Analog I/O Panel digital voltmeter utility

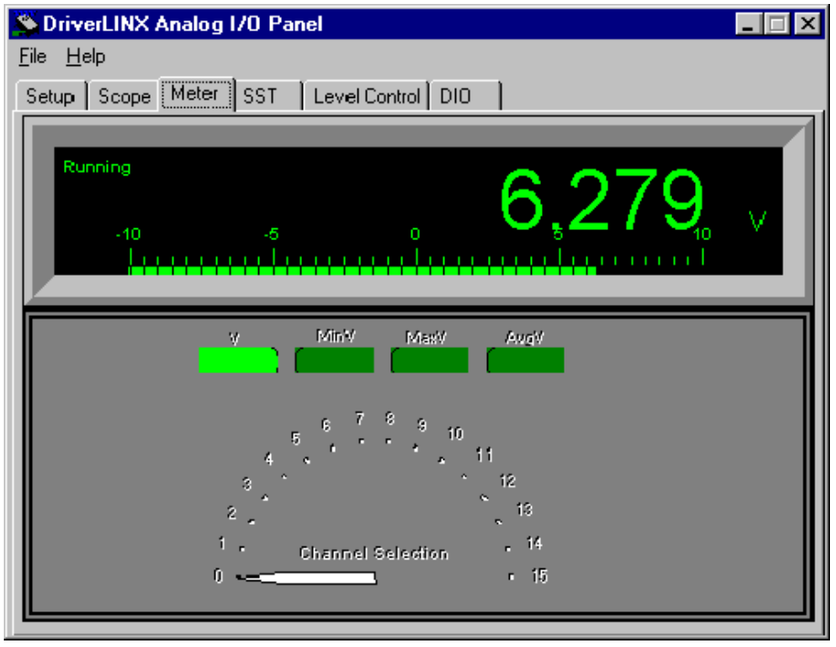
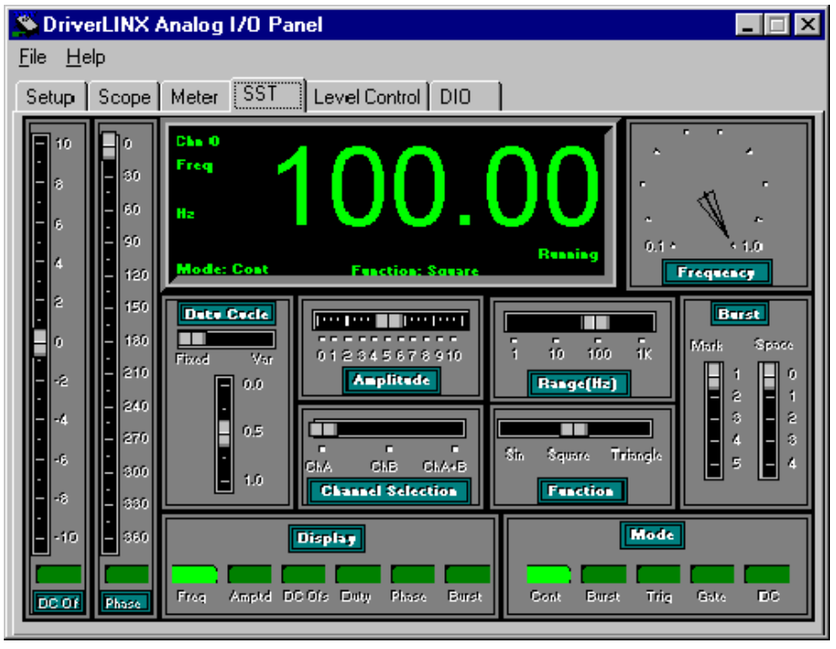


Figure 4-3
Analog I/O Panel function generator utility



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Figure 4-4
Analog I/O Panel output level control utility

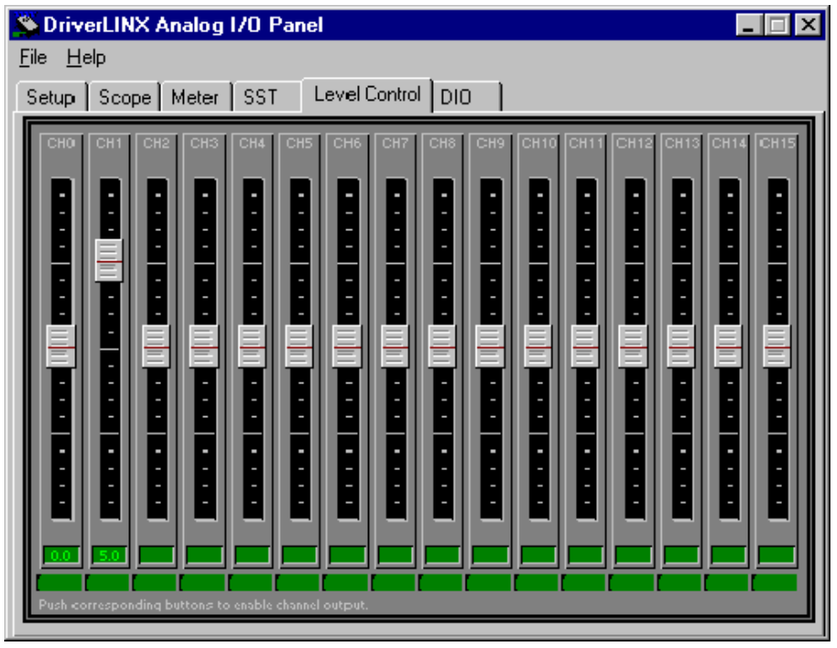
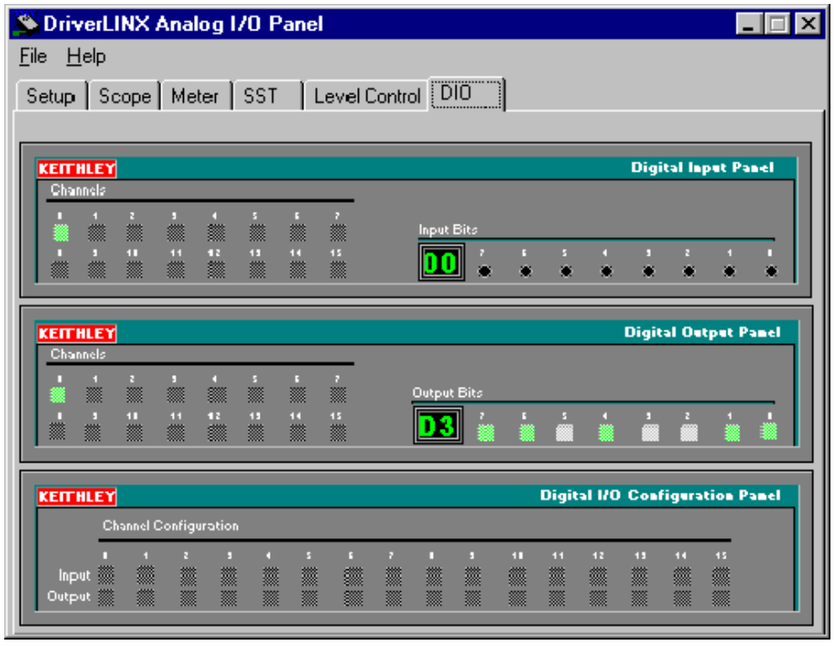


Figure 4-5
Analog I/O Panel digital I/O utility



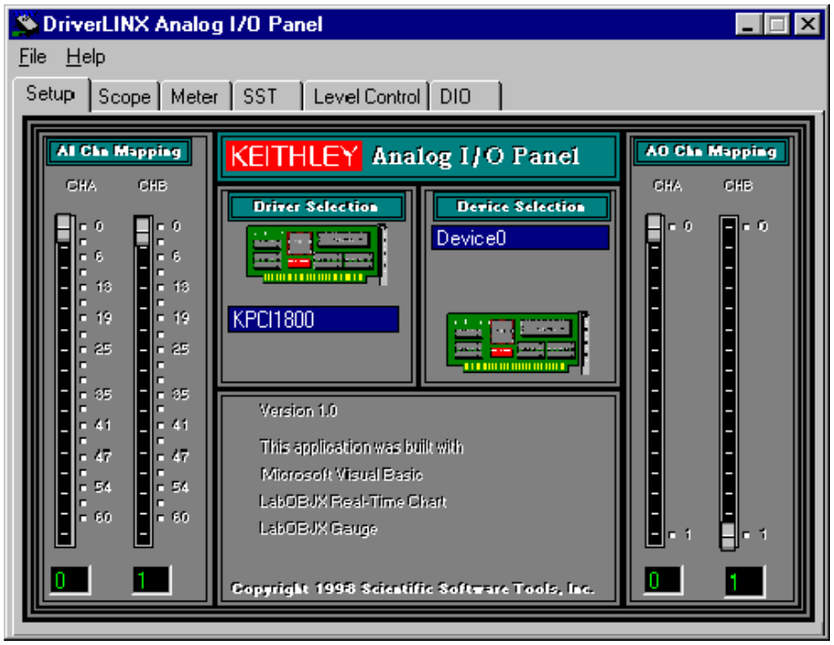
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Starting the Analog I/O Panel

Start the DriverLINX Analog I/O Panel as follows:

1. In the **Start** menu, click **Programs.**
2. Find the **DriverLINX** → **Test Panels** folder, under which you should find the **AIO Panel** entry.
3. Click on the **AIO Panel** entry. The Analog I/O Panel setup screen appears.
   - If a KPCI-1800HC Series board is the only board in your computer installed under DriverLINX, the setup screen looks like Figure 4-6.

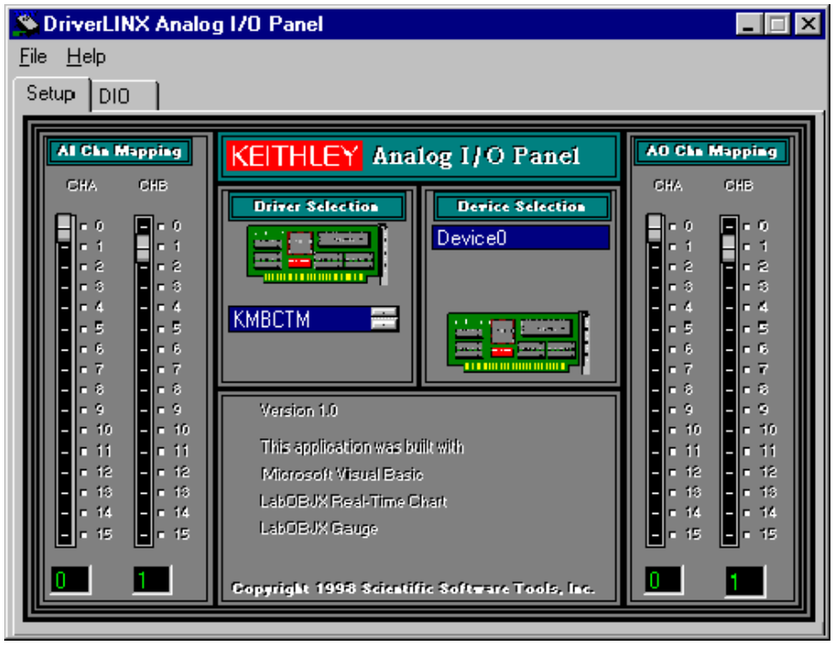
Figure 4-6
Analog I/O Panel setup screen when only a KPCI-1800HC series board is installed under DriverLINX



- If more than one type of board is installed in your computer under DriverLINX, the Analog I/O Panel may appear more like Figure 4-7. Your board type and device number may not be displayed initially, and fewer tabs may be displayed at the top of the screen than in Figure 4-6. If so, click the scroll buttons next to the Driver Selection and Device Selection text boxes until your KPCI-1800 Series board type and device number are displayed. All six tabs will then be displayed.

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Figure 4-7
Analog I/O Panel setup screen example when multiple board types are installed under DriverLINX



Using the Analog I/O Panel

For more details about the program, refer to the Analog I/O Panel help menu. To review test procedures that use the digital voltmeter and level control utilities of the AIO panel, refer to Section 6, *Analog input hardware test* and *Analog output hardware test*.

DriverLINX Calibration Utility

The DriverLINX Calibration Utility displays the information needed to calibrate the analog I/O of your board and sets up the analog calibration parameters. It displays the following information for each calibration adjustment, tailored specifically to your board:

- When and where to connect a short circuit, a DVM/DMM, or a calibration voltage source.
- Which calibration voltage to use.
- Which calibration potentiometer to set and where it is physically located on the board, relative to the other calibration potentiometers.
- What you are trying to adjust to for a successful calibration: the A/D converter counts goal or Digital-to-Analog Converter (DAC) output voltage goal.
- How close the input calibration is to the goal — the A/D converter output, in counts.

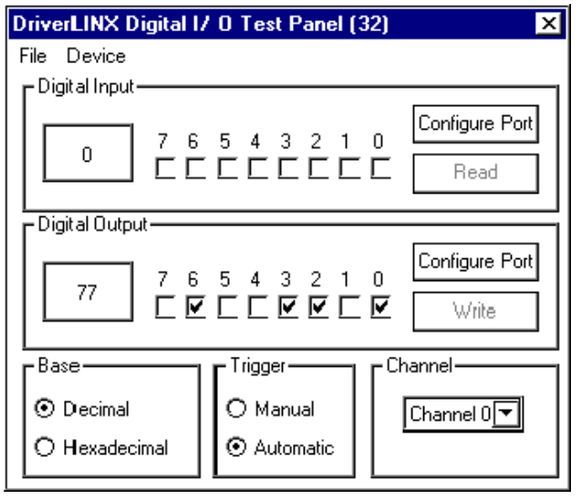
For more information about the DriverLINX Calibration Utility and using it to calibrate your board, refer to Section 5, *Calibration*.

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DriverLINX Digital I/O Test Panel

The DriverLINX Digital I/O Test Panel provides a second means to set and read the digital I/O bits of your KPCI-1800HC board, in addition to the digital I/O utility of the Analog I/O panel. Because of its simplicity, the Digital I/O Test Panel is a convenient alternative for certain types of tests. Figure 4-8 shows the Digital I/O Test Panel.

Figure 4-8
DriverLINX Digital I/O Test Panel



When the Trigger option is set to Automatic, clicking on an output check box toggles the outputs of the eight KPCI-1800HC output bits ON or OFF. A check mark (√) in a check box signifies ON. Bits 0, 1, 2,…7 correspond to digital outputs DO0, DO1,…DO7. When the Trigger option is set to Manual, the action is the same, except that you must click the Write button to update the outputs.

Clicking on input check boxes has no effect; they are read-only. When the Trigger option is set to Automatic, input check boxes 0, 1, 2, and 3 display the responses of the four KPCI-1800HC digital input bits (DI0/XPCLK, DI1/TGIN, DI2, and DI3). Input check boxes 4, 5, 6, and 7 are inactive. When the Trigger option is set to Manual, the action is the same, except that you must click the Read button to update the inputs.

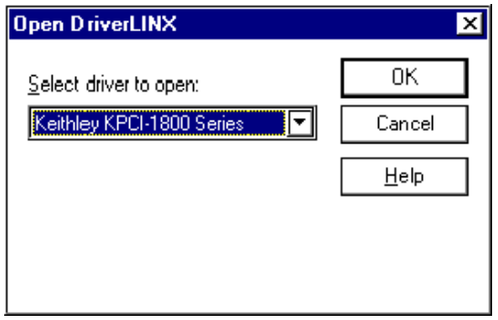
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Starting the Digital I/O Test Panel

Start the Digital I/O Test Panel as follows:

1. Open the Windows Explorer.
2. Find and open the DrvLNX4 folder.
3. In the DrvLNX4 folder, find and open the Bin folder.
4. In the DrvLNX4\Bin folder, double click the dio32.exe entry. A dialog box like Figure 4-9 appears.

Figure 4-9
Open DriverLINX dialog box



5. Under Select driver to open, select Keithley KPCI-1800 Series.
6. Click OK. The Digital I/O Test Panel appears.

Using the Digital I/O Test Panel

For Digital I/O Test Panel application examples, refer to Section 6, *Digital I/O hardware test* and *Digital output hardware test*.

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5
Calibration

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Introduction

Your KPCI-1800HC Series board was initially calibrated at the factory. You are advised to check the calibration of a board every six months and to calibrate again when necessary. This chapter provides the information you need to calibrate a KPCI-1800HC Series board.

Objectives

For analog inputs, the objective of this procedure is to zero the offsets and adjust the combined gain of the A/D converter and instrumentation amplifier. For analog outputs, the objective is to independently zero the offset and adjust the gain for each of the two digital-to-analog converters (DACs) on your KPCI-1800HC board.

Calibration summary

Analog inputs and outputs are calibrated using onboard calibration potentiometers, a DC calibrator, a DVM/DMM, and the DriverLINX Calibration Utility. (The DriverLINX Calibration Utility was installed on your computer when you installed the DriverLINX software.) No test points on the board are used. Only connections to the I/O connector pins, via a screw terminal accessory, are needed.

The DriverLINX calibration utility displays the following information for each calibration adjustment:

- When and where to connect a short circuit, a DVM/DMM, or a calibrator.
- Which calibrator voltage to use if you are calibrating an input for gain or unipolar offset.
- Which specific potentiometer to set and where it is physically located on the board relative to the other calibration potentiometers. The correct potentiometer to adjust for each calibration operation is both highlighted in red and named in on-screen instructions.
- What you are trying to adjust to for a successful calibration: the ADC counts goal or DAC output voltage goal.
- How close the input calibration is to the goal. The A/D converter output is displayed, in counts.

Equipment

The following equipment is needed to calibrate your KPCI-1800HC Series board:

- A digital voltmeter (DVM) or digital multimeter (DMM) accurate to 4½ digits, such as a Keithley Model 2000.
- An STP-100 or STA-1800HC screw terminal accessory to make analog connections to the board.
- A CAB-1800 Series cable to connect the screw terminal accessory to the KPCI-1800HC I/O connector.
- A DC calibrator or precisely adjustable and metered power supply having a 5VDC range and accurate to 4½ digits.

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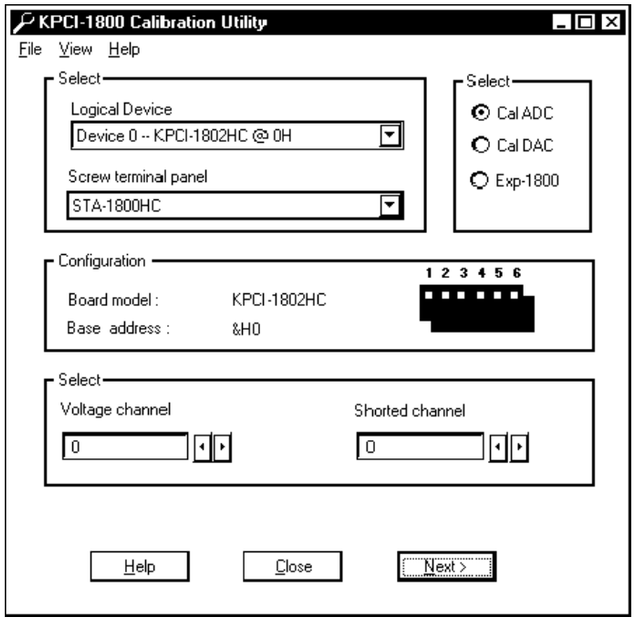
Calibration procedure

This section describes the steps required to calibrate the analog inputs and outputs of your KPCI-1800HC board.

Preparing for the calibrations

1. Prepare your system for calibration as follows:
2. Warm up the calibrator and the DVM/DMM.
3. Turn OFF the host computer.
4. Connect the STP-100 or STA-1800HC screw terminal accessory to your KPCI-1800HC board, using a CAB-1800 series cable. Refer to Section 3, *Connecting interface accessories to a KPCI-1800HC Series board* for more information about connecting these accessories.
5. Turn ON the host computer.
6. Start the calibration program as follows:
   a. Click on the Windows **Start** tab.
   b. In the **Start** menu, click **Programs**.
   c. Find the **DriverLINX** folder and click the **Test Panels** → **KPCI-1800 Calibration Utility** entry.
   d. On the About dialog box that appears, click OK. The KPCI-1800 Calibration Utility dialog box appears. See Figure 5-1.
   e. Continue with the next section, *Calibrating the analog inputs*.

Figure 5-1
KPCI-1800 Calibration Utility dialog box example



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Calibrating the analog inputs

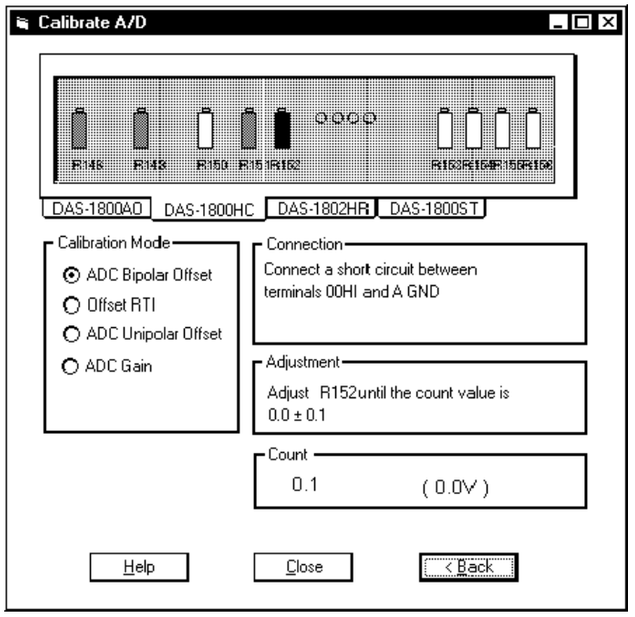
In this part of the procedure, offset and gain adjustments for the analog input and A/D Converter (ADC) circuits are made. Connect test signals through input channel 0. This suffices for all input channels, because all input channels are essentially equivalent. The multiplexer introduces essentially no error. For example, only one gain adjustment simultaneously calibrates all channel gains to within specified accuracy.

Opening the Calibrate A/D dialog box

Open the Calibrate A/D dialog box by making the following selections in the KPCI-1800 Calibration Utility dialog box:

1. Under the Select categories located at the upper left side of the KPCI-1800 Calibration Utility dialog box, make the following selections:
   a. Under Logical Device, select the KPCI-1800HC Series board that you wish to calibrate. If only one KPCI-1800HC Series board is installed, it is displayed as the default.
   b. Under Screw terminal panel, select the screw terminal accessory that you are using for this procedure. Subsequent on-screen calibration instructions refer to terminal labels specific to your screw terminal accessory.
2. Under the Select categories at the upper right side of the dialog box, select Cal ADC.
3. Under Select categories near the bottom of the dialog box, select the following:
   a. Under Voltage Channel, select 0.
   b. Under Shorted Channel, select 0.
4. At the bottom of the dialog box click Next. The Calibrate A/D dialog box now appears. See Figure 5-2.

Figure 5-2
Example of a Calibrate A/D dialog box



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In the Calibrate A/D dialog box, the tab attached to the frame picturing the calibration potentiometers should display the model number of your KPCI-1800HC Series board.

NOTE *In each calibration procedure below, the potentiometer to be adjusted is highlighted in red at the top of the Calibrate A/D dialog box.*

Sequencing the analog input calibrations

In the next sections, four types of calibrations are outlined individually. The calibrations must be performed in the following basic order: ADC bipolar offset calibration, Offset RTI (referred to input), ADC unipolar offset, and ADC gain calibration. The recommended calibration sequence, with repetitions to compensate for slight interactions, is as follows:

1. ADC bipolar offset calibration
2. Offset RTI calibration
3. ADC bipolar offset calibration
4. Offset RTI calibration
5. ADC unipolar offset calibration
6. ADC gain calibration
7. ADC unipolar offset calibration
8. ADC gain calibration

For best results, repeat each calibration once more in the order below:

9. DC bipolar offset calibration
10. Offset RTI calibration
11. ADC unipolar offset calibration
12. ADC gain calibration

Performing the ADC bipolar offset calibration

Using the Calibrate A/D dialog box, perform the ADC bipolar offset calibration as follows:

1. Under Calibration Mode at left, click ADC Bipolar offset.
2. Short analog input channel 00 to ground as instructed on-screen under Connection.
3. While monitoring the A/D converter counts on-screen under Count, adjust potentiometer R152 until you achieve the count value that is specified on-screen under Adjustment.

Performing the offset RTI calibration

Using the Calibrate A/D dialog box, perform the offset RTI calibration as follows:

1. Under Calibration Mode at left, click Offset RTI.
2. Short analog input channel 00 to ground as instructed on-screen under Connection.
3. While monitoring the A/D converter counts on-screen under Count, adjust potentiometer R146 until you achieve the count value that is specified on-screen under Adjustment.

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Performing the ADC unipolar offset calibration

Using the Calibrate A/D dialog box, perform the ADC unipolar offset calibration as follows:

1. Under Calibration Mode at left, click ADC Unipolar Offset.
2. Connect analog input channel 00 to the calibrator as instructed on-screen under Connection.
3. Set the calibrator voltage as instructed on-screen under Connection.
4. Under Count in the dialog box**,** monitor the A/D converter counts and adjust potentiometer R148 until you achieve the count value that is specified on-screen under Adjustment.

Performing the ADC gain calibration

Using the Calibrate A/D dialog box, perform the ADC gain calibration input gain as follows:

1. Under Calibration Mode at left, click ADC Gain.
2. Connect analog input channel 00 to the calibrator as instructed on-screen under Connection.
3. Set the calibrator voltage as instructed on-screen under Connection.
4. Under Count in the dialog box**,** monitor the A/D converter counts and adjust potentiometer R151 until you achieve the count value that is specified on-screen under Adjustment.

Calibrating the analog outputs

The KPCI-1800HC Series boards each have two independent analog outputs, provided by two digital-to-analog converters (DACs or D/A converters). The calibration first zeros the offset and then adjusts the gain of each DAC.

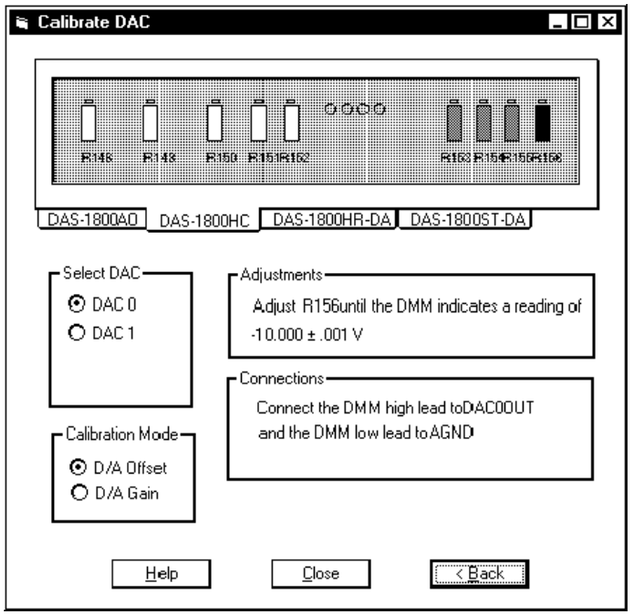
Opening the Calibrate DAC dialog box

Open the Calibrate DAC dialog box as follows:

1. At the bottom of the Calibrate A/D dialog box click Back. The KPCI-1800 Calibration Utility dialog box reappears.
2. Under the Select at the upper right of the KPCI-1800 Calibration Utility dialog box, select Cal DAC.
3. Click Next at the bottom of the KPCI-1800 Calibration Utility dialog box. The Calibrate DAC dialog box appears. See Figure 5-3.

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Figure 5-3
Example of a Calibrate DAC dialog box



In the Calibrate DAC dialog box, the tab attached to the frame picturing the calibration potentiometers should display the model number of your KPCI-1800HC Series board.

NOTE *In each remaining step, the potentiometer to be adjusted is highlighted in red at the top of the Calibrate A/D dialog box.*

Sequencing the analog output calibrations

In the next sections, two types of calibrations are outlined individually for each of the two analog outputs. The calibrations must be performed in the following basic order: D/A offset output voltage adjustment, then D/A gain output voltage adjustment. The recommended calibration sequence, with repetitions to compensate for slight interactions, is as follows:

1. D/A offset output voltage adjustment for DAC 0
2. D/A gain output voltage adjustment for DAC 0
3. D/A offset output voltage adjustment for DAC 0
4. D/A gain output voltage adjustment for DAC 0
5. D/A offset output voltage adjustment for DAC 1
6. D/A gain output voltage adjustment for DAC 1
7. D/A offset output voltage adjustment for DAC 1
8. D/A gain output voltage adjustment for DAC 1

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Performing D/A offset output voltage adjustment

Using the Calibrate DAC dialog box, perform the D/A offset output voltage adjustment as follows:

1. Under Select DAC at left, select DAC 0 or DAC 1, as appropriate.
2. Under Calibration Mode at left, click D/A Offset.
3. Connect the DVM/DMM as instructed under Connections.
4. While monitoring the DVM/DMM, adjust the potentiometer specified under Adjustments until you achieve the DVM/DMM reading specified under Adjustments.

Performing the D/A gain output voltage adjustment

Using the Calibrate DAC dialog box, perform the D/A gain output voltage adjustment as follows:

1. Under Select DAC at left, select DAC 0 or DAC 1, as appropriate.
2. Under Calibration Mode at left, click D/A Gain.
3. Connect the DVM/DMM as instructed under Connections.
4. While monitoring the DVM/DMM, adjust the potentiometer specified under Adjustments until you achieve the DVM/DMM reading specified under Adjustments.

Finishing

To finish the calibration procedure, click Close at the bottom of on any of these dialog boxes:

- The Calibrate DAC dialog box
- The Calibrate A/D dialog box
- The KPCI-1800 Calibration Utility dialog box

The KPCI-1800 Calibration Utility closes.

NOTE *Keithley recommends using Close to end the program, rather than the X button in the upper right corner of the dialog box.*

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6
Troubleshooting

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If your KPCI-1800HC Series board is not operating properly, use the information in this Chapter to isolate the problem before calling Keithley Applications Engineering. If you then need to contact an applications engineer, refer to the *Technical support* section.

Identifying symptoms and possible causes

Try to isolate the problem using Table 6-1, which lists general symptoms and possible solutions for KPCI-1800HC Series board problems.

Table 6-1
Basic troubleshooting information

Symptom	Possible cause	Possible cause validation/solution
Computer does not boot when board is installed.	Resource conflict. KPCI-1800HC series board is conflicting with other boards in the system.	1. Validate the cause of the conflict. Temporarily unplug boards — especially ISA boards[1] — one at a time, and try booting the computer. Repeat until a boot is attained. 2. Try resolving conflicts by reinstalling one PCI board at a time and rebooting after each reinstallation.[2] However, you may ultimately need to change ISA board resource allocations, such as base address or interrupt assignments.
	Board not seated properly.	Check the installation of the board.
	The power supply of the host computer is too small to handle all the system resources.	Check the needs of all system resources and obtain a larger power supply.
After board and software are installed, mouse control is lost or system freezes.	An interrupt conflict occurred.	Unplug the board to regain mouse control. Look closely at the COM ports and at the interrupts of other devices.
Board does not respond to 1800HC Test Panel.	DriverLINX is not installed properly.	Check the Windows Device Manager and follow the installation troubleshooting instructions in the DriverLINX on-line help.
	The board is incorrectly aligned in the expansion slot.	Check the board for proper seating.
	The board is damaged.	Contact Keithley Applications Engineering.
Data appears to be invalid.	An open connection exists.	Check screw terminal wiring.
	Transducer is not connected to channel being read.	Check the transducer connections.
	Signal and/or connections inappropriate for the selected input mode, differential or single-ended.	Ensure that correct input mode — differential or single-ended — is being used for your signal conditions and that input is wired properly for this mode. Refer to Section 3, *Wiring analog input signals*.

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Table 6-1 (cont.)
Basic troubleshooting information

Symptom	Possible cause	Possible cause validation/solution
Intermittent operation	Vibrations or loose connections exist.	Cushion source of vibration and tighten connections.
	The board is overheating.	Check environmental and ambient temperature. Refer to your computer documentation.
	Electrical noise exists.	Provide better shielding or reroute unshielded wiring.
System lockup during operation.	A timing error occurred.	Restart your computer. Then analyze your program by debugging and narrowing the list of possible failure locations.

[1]Plug and Play cannot tell if an ISA board already uses an address that it assigns to a PCI board.
[2]Plug and Play may then assign different, nonconflicting addresses to the PCI boards.

If your board is not operating properly after using the information in Table 6-1, continue with the next section to further isolate the problem.

Systematic problem isolation

If you were unable to isolate the problem by using Table 6-1, then use the systematic problem isolation that follows.

For clarity, the systematic problem isolation procedure is divided into seven schemes, each of which checks for, eliminates, and/or resolves problem causes. Each scheme consists of a flowchart and, in some cases, an amplified written procedure. The numbers of flowchart blocks are keyed to the numbers of written steps.

For simplicity, your problem is assumed to have only one cause. A particular scheme may not itself isolate this cause. Rather, performance of several schemes in series may be required to analyze your problem. One scheme may eliminate potential causes from further consideration, then direct you to another scheme that ultimately isolates the problem. You need perform only those schemes to which you are directed.

If the cause of your problem appears to be outside the scope of the systematic isolation procedure, the procedure directs you to call Keithley for help.

The seven problem isolation schemes are as follows:

- Scheme A checks for three basic system problems.
- Scheme B checks DriverLINX installation and board recognition by DriverLINX.
- Scheme C addresses application software bugs when the source code is accessible.
- Scheme D addresses apparent expansion slot malfunctions and attempted remedies.
- Scheme E addresses potential external connection problems.
- Scheme F addresses apparently malfunctioning board(s).
- Scheme G verifies that earlier schemes have found and addressed the problem.

Start the systematic isolation procedure at the next section, entitled *Problem isolation Scheme A: basic system.*

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CAUTION **Always turn OFF your computer and any external circuits connected to the KPCI-1800HC Series board before removing or replacing the board. Removing or replacing a board with the power ON can damage the board, the computer, the external circuit, or all three.**

Handle the board at the mounting bracket, using a grounded wrist strap. Do not touch the circuit traces or connector contacts. If you do not have a grounded wrist strap, periodically discharge static electricity by placing one hand firmly on a grounded metal portion of the computer chassis.

NOTE *In the following procedure, the term "board" always refers to a KPCI-1800HC Series board. The procedure never directs you to install or remove any type of board other than a KPCI-1800HC Series board.*

In the flowcharts of Schemes A through G, the number in brackets in each block (e.g. [6]) refers to the corresponding step number in the amplified written procedure. If multiple blocks in the flowchart have the same number, each of those blocks is part of a single verbal step. Conversely, if there is a range of numbers in the brackets (e.g. [4, 5 or 8-10], the block summarizes multiple verbal steps.

The logic used in the systematic problem isolation schemes assumes that the problem has only one cause. Therefore, once a cause is found and corrected, the reader is instructed to reassemble the system and verify proper operation.

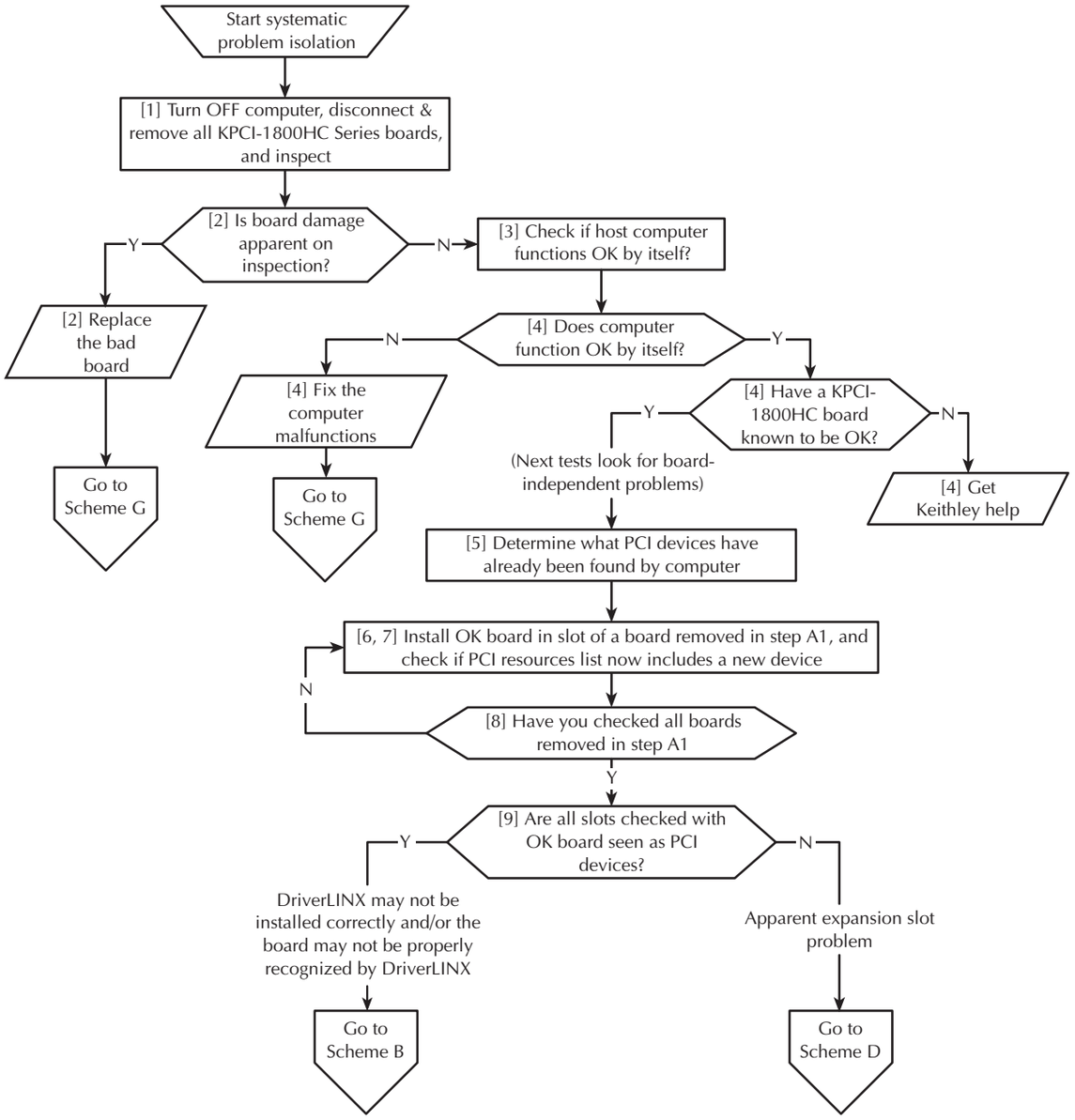
Each individual scheme in this procedure, except for Scheme A, is designed to be used only if called for by other schemes or procedures. For example, Scheme B is called for by Scheme A. Scheme B is also called for as a post-installation check in Section 3 of this manual and in the "Read This First" sheet that shipped with your board. If you attempt to use schemes independently, you will lose the benefits of systematic problem isolation.

Problem isolation Scheme A: basic system

In Scheme A, you start the systematic problem isolation procedure. You remove your KPCI-1800HC Series board(s) and check them for apparent damage. If the board looks okay, you check the independent functionality of your computer. If the computer is okay, you check the expansion slots that held your KPCI-1800HC board(s). Refer to Figure 6-1 and the written amplification following it.

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Figure 6-1
Problem isolation Scheme A: basic system



Follow these amplified instructions as you perform Scheme A:

1. Remove and inspect the board for damage as follows:
   a. Shut down Windows 95/98/NT and turn OFF power to the host computer.
   b. Turn OFF power to all external circuits and accessories connected to the KPCI-1800HC Series board(s) that is installed.
   c. Disconnect STP-100 or STA-1800HC screw terminal accessory(s) from your KPCI-1800HC series board(s).

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d. Remove the KPCI-1800HC Series board from the computer, making note of the socket in which it was installed. If more than one KPCI-1800HC Series board is installed, remove all KPCI-1800HC Series boards.

e. Visually inspect the removed KPCI-1800HC Series board(s) for damage.

2. Based on the results of step 1, do the following:
   - If the board(s) you removed in step 1 is not obviously damaged, then skip to step 3 and check for host computer malfunction.
   - If the board(s) you removed in step 1 is obviously damaged, then repair or replace the board. Refer to *Technical support* for information on returning the board for repair or replacement. Skip to Scheme G.
3. Check if the computer functions satisfactorily by itself. Proceed as follows:
   a. Place the board(s) that you removed from the computer in step 1 in an electrostatically safe location. Do not reinstall it.
   b. Turn ON power to the host computer.
   c. Perform all needed diagnostics to determine whether your computer hardware and operating system are functioning properly.
4. Based on the results of step 3, do one of the following:
   a. If you find no computer or operating system malfunctions in step 3, then the problem likely lies elsewhere; perform the following steps:
      - If you have another KPCI-1800HC Series board that you know is good, i.e. works properly, then proceed to step 5.
      - If you do not have another KPCI-1800HC Series board that you know is good, i.e. works properly, read the instructions in *Technical support*. Then contact Keithley for help in isolating the cause of your problem.
   b. If you find computer or operating system malfunctions in step 3, do the following:
      - Determine the cause of the computer hardware or operating system malfunctions and fix them.
      - Assume that fixing the malfunctions has solved your problem, and skip to Scheme G.
5. Determine the PCI resources detected by your computer before any KPCI-1800HC Series boards are installed. Proceed as follows:
   a. Shut down Windows 95/98/NT and turn OFF power to the host computer.
   b. Insert a blank diskette, or any diskette that you are sure is unbootable, into the A: drive.
   c. Turn ON the computer and allow it to start the boot cycle.
   The boot cycle stalls at a text screen listing system characteristics and resources and, at the bottom, saying: Non-system disk or disk error. Replace and press any key when ready.

NOTE *This system characteristics and resources screen is normally displayed only fleetingly during the boot cycle. Having an unbootable diskette in your computer automatically stops the boot cycle at this screen, allowing for convenient viewing. This is not harmful to your computer. The more common approach — using the* PAUSE *key to pause the boot cycle at this screen — requires fast reflexes with some systems.*

   d. Note the displayed list of PCI devices under a heading something like PCI device listing… . If you have a printer, print the screen by pressing the Print Screen key.
   e. Remove the diskette and allow the boot cycle to finish.

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6. Install a good board — a KPCI-1800HC Series board that you know is fully functional — as follows:
   a. Shut down Windows 95/98/NT and turn OFF power to the host computer.
   b. Install the good board in the slot from which you removed the potentially faulty board in step 1. Refer to *Installing the KPCI-1800HC Series board* near the beginning of Section 3, for board installation instructions.

NOTE *If you removed more than one board in step 1, install only one good board in only one expansion slot.*

Do not connect any external circuits to the board at this point

7. Again determine the PCI resources detected by your computer, after the KPCI-1800HC Series board is installed. Windows 95 Plug and Play should find and configure the new board as a PCI resource if all of the following are true:
   - The board functions properly as a PCI device.
   - The contacts of the expansion slot in which the OK board is installed are in good condition.
   - The OK board is seated properly in the expansion slot.

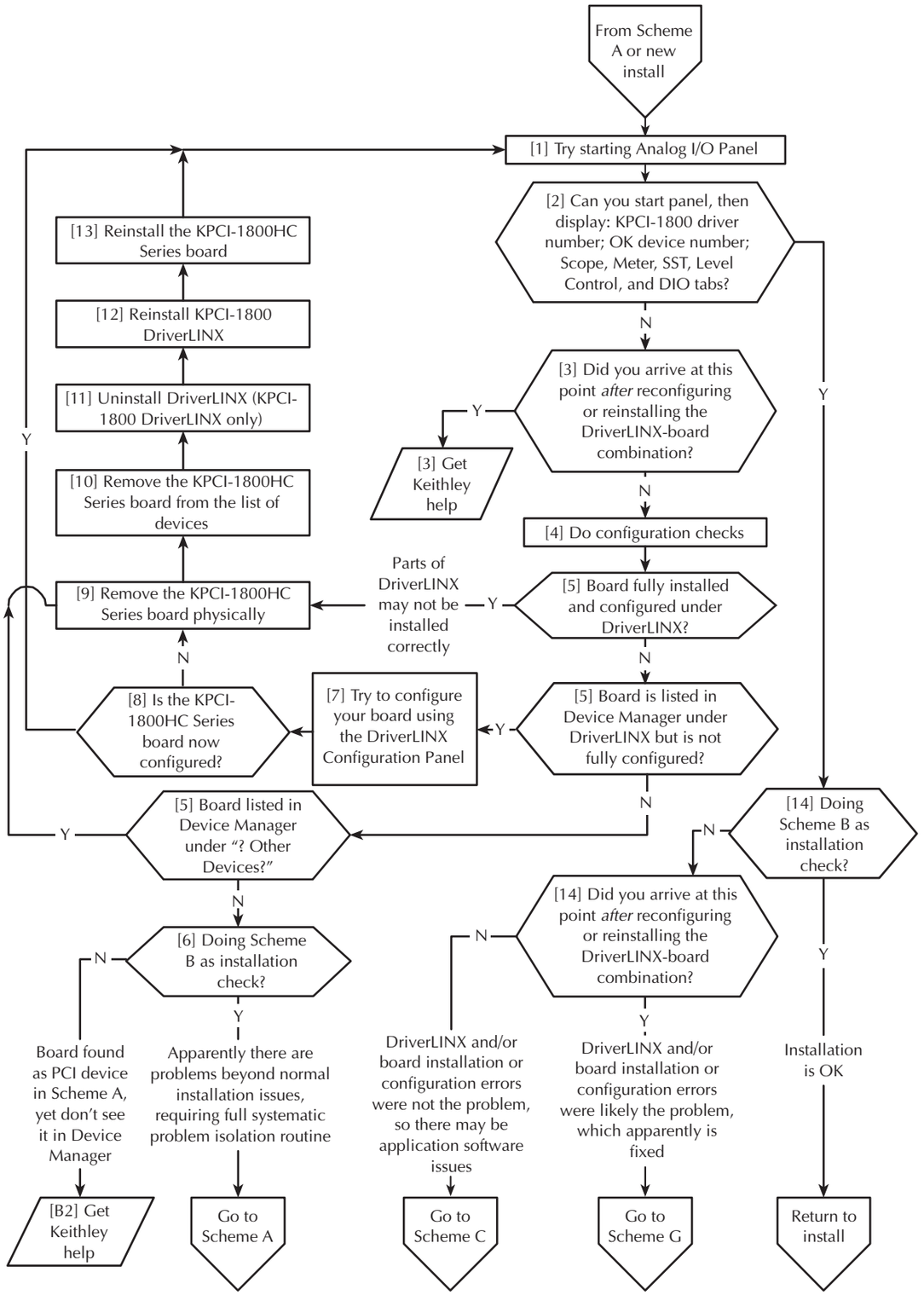
   Do the following, as you did in step 5:
   a. Insert an unbootable diskette.
   b. Turn ON the computer and allow the boot cycle to stall at the Non-system disk or disk error… message.
   c. Again, note the displayed list of PCI devices. A new device should be listed, likely as an unidentified peripheral. If your resource listing includes PCI slot numbers, the slot number for the new device should match the number of the slot in which your board is installed.
   d. Remove the diskette and allow the boot cycle to finish.
8. If you removed KPCI-1800HC Series boards from other PCI slots in step 1, then repeat steps 6 and 7 with the good board in each of these other slots.
9. Based on the results of steps 5 through 8, do one of the following:
   a. If the good board is recognized as a PCI component in all slots tested, then the PCI slots are apparently satisfactory. DriverLINX may not be installed correctly and/or the board may not be properly configured. Continue with Scheme B.
   b. If the good board is not recognized as a PCI component in a slot(s), then the PCI slot connector(s) is suspect. Continue with Scheme D.

Problem isolation Scheme B: installation

In Scheme B, you check whether DriverLINX and your board are installed correctly and work together properly. A proper start of the DriverLINX Analog I/O Panel utility means that the combined DriverLINX/board installation is okay. If the installation is not okay, you try to diagnose and fix the problem, ultimately reinstalling DriverLINX and the board if necessary. Refer to Figure 6-2 and the written amplification following it.

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Figure 6-2
Problem isolation Scheme B: installation

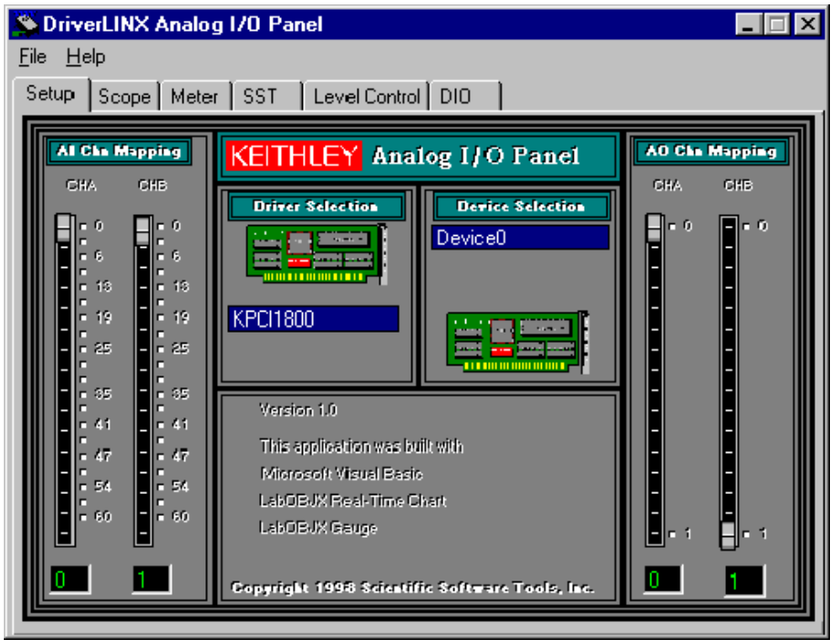


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Follow these amplified instructions as you perform Scheme B:

1. Try starting the DriverLINX Analog I/O Panel. Proceed as follows:
   a. In the **Start** menu, click **Programs.**
   b. Find the **DriverLINX** → **Test Panels** folder, under which you should find the **AIO Panel** entry.
   c. Click on the **AIO Panel** entry.
2. Based on the results of Step 1, select one of the following:
   - Case A — If both of the following statements are true, then skip to step 14; DriverLINX and your board are installed properly and are working together.
     - KPCI-1800HC board is the only board in your computer installed under DriverLINX.
     - The DriverLINX Analog I/O Panel appears as in Figure 6-3, with KPCI1800 listed under Driver Selection and Device 0 listed under Device Selection.

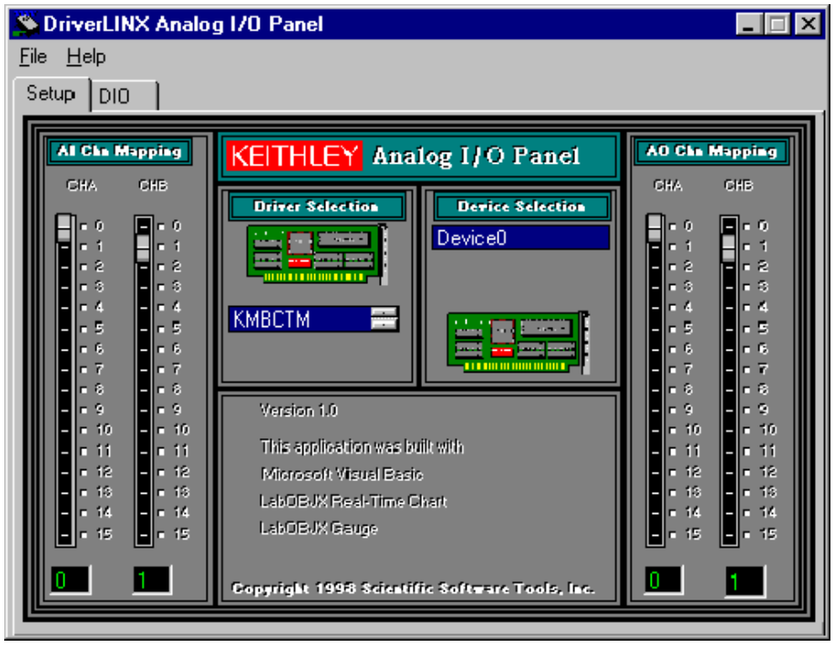
Figure 6-3
Analog I/O Panel setup screen when only KPCI-1800HC series boards are installed under DriverLINX



   - Case B — If all three of the following statements are true, then skip to step 14; DriverLINX and your board are installed properly and are working together.
     - More than one type of board is installed in your computer under DriverLINX.
     - The DriverLINX Analog I/O Panel initially appears similar to Figure 6-3 but with any or all of the following differences: 1) tiny buttons located at the right side of the Driver Selection text box and/or the Device Selection text box; 2) a different board driver under Driver Selection; 3) a different device number under Device Selection; 4) different tabs at the top of the screen. See Figure 6-4.
     - The tabs at the top of the screen look like the tabs in Figure 6-3 after you do the following, using the tiny buttons next to the text boxes: 1) select the board driver under Driver Selection to be KPCI1800 and 2) select the correct device number under Device Selection, which is 0 if only one KPCI-1800HC Series board is installed.

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Figure 6-4
Analog I/O Panel example setup screen when multiple board types are installed under DriverLINX

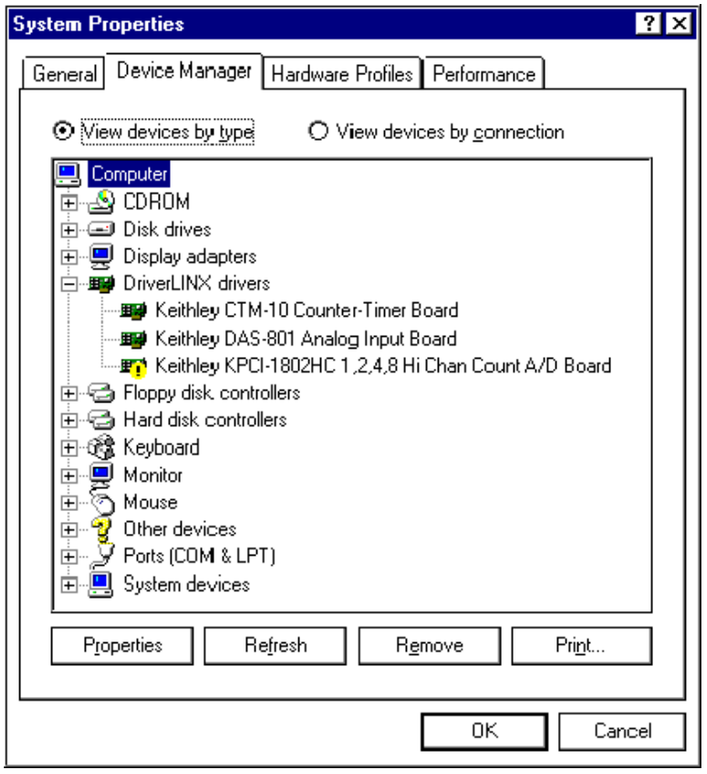


- Case C — If neither of the two scenarios above apply — neither Case A nor Case B, then continue with step 3; there may be a problem with the DriverLINX installation and/or board configuration.

3. Select the next step in Scheme B based on the criteria given in the following alternatives:
   - If you have already reconfigured or reinstalled DriverLINX and the board, yet still cannot successfully start the Analog I/O Panel, then the cause of your problem may be outside the scope of these diagnostics. Read the instructions in *Technical support* and then contact Keithley for help in isolating the cause of your problem.
   - If you have not yet tried to fix the combined DriverLINX/board problem, then continue with step 4.
4. See if and how your KPCI-1800HC Series board is listed in the Windows Device Manager. Proceed as follows:
   a. Right-click the **My Computer** icon on your desktop.
   b. On the menu that appears, click Properties.
   c. On the System Properties dialog box that appears, click the **Device Manager** tab. The Device Manager appears.
   d. In the Device Manager look for a DriverLINX drivers item.
   e. If you find a DriverLINX drivers item, click the + sign to the left of this item. A second level list may appear with the specific model number of your KPCI-1800HC Series board. More than one KPCI-1800HC Series board may be listed here if you installed more than one KPCI-1800HC Series board.
   f. Select your next action based on the criteria given in the following alternatives:
      - If a board is recognized as a device under DriverLINX but is not configured to work with DriverLINX, then the board is normally listed with a large exclamation point over it, as shown in Figure 6-5. If you find a KPCI-1800HC Series board listed with an exclamation point over it, keep the Device Manager open and go directly to step 5. Skip substeps 4g through 4j.

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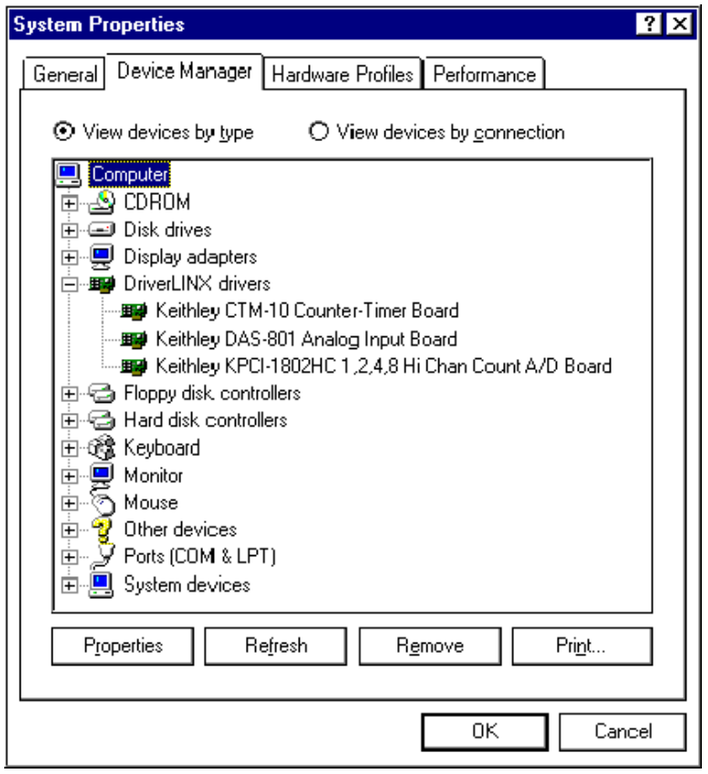
Figure 6-5
Listing of improperly configured/installed KPCI-1800HC Series board



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- If a board is recognized as a device under DriverLINX and *is* configured to work with DriverLINX, then the board is listed without the large exclamation point over it, as shown in Figure 6-6. However, though a listing as in Figure 6-6 is a necessary indication of a complete KPCI-1800HC Series board configuration, it is not by itself a sufficient indication in at least one situation. Therefore, if you find that *all* of your KPCI-1800HC Series boards are listed in the Device Manger without exclamation points, do as follows:
  - Leave the Device Manager open for now.
  - Continue with substeps 4g through 4j, in which you open and check the DriverLINX Configuration Panel.

Figure 6-6
Appearance of device manager listing when KPCI-1800HC Series board is properly configured/installed



- If the list of devices in the Device Manager includes an **?** Other Devices item, also click the + sign to the left of this item (see the **?** near the bottom of Figure 6-6). If a KPCI-1800HC Series board is listed under **?** Other Devices, then keep the Device Manager open and go directly to step 5. Skip substeps 4g through 4j.
- If one or more of your KPCI-1800HC Series boards is not listed anywhere in the Device Manager, then keep the Device Manager open and go directly to step 5. Skip substeps 4g through 4j.

g. In the **Start** menu, click **Programs.**

h. Find the **DriverLINX folder** and under it click **DriverLINX Configuration Panel.** The DriverLINX Configuration Panel appears. See the examples in Figures 6-7 and 6-8.

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Figure 6-7
Example of a DriverLINX Configuration Panel before a KPCI-1800HC Series board is configured

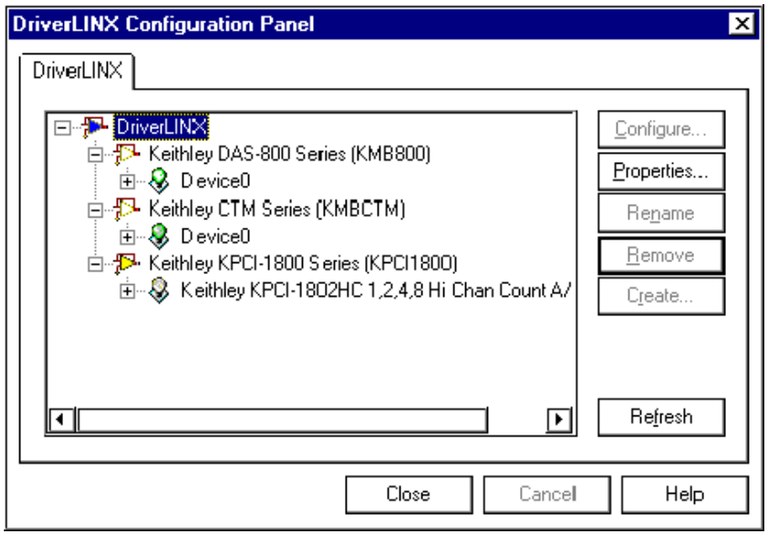
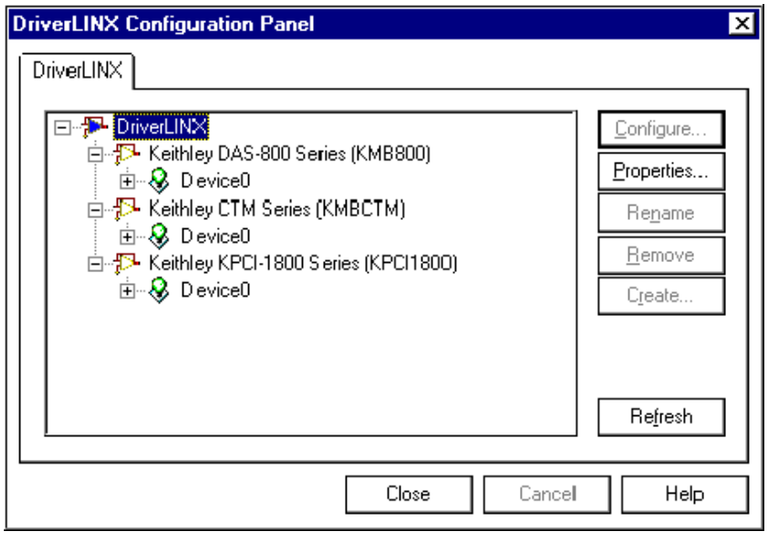


Figure 6-8
Example of a DriverLINX Configuration Panel after a KPCI-1800HC Series board is configured



i. Inspect the DriverLINX Configuration Panel

- If you see the following on the screen for a KPCI-1800 Series board (and partly on uncolored Figure 6-7), then the board is recognized as a device under DriverLINX but is not properly configured:
  - Keithley KPCI-1800 Series is listed under DriverLINX.
  - The amplifier icon next to Keithley KPCI-1800 Series is colored yellow.

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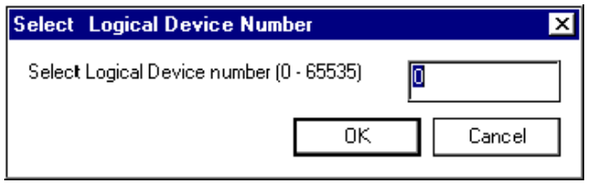
- The specific board part number(s) of the unconfigured Keithley KPCI-1800HC Series board(s) is listed under Keithley KPCI-1800 Series.
- The lamp icon next to the specific board part number is uncolored.

- If you see the following on the screen for a KPCI-1800 Series board (and partly on uncolored Figure 6-8), then the board is recognized as a device under DriverLINX and *is* properly configured:
  - Keithley KPCI-1800 Series is listed under DriverLINX.
  - The amplifier icon next to Keithley KPCI-1800 Series is colored pale gray.
  - A device number — for example, Device0 — is listed under Keithley KPCI-1800 Series, instead of a specific board part number.
  - The lamp icon next to the device number is colored green.

j. Leave the DriverLINX Configuration Panel open for now and continue with step 5.

5. Based on the results of step 4, do one of the following:
   - If your board is properly installed and configured, your inability to run the Analog I/O Panel may be due to an improperly installed component of DriverLINX. Skip to step 9, and begin uninstalling, then reinstalling DriverLINX and the board.
   - If one of your KPCI-1800HCD boards is apparently recognized by DriverLINX but is listed in the Device Manager under DriverLINX with a large exclamation point, then try configuring it with the DriverLINX Configuration Panel. Skip to step 7.
   - If one of your KPCI-1800HC boards is listed under **?** Other Devices, or is listed in the Device Manager at multiple places, then skip to step 9 and begin uninstalling, then reinstalling DriverLINX and the board.
   - If your board is not listed at all in the Device Manager, there are apparently issues other than the combined DriverLINX/board installation. Continue with step 6.
6. Select the next step in Scheme B based on the criteria given in the following alternatives:
   - If you are performing Scheme B independently as an installation check, then non-installation issues must apparently be resolved before you can successfully run your board. Starting at Scheme A, proceed through the systematic problem isolation procedure.
   - If you are performing Scheme B as part of the systematic problem isolation procedure, then you should have seen your board listed in the device manager at this point in the procedure. The cause of your problem may be outside the scope of these diagnostics. Read the instructions in *Technical support*, and then contact Keithley for help in isolating the cause of your problem.
7. Try to reconfigure your board using the DriverLINX configuration panel, which you opened in step 4 and should still be open. Proceed as follows:
   a. In the DriverLINX Configuration Panel, select an unconfigured KPCI-1800HC Series board by clicking on the part number.
   b. Click the Configure button. The Select Logical Device dialog box appears as in Figure 6-9.

Figure 6-9
Selecting the logical device number

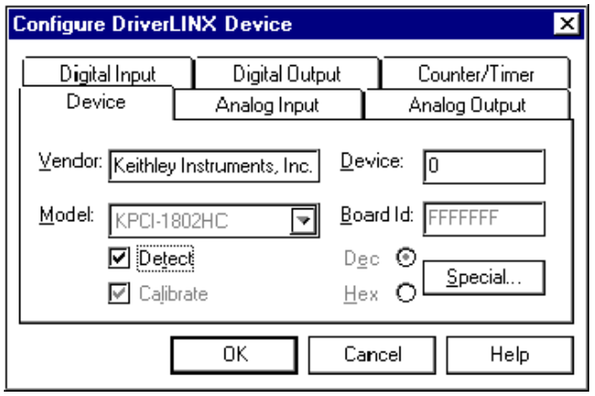


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c. Select your next action based on the criteria given in the following alternatives:
   - If only one KPCI-1800 Series board is installed, a default device number of 0 in the text box is correct. Click OK.
   - If other KPCI-1800HC Series boards are installed and configured and have been assigned device numbers, then type in a device number for the board you are configuring — the next, unassigned number in the numbering sequence. Then click OK.

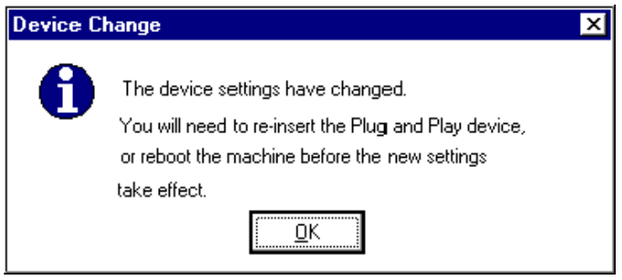
   The Configure DriverLINX Device dialog box appears, Figure 6-10, as well as the Device Manager.

Figure 6-10
Configure DriverLINX Device dialog box example



d. No changes in the Device dialog box changes are normally required. Click OK.
e. If a Device Change message appears as in Figure 6-11, click OK.

Figure 6-11
Device Change message



f. If more than one unconfigured board was found in the DriverLINX Configuration Manager in step 4, configure the additional boards now. Repeat substeps 7a through 7e for each remaining unconfigured board.
g. Close out all programs and reboot your computer to complete the configuration process.
h. Open and check the Device Manager as you did in step 4. Your KPCI-1800 Series board(s) should now be listed under the DriverLINX with no exclamation mark over it, as was illustrated in Figure 6-6.

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i. Open and check the DriverLINX Configuration panel as you did in step 4. If you successfully configured your board(s), you should now see the following listed below Keithley KPCI-1800HC Series. Refer back to step 4, substep i and Figure 6-8.

- Instead of a specific board part number(s), there should now be a device number(s) — for example, Device0.
- The lamp icon next to the device number(s) should be colored green.

8. Based on the results of step 7, do one of the following:
   - If the board was successfully configured, return to step 1 and retry starting the Analog I/O Panel.
   - If the board was not successfully configured, continue with step 9 and begin uninstalling, then reinstalling DriverLINX and the board.
9. Remove all KPCI-1800HC Series boards physically.

NOTE *It is necessary to remove all KPCI-1800HC Series boards before reinstalling the KPCI-1800 version of DriverLINX, because the required installation order is DriverLINX first, board second. If a KPCI-1800HC Series board is present, physically or in the computer list of devices, driver installation difficulties will occur.*

Proceed as follows:

a. Turn OFF the computer.

b. Remove all KPCI-1800HC Series boards from their computer expansion slots.

CAUTION **Wear a grounded wrist strap to avoid electrostatic damage to the board. Do not touch board components or conductors when handling the board.**

10. Remove all KPCI-1800HC Series boards from the list of devices in your system. If your operating system is Windows 95/98, remove the KPCI-1800HC Series boards using the Windows 95/98 device manager, as follows:

a. Shut down and turn OFF the computer.

b. Open the Device Manager by right clicking the **My Computer** icon, clicking Properties on the menu that appears, then clicking the Device Manager tab. A list of installed devices appears. See example in Figure 6-5.

c. Select your next step based on the criteria given in the following alternatives:

- If the Device Manager lists a DriverLINX drivers item, click the + sign to the left of this item. A second level list may appear with the specific model number of your KPCI-1800HC Series board. More than one KPCI-1800HC Series board may be listed if you previously installed more than one KPCI-1800HC Series board. Alternatively, if a previously installed board is not properly recognized by DriverLINX, it may not be listed here or may be listed with a large exclamation point over it.
- If the Device Manager lists an **?** Other Devices item, also click the + sign to the left of this item. You should not, but could, find a KPCI-1800HC board listed under this item if it is not properly recognized by DriverLINX.

d. Select any one of the KPCI-1800HC Series boards that you find in the Device Manager, wherever you find it.

e. At the bottom of the list of devices, click Remove.

f. On the Confirm Device Removal dialog box that appears, click OK. The board is removed from the list of devices.

g. If more than one KPCI-1800HC Series board was listed in the Device Manager, or if the same board was listed in more than one place, then repeat steps d, e, and f until no KPCI-1800HC Series boards are listed anywhere in the Device Manager.

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11. Uninstall *only* the KPCI-1800 Series version of DriverLINX from your system using the Windows 95/98/NT Add/Remove Programs feature. Proceed as follows:
    a. In the **Start** menu of Windows 95/98/NT, click **Settings → Control Panel.**
    b. In the Control Panel that appears, click **Add/Remove Programs.**
    c. In the Add/Remove Programs Properties dialog box that appears, select DriverLINX for Keithley 1800 Series.

    NOTE *Uninstall only "DriverLINX for Keithley 1800 Series." If additional DriverLINX versions are installed, leave them installed.*

    d. At the bottom of the Add/Remove Programs Properties dialog box, click Add/Remove and then follow the remainder of the Windows uninstall prompts.

    CAUTION **During the course of an uninstall procedure, you will typically be asked if you wish to uninstall certain files that may be shared by other programs. In such cases, always click No. Mistakenly uninstalling files needed by other programs causes serious problems. Mistakenly keeping files causes no harm, and some uninstalled files may be overwritten anyway when you subsequently reinstall DriverLINX.**

12. Reinstall DriverLINX, referring to the brief DriverLINX installation instructions on the Read This First sheet that was shipped with your KPCI-1800HC board and is also provided on the CD-ROM containing this manual. Make sure that DriverLINX installs smoothly and completely.
13. Reinstall the board(s).

    CAUTION **Wear a grounded wrist strap to avoid electrostatic damage to the board. Do not touch board components or conductors when handling the board.**

    NOTE *If you are performing Scheme B independently as an installation check, then reinstall all boards that you removed in step 9. If you are performing Scheme B as part of the systematic problem isolation procedure, then reinstall only the good board that you began using near the end of Scheme A.*

    Proceed as follows:
    a. Shut down and turn OFF the computer.
    b. Install the board(s) in its expansion slot(s), following this brief procedure in Section 3 of this manual: *Installing the KPCI-1800HC Series board.*
    c. Turn ON and reboot the computer.
    d. Run the procedure in Section 3, *Configuring the board to work with DriverLINX*.
    e. Return to step 1 and run the installation check again.
14. You arrived at this step from step 2, after successfully starting the Analog I/O Panel. Select your next action based on the criteria given in the following alternatives:
    - If you are performing Scheme B independently as an installation check, then DriverLINX and your KPCI-1800HC Series board are installed correctly. Return to Section 3 and finish installing your data acquisition system, starting with *Identifying I/O connector pin assignments for KPCI-1800HC series*.
    - If you performed Scheme B as part of the systematic problem isolation procedure AND arrived at this point after reconfiguring the board or reinstalling DriverLINX and the board, then that effort has apparently solved your problem. Finish the systematic problem isolation procedure with Scheme G.

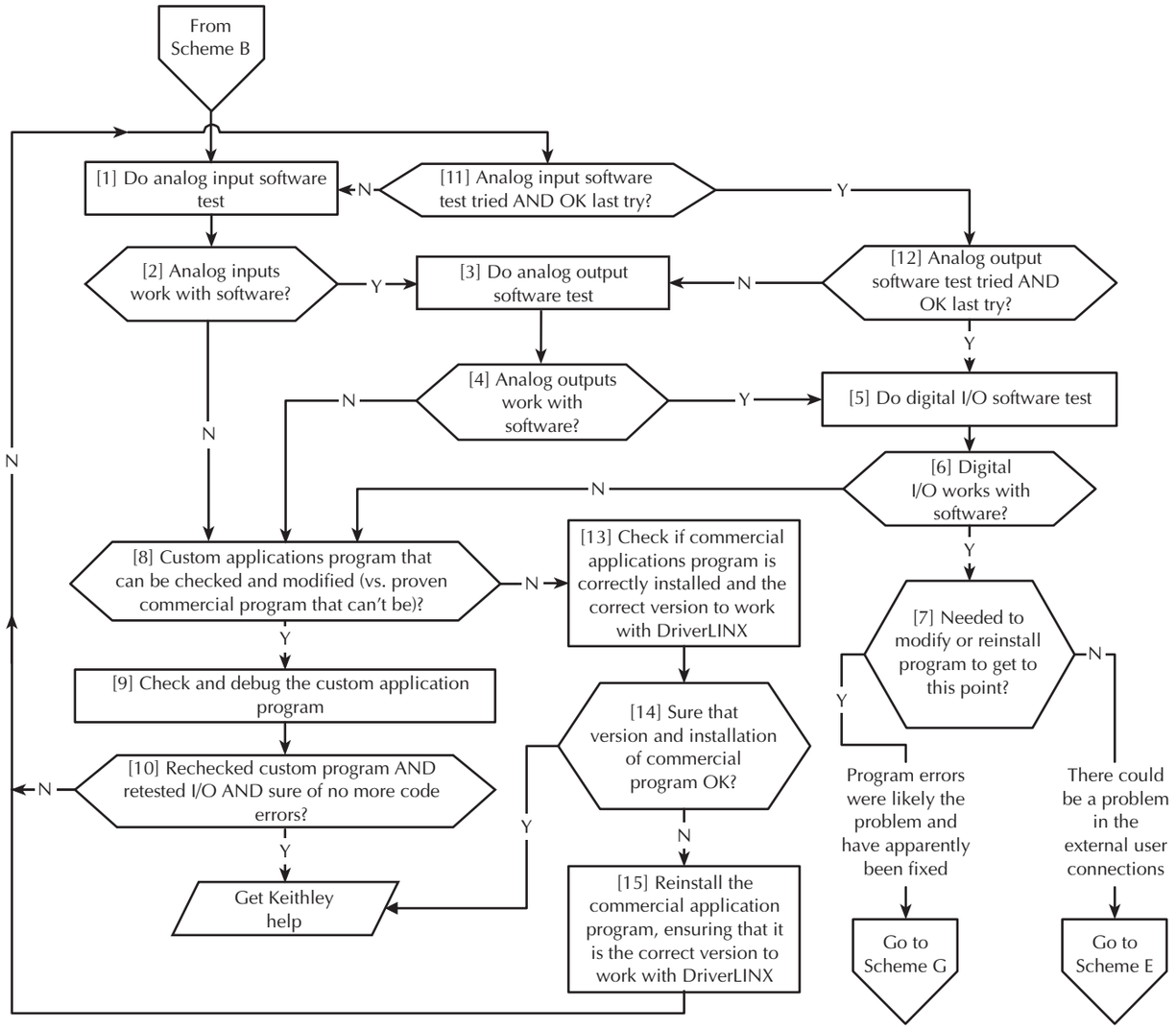
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- If you performed Scheme B as part of the systematic problem isolation procedure AND arrived at this point without performing any remedial efforts, then your problem must lie elsewhere. Go to Scheme C and check for application software issues.

Problem isolation Scheme C: application software

In Scheme C, you check for bugs in custom application software, assuming that you can access the source code. Alternatively, you check for compatibility and installation issues in commercial application software. In Scheme A, temporarily install a KPCI-1800HC board that is known to be good, in place of a KPCI-1800HC board that you removed from the computer. This substitution eliminates possible board I/O problems during the scheme. You now perform I/O tests using your application software. You debug custom code, if necessary, and recheck. Refer to Figure 6-12 and the written amplification following it.

Figure 6-12
Problem isolation Scheme C: application software



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Follow these amplified instructions as you perform Scheme C:

1. Perform the procedure outlined in the *Analog input software test*, found later in Section 6.
2. Based on the results of the Analog input software test, do one of the following:
   - If your software appears not to be working properly with your analog inputs, skip to step 8.
   - If your software appears to be working properly with your analog inputs, continue with step 3.
3. Perform the procedure outlined in the *Analog output software test* found later in Section 6.
4. Based on the results of the Analog output software test, do one of the following:
   - If your software appears not to be working properly with your analog outputs, skip to step 8.
   - If your software appears to be working properly with your analog outputs, continue with step 5.
5. Perform the procedure outlined in the *Digital I/O software test* found later in Section 6.
6. Based on the results of the Analog output software test, do one of the following:
   - If your software appears not to be working properly with your digital I/O, skip to step 8.
   - If your software appears to be working properly with your digital I/O, continue with step 7.
7. Select the next step in Scheme C based on the criteria given in the following alternatives:
   - If you reached this point without modifying the custom software or reinstalling the commercial software — you experienced no problems in the tests at any point — then the problem you originally experienced must lie elsewhere. Go to Scheme E and check your external connections.
   - If you reached this point by having to modify the custom software or reinstall the commercial software — you now experience no more problems in the tests — then assume that you have solved the original problem. Go to Scheme G and verify that the problem is solved.
8. You arrived at this point because one of the I/O software tests failed. Select the next step in Scheme C based on the criteria given in the following alternatives:
   - If your applications program is a proven program — potentially a commercial program that you cannot modify — then the software may be installed incorrectly or perhaps is incompatible with DriverLINX. Skip to step 13.
   - If your applications program is a custom program that can be modified — the source code is available — then continue with step 9.
9. Check and debug the source code as necessary.
10. At this point, you have presumably found and corrected some program bugs. Select the next step in Scheme C based on the criteria given in the following alternatives:
    - If both of the following statements are true, then the cause of your problem may be outside the scope of these diagnostics. Read the instructions in *Technical support*, and then contact Keithley for help in isolating the cause of your problem.
      - You are at this point after having debugged the source code at least once and having failed the I/O software tests at least a second time.
      - You have tried to find more code bugs after two or more I/O test failures and cannot find any more bugs.
    - If either or both of the above statements are not true, then continue with step 11, and selectively redo I/O software tests.

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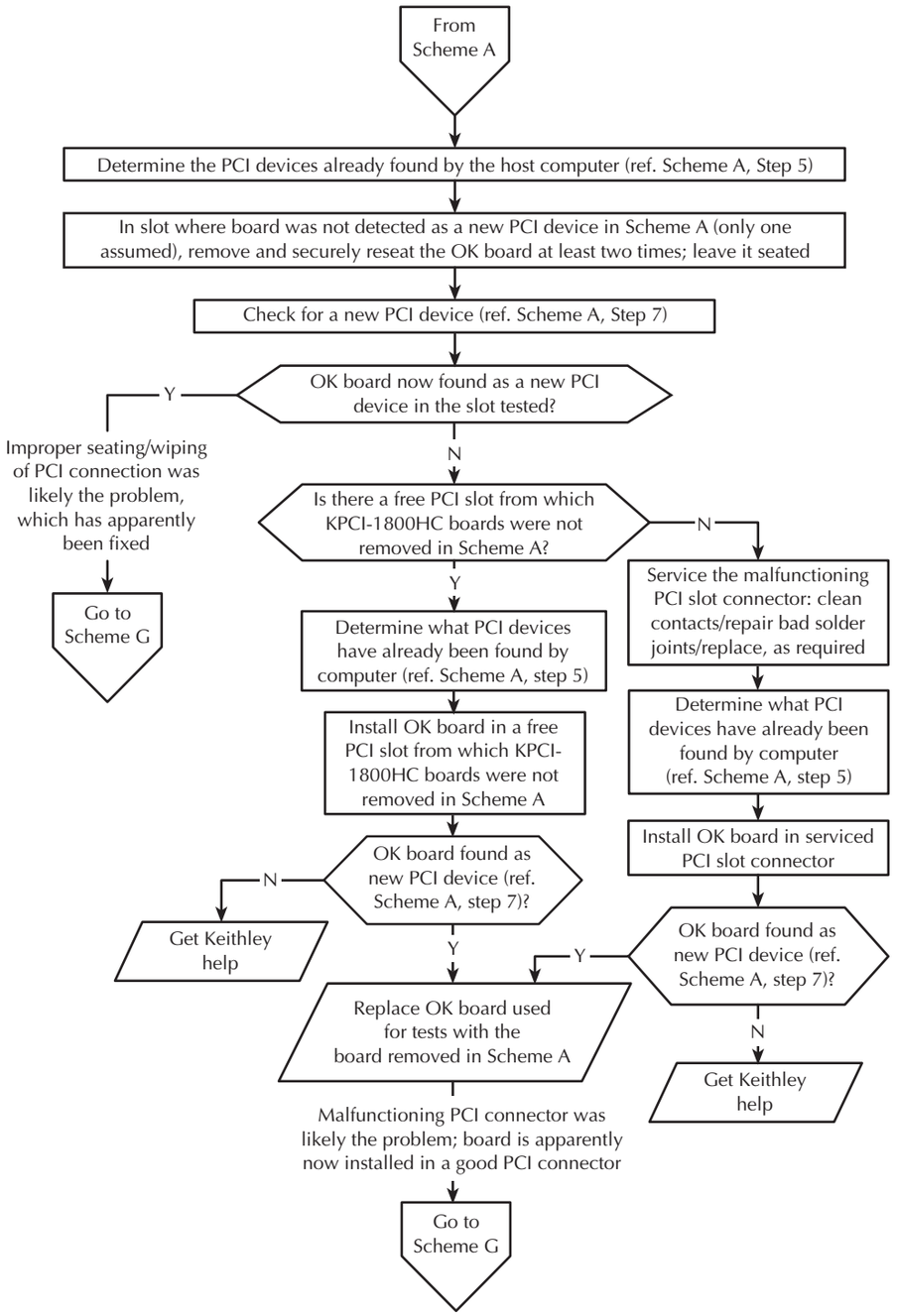
11. Select your next step in Scheme C based on the criteria given in the following alternatives:
    - If your software did not pass the analog input software test the last time, return to step 1 and redo that test.
    - If your software passed the analog input software test the last time, assume that you do not need to repeat it. Continue with step 12.
12. Select your next step in Scheme C based on the criteria given in the following alternatives:
    - If your software did not pass the analog output software test the last time you tried, return to step 3 and redo that test.
    - If your software passed the analog input software test the last time, assume that you do not need to repeat it. However, by process of elimination, you failed the digital I/O software test the last time you tried. Return to step 5 and redo the digital I/O software test.
13. You arrived at this point from step 8, because presumably you have a commercial or otherwise unmodifiable applications program that is assumed to be proven. Contact the maker of your software to determine whether you have a version designed to work with the KPCI-1800 version of DriverLINX. For example, not all versions of TestPoint will work with KPCI-1800 DriverLINX. Also, check whether the program is installed correctly.
14. Select your next step in Scheme C based on the criteria given in the following alternatives:
    - If you are certain at this point that your application program is the correct version AND is properly installed, then the cause of your problem may be outside the scope of these diagnostics. Read the instructions in *Technical support*, and then contact Keithley for help in isolating the cause of your problem. Also, contact Keithley if you have been unable to find out elsewhere whether you have the correct version of software.
    - If you are uncertain at this point that your application program is properly installed, then reinstall it now. When you are satisfied that it is properly installed, go to step 11 and retry selected I/O software tests.

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Problem isolation Scheme D: expansion slot connectors

In Scheme D, you further check and try to remedy apparent expansion slot malfunctions. Refer to Figure 6-13.

Figure 6-13
Problem isolation Scheme D: expansion slot connectors

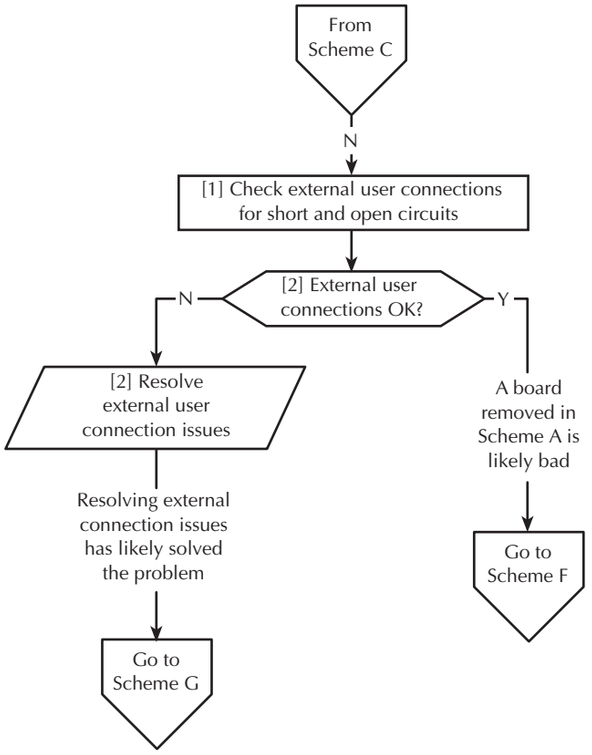


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Problem isolation Scheme E: user wiring

In Scheme E, after having eliminated other problem causes, you physically check your external connections to see if they are the problem cause. Refer to Figure 6-14.

Figure 6-14
Problem isolation Scheme E: user wiring



Follow these amplified instructions as you perform Scheme E:

1. Check the I/O connections between each external signal source and the screw terminal accessory, one at a time, for short circuits and open circuits. If KPCI-1800HC Series boards were installed in more than one PCI slot, check the I/O connections for all boards.

NOTE *Do not connect the screw terminal accessory to the board during this scheme.*

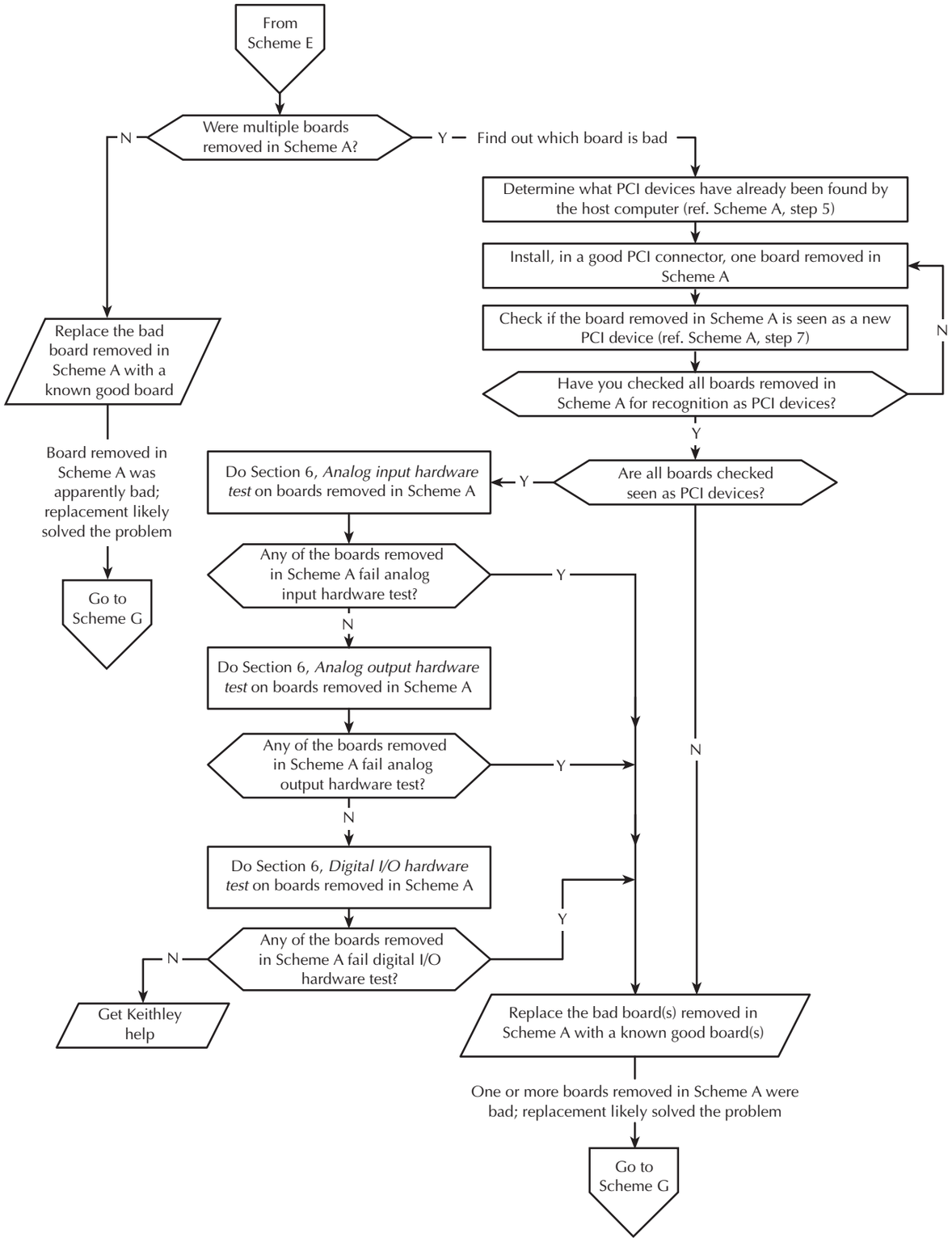
2. Based on the results of step 1, do the following:
   - If any external I/O connections are found to be faulty, assume that the problem was caused by the faulty connections, then proceed as follows:
     a. Correct the faulty external connections.
     b. Skip to Scheme G.
   - If all external I/O connections are found to be normal, then, by process of elimination, the KPCI-1800HC Series board(s) originally installed in the computer is likely the cause of the problem. Continue with Scheme F.

Problem isolation Scheme F: the board

In Scheme F, after having eliminated other problem causes, you assume that KPCI-1800HC Series hardware malfunctions are at fault. If only one KPCI-1800HC Series board was installed, you replace or repair it. If more than one KPCI-1800HC Series board was installed, you use PCI connection tests, and if necessary I/O tests, to find which board is bad. Refer to Figure 6-15.

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Figure 6-15
Problem isolation Scheme F: the board

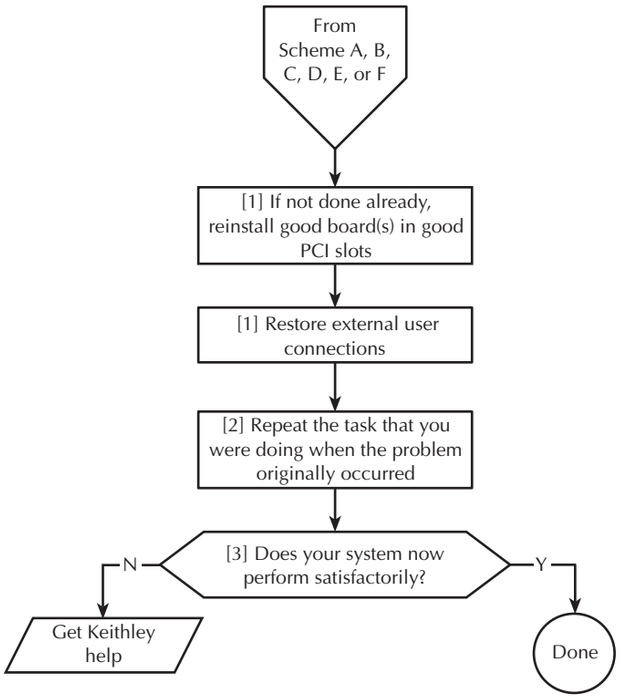


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Problem isolation Scheme G: verification of problem solution

In Scheme G, you put your system back together and verify that it works, after apparently resolving the problem in prior schemes. Refer to Figure 6-16 and the written amplification following it.

Figure 6-16
Problem isolation Scheme G: verification of problem solution



Follow these amplified instructions as you perform Scheme G:

1. Assuming that the problem has been resolved, do the following:
   a. Turn OFF the computer.
   b. Install good KPCI-1800HC Series boards in good slots.
   c. Reconnect all external circuits. If you left external circuits connected to the screw terminal accessory, connect the accessory to your board. If you disconnected external circuits from the screw terminal accessory, reconnect them and the accessory as discussed in Section 3, *Installation*.
   d. Turn ON the computer and start your data acquisition software.
2. Repeat the task that you were doing with your data acquisition system when the problem occurred, and observe the performance.
3. Based on the results of step G2, do one of the following:
   - If the system now performs satisfactorily, you have successfully isolated and corrected the problem.
   - If the system still does not perform satisfactorily, then the cause of your problem may be outside the scope of these diagnostics. Read the instructions in *Technical support*, and then contact Keithley for help in isolating the cause of your problem.

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Specified hardware I/O tests

The tests in this section check whether the analog and digital I/O of the board work properly. The I/O are tested using proven DriverLINX utilities, thereby bypassing any unresolved application software issues. These tests are intended to be used when specified in the preceding *Systematic problem isolation* procedure. However, they may also be used at any time for general functional checks of your KPCI-1800HC board.

NOTE *During these tests, disconnect all user circuits from board, except for connections specified in individual test procedures.*

Analog input hardware test

The analog input test checks whether the analog inputs, particularly the instrumentation amplifier and A/D converter, are working correctly. In this test, a voltage applied to KPCI-1800HC channel 1 is measured using the on-screen digital voltmeter utility that is supplied with DriverLINX. In the same way, channel 0 is grounded and checked for offset voltage. One voltage measurement and one grounded-input measurement are sufficient because of the following:

- All analog channels are connected to the same instrumentation amplifier and A/D converter, via the multiplexer.
- The multiplexer is unlikely to be a problem source.

Both the voltage and grounded-input measurements are made in the single-ended input mode.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for analog input connections specified for the test.*

The analog input test is a functional test, not a calibration check, although readings from a properly calibrated board should correspond to a known test voltage within the accuracy specifications of the board. If you wish to check and adjust the accuracy, refer to Section 5, "Calibration."

Equipment for the analog input hardware test

The following equipment is needed for the analog input test:

- A voltage source supplying a known voltage at < 5V. Refer to Table 6-7 for more details.
- (Optional) A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) to accurately determine the voltage of the voltage source.
- An STP-100 or STA-1800HC screw terminal accessory wired as shown in Table 6-2.

  If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

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Table 6-2
Wiring for analog input hardware test

If you have an STP-100 accessory:			If you have an STA-1800HC accessory:		
Connect this test voltage…	**…between this analog input terminal…**	**…and an analog ground terminal.**	**Connect this test voltage…**	**…between this analog input terminal…**	**…and an analog ground terminal.**
0V, via a short between the analog input terminal and ground	P1B-02 (Channel 00)	P1A-01 P1B-01 P1A-35 or P1B-35	0V, via a short between the analog input terminal and ground	00HI (Channel 00)	Any terminal labeled A GND
< +5V from one of the following: • A battery • An isolated power supply • A voltage divider — e.g. 10KΩ or 20KΩ — between +5V board power output (any of terminals labeled P1A-47, P1B-47, P1A-48, or P1B-48) and analog ground *	P1B-04 (Channel 01)	P1A-01 P1B-01 P1A-35 or P1B-35	< +5V from one of the following: • A battery • An isolated power supply • A voltage divider — e.g. 10KΩ or 20KΩ — between +5V board power output (terminal labeled +5V) and analog ground *	01HI (Channel 01)	Any terminal labeled A GND

*For example, composed of two 5KΩ or 10KΩ resistors. Observe the CAUTION below.

CAUTION **If you use the +5V board power to energize a voltage divider, ensure that the +5V board power terminal cannot accidentally short to ground. A short to ground can damage one or more of the following: the screw terminal accessory, the board, the computer.**

Procedure for the analog input hardware test

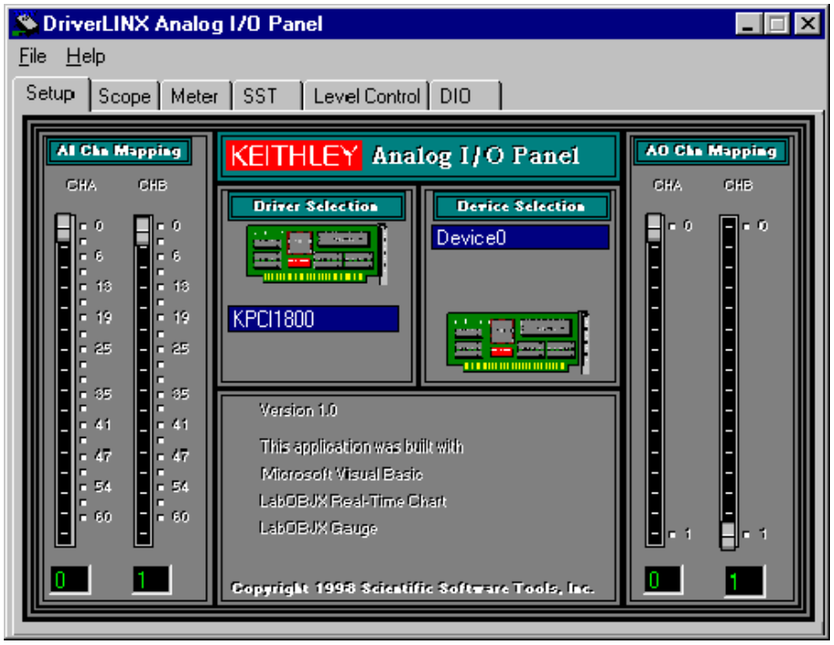
Perform the analog input test as follows:

1. Turn OFF the host computer.
2. Wire a screw terminal accessory as described under *Equipment for the analog input hardware test*.
3. Connect the screw terminal accessory, as wired in step 2, to the KPCI-1800HC Series I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.

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5. In the **Start** menu, click **Programs.**
6. Find the **DriverLINX** → **Test Panels** folder, under which you should find the **AIO Panel** entry.
7. Click on the **AIO Panel** entry. The Analog I/O Panel setup screen appears.
   - If a KPCI-1800HC Series board is the only board in your computer installed under DriverLINX, the setup screen looks like Figure 6-17.

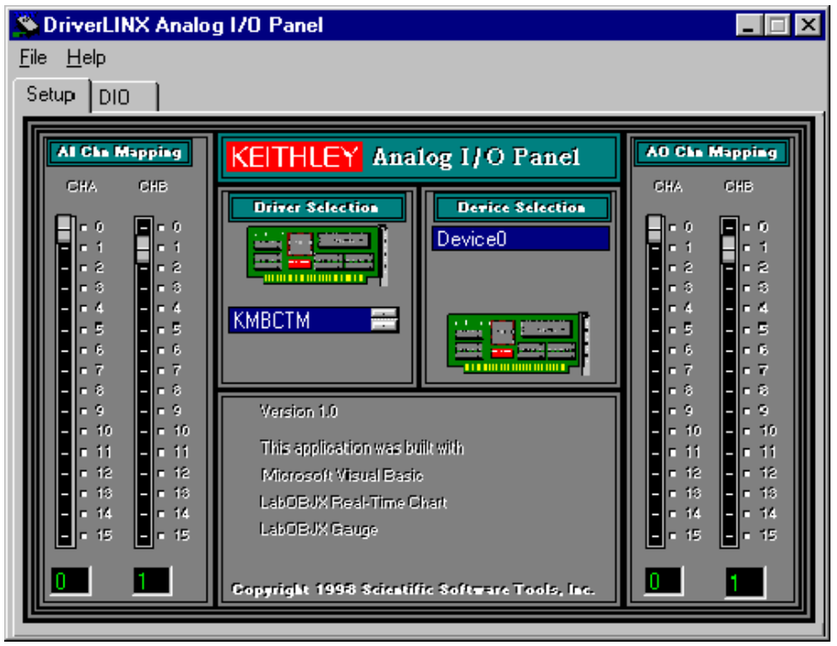
Figure 6-17
Analog I/O Panel setup screen when only a KPCI-1800HC series board is installed under DriverLINX



   - If more than one type of board is installed in your computer under DriverLINX, the Analog I/O Panel may appear more like Figure 6-18. Your board type and device number may not be displayed initially, and fewer tabs may be displayed at the top of the screen than in Figure 6-17. If so, click the scroll buttons next to the Driver Selection and Device Selection text boxes until your KPCI-1800 Series board type and device number are displayed. All six tabs will then be displayed.

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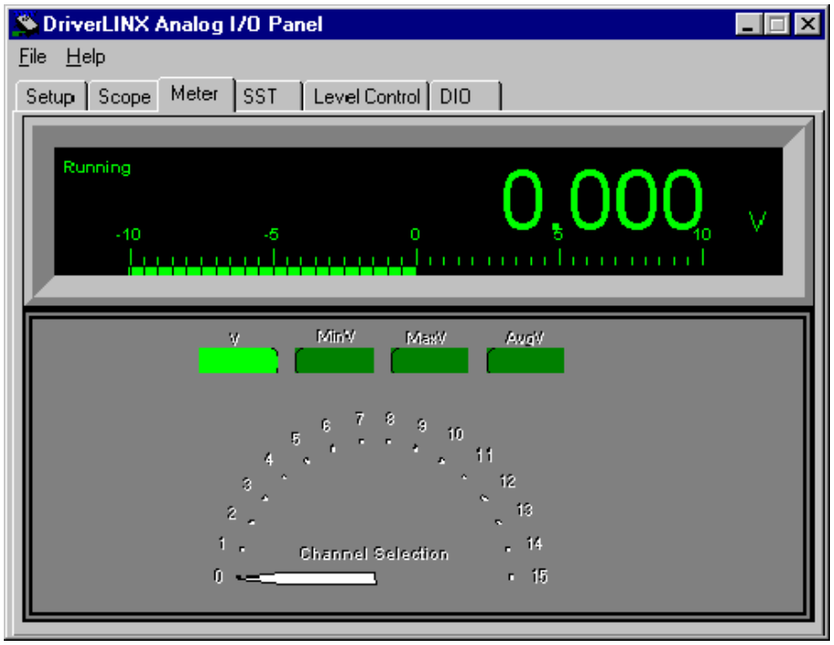
Figure 6-18
Analog I/O Panel setup screen example when multiple board types are installed under DriverLINX



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8. Click the Meter tab. An on-screen digital voltmeter appears, displaying the voltage connected to Channel 0. Because Channel 00 is grounded, the displayed voltage should be nominally zero, as illustrated in Figure 6-19.

Figure 6-19
On-screen digital voltmeter display example: channel 0 connected to ground



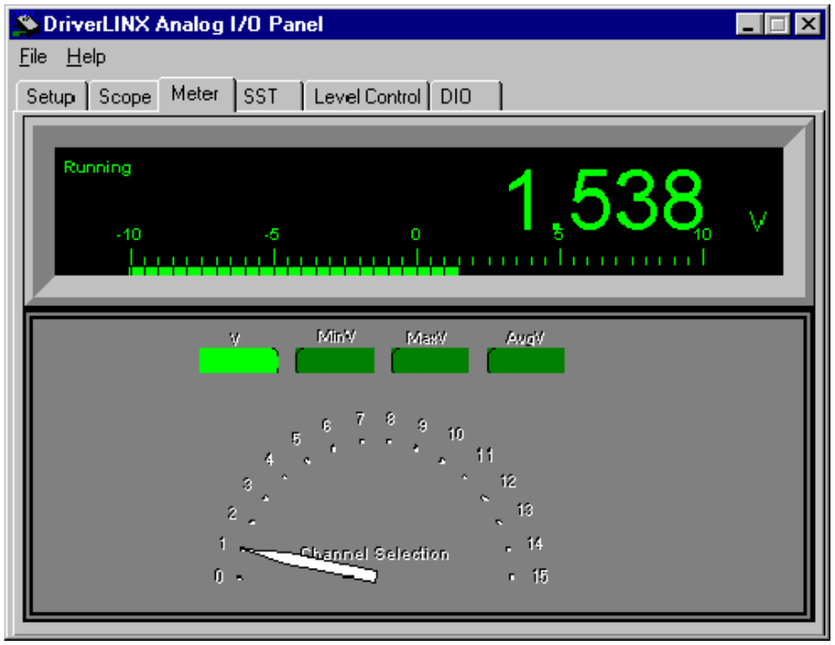
9. Using your mouse, move the channel selection pointer of the on-screen digital panel meter to 1.

NOTE *To move the channel selection pointer, you must contact the wide part of the pointer with the tip of the cursor.*

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The on-screen digital voltmeter now displays the voltage connected to channel 01. Figure 6-20 shows the on-screen digital voltmeter and the voltage that was displayed when channel 01 was connected to a flashlight battery.

Figure 6-20
On-screen digital voltmeter display example: channel 1 connected to flashlight battery



10. Based on the displayed voltages in steps 12 and 13, act as follows:
    - If the channel 00 voltage displayed in step 12 is not 0V and/or if the channel 01 voltage displayed in step 13 does not nominally agree with the applied voltage, then there are apparently analog input problems with your board.
    - If the channel 00 voltage displayed in step 12 is 0V and the channel 01 voltage displayed in step 13 nominally agrees with the applied voltage, then the analog inputs are working satisfactorily.
11. Stop here, and return to Scheme F in the systematic problem isolation procedure.

NOTE *If the analog inputs appear to work satisfactorily but the displayed channel 00 and channel 01 voltages appear to be nominally outside specified limits, you may wish to calibrate your board after concluding the "Systematic problem isolation" procedure. For board specifications refer to Appendix A. for calibration procedures, refer to Section 5, "Calibration."*

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Analog output hardware test

The analog output test checks whether the two Digital-to-Analog Converters (DACs) of the KPCI-1800HC are working correctly. Zero voltages are set at the two analog outputs, using the on-screen level control utility that is supplied with DriverLINX. The two output voltages are then measured with a digital voltmeter to verify reasonable DAC offsets. Similarly, a mid-range voltage is set for each of the two analog outputs and the procedure is repeated to verify proper digital to analog conversion.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for analog output connections specified for the test.*

The analog output test is primarily a functional test, not a calibration check, although measured outputs from a properly calibrated board should correspond to DAC settings, within the accuracy specifications of the board. If you wish to check and adjust the accuracy, refer to Section 5, "Calibration".

Equipment for the analog output hardware test

The following equipment is required to perform the analog output test:

- A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) set to the 10V range.
- An STP-100 or STA-1800HC screw terminal accessory, to which you connect the DVM/DMM as indicated in Table 6-3.

  If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

Table 6-3
Screw terminals to which DVM/DMM is connected in analog output hardware test

To check this analog output…	**…the DVM or DMM will be connected to these terminals on an STP-100 accessory.**		**…the DVM or DMM will be connected to these terminals on an STA-1800HC accessory.**	
	Analog output screw terminal	**Analog-ground screw terminal (any of those listed below)**	**Digital output screw terminal**	**Analog-ground screw terminal**
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND
Analog output 1	PIA-36		DAC1OUT	

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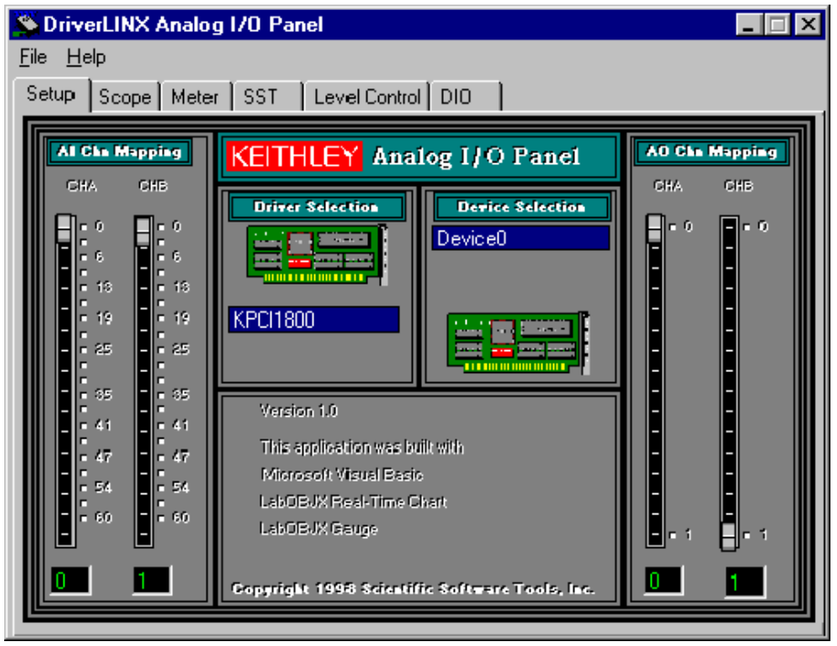
CAUTION **The following test procedure involves changing DVM/DMM connections while the computer and KPCI-1800HC board are powered. Take great care not to short analog outputs to the adjacent or nearby ground, +5V, +15V or –15V terminals. Shorting the analog outputs can damage the Digital-to-Analog Converters (DACs). As a precaution, do the following:**

- **Before powering the computer, connect the DVM/DMM negative lead to a ground screw terminal.**
- **After powering the computer, connect the DVM/DMM positive lead to each specified analog output screw terminal by touching the tip of the lead to the screw head of the screw terminal (for example, via a probe).**

Procedure for the analog output hardware test

1. Turn OFF the host computer.
2. Connect the negative lead of the DVM/DMM to a ground terminal of the screw terminal accessory, as indicated in Table 6-3.
3. Connect the STP-100 or STA-1800HC screw terminal accessory to the KPCI-1800HC Series I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.
5. In the **Start** menu, click **Programs.**
6. Find the **DriverLINX** → **Test Panels** folder, under which you should find the **AIO Panel** entry.
7. Click on the **AIO Panel** entry. The Analog I/O Panel setup screen appears.
   - If a KPCI-1800HC Series board is the only board in your computer installed under DriverLINX, the setup screen looks like Figure 6-21.

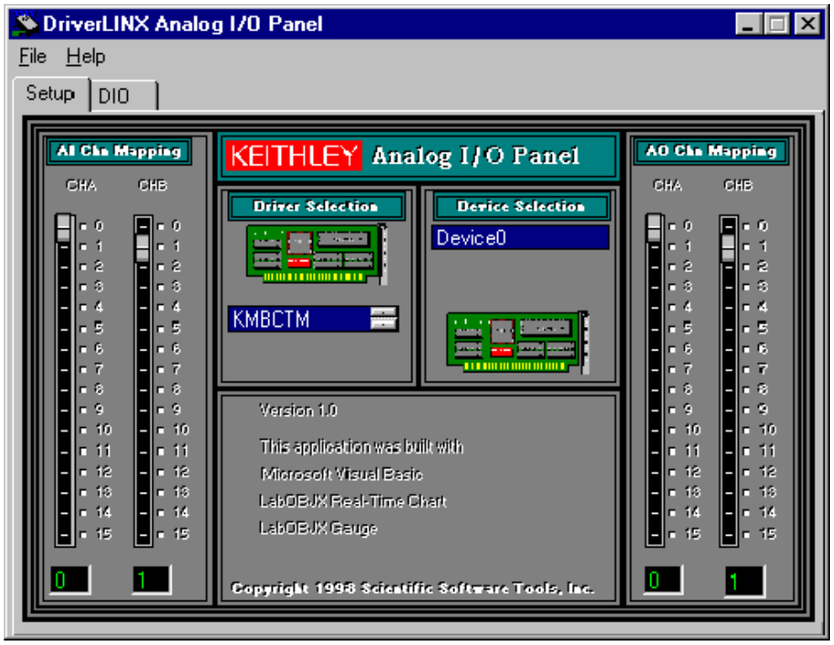
Figure 6-21
Analog I/O Panel setup screen when only a KPCI-1800HC series board is installed under DriverLINX



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- If more than one type of board is installed in your computer under DriverLINX, the Analog I/O Panel may appear more like Figure 6-22. Your board type and device number may not be displayed initially, and fewer tabs may be displayed at the top of the screen than in Figure 6-21. If so, click the scroll buttons next to the Driver Selection and Device Selection text boxes until your KPCI-1800 Series board type and device number are displayed. All six tabs will then be displayed.

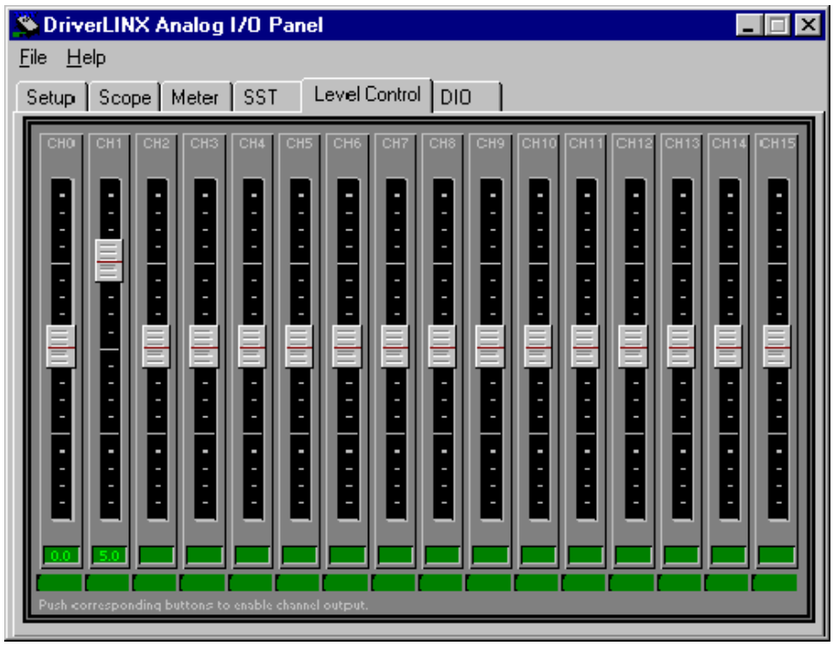
Figure 6-22
Analog I/O Panel setup screen example when multiple board types are installed under DriverLINX



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8. Click the Level Control tab. The on-screen analog-output level control appears, similar to Figure 6-23.

Figure 6-23
On-screen analog-output level control



9. Using your mouse, slide the CH0 level control button until the tiny display at the bottom of the level control reads 0.0 (volts).
10. In the same way, set the CH1 level control so that its tiny display reads 0.0 (volts).
11. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM, and compare these with voltages you set via the analog-output level control, as indicated in Table 6-4.

Table 6-4
Test connections and correct readings for zero-voltage analog output

To test this analog output…	… connect the DVM or DMM to these terminals on an STP-100 accessory.		… connect the DVM or DMM to these terminals on an STA-1800HC accessory.		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	Analog-ground screw terminal (any of those listed below)	Analog output screw terminal	Analog ground screw terminal	Level control setting	Voltage reading at DVM or DMM
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND	0.0V	0.0V
Analog output 1	PIA-36		DAC1OUT		0.0V	0.0V

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12. Using your mouse, slide the CH0 and CH1 level control buttons until the tiny displays at the bottoms of the level controls read 5.0.
13. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM, and compare these with voltages you set via the analog-output level control, as indicated in Table 6-5.

Table 6-5
Test connections and correct readings for mid-range analog output, during analog output hardware tests

To test this analog output…	… connect the DVM or DMM to these terminals on an STP-100 accessory.		… connect the DVM or DMM to these terminals on an STA-1800HC accessory.		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	Analog-ground screw terminal (any of those listed below)	Analog output screw terminal	Analog ground screw terminal	Level control setting	Voltage reading at DVM or DMM
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND	5.0V	5.0V
Analog output 1	PIA-36		DAC1OUT		5.0V	5.0V

14. Based on the measured voltages in steps 11 and 13, take action as follows:
    - If the voltages measured with the DVM/DMM do not agree with the level control settings, then there is an apparent problem with the analog output part of your board.
    - If the voltages measured with the DVM/DMM agree with level control settings, then the analog outputs are working satisfactorily.
15. Stop here, and return to Scheme F in the systematic problem isolation procedure.

NOTE *If the analog outputs appear to work satisfactorily, but some measured analog output voltages are outside the accuracy limits specified in Appendix A, consider calibrating your board after concluding the "Systematic problem isolation" procedure. For calibration procedures, refer to Section 5, "Calibration."*

Digital I/O hardware test

The digital I/O hardware test checks whether both digital input and output functions of the board are operating properly. Temporarily wire a screw terminal accessory so that the eight digital outputs of the KPCI-1800HC Series board are connected, in groups of four, to the four digital inputs. Then, using a DriverLINX graphical interface, set different output bit patterns and check in each case for corresponding input bit patterns. The bit patterns are chosen to check both for direct ON/OFF response and for shorts between bits. The digital I/O of the board is performing satisfactorily if all bits respond appropriately.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for connections specified for the test.*

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Equipment for the digital I/O hardware test

All I/O is set and read using the DriverLINX Digital Input/Output test panel, and no instruments are required. However, you must wire an STP-100 or STA-1800HC screw terminal accessory in the loop-back configuration shown in Table 6-6.

If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

Table 6-6
Wiring for digital I/O hardware test

If you have an STP-100 accessory:			If you have an STC-1800HC accessory:		
Connect these pairs of digital-output screw terminals, via double-throw switch poles…	**…to these digital input screw terminals**	**Switch pole position**	**Connect these pairs of digital-output screw terminals, via double-throw switch poles…**	**…to these digital input screw terminals**	**Switch pole position**
P1B-43 —o ↔ o— P1A-43 —o o—	|— P1B-39	B A	DO0 —o ↔ o— DO4 —o o—	|— DI0/XPCLK	B A
P1B-44 —o ↔ o— P1A-44 —o o—	|— P1B-40	B A	DO1 —o ↔ o— DO5 —o o—	|— D11/TGIN	B A
P1B-45 —o ↔ o— P1A-45 —o o—	|— P1B-41	B A	DO2 —o ↔ o— DO6 —o o—	|— D12	B A
P1B-46 —o ↔ o— P1A-46 —o o—	|— P1B-42	B A	DO3 —o ↔ o— DO7 —o o—	|— D13	B A

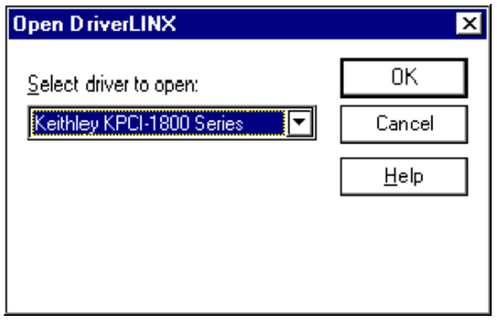
Procedure for the digital I/O hardware test

Perform the I/O hardware test as follows:

1. Turn OFF the host computer.
2. Wire the screw terminal accessory as described in Table 6-6.
3. Connect the wired screw terminal accessory to the KPCI-1800HC board I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.
5. Start the DriverLINX Digital Input/Output Test Panel as follows:
   a. Open the Windows Explorer.
   b. Find and open the DrvLNX4 folder.
   c. In the DrvLNX4 folder, find and open the Bin folder.
   d. In the DrvLNX4\Bin folder, double click the dio32.exe entry. A dialog box similar to the example in Figure 6-24 appears.

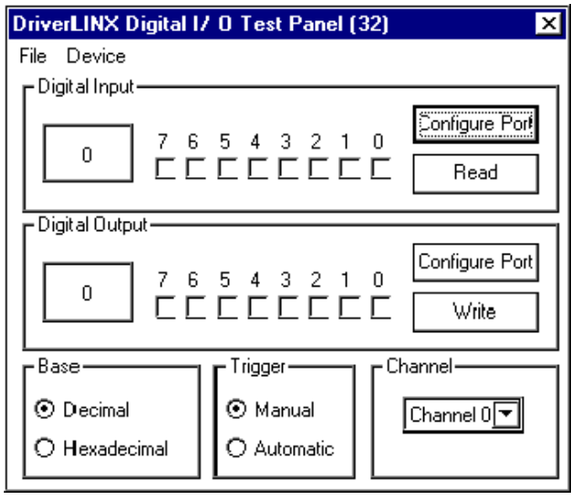
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Figure 6-24
Example of Open DriverLINX dialog box



e. Under Select driver to open, select Keithley KPCI-1800 Series.
f. Click OK. The DriverLINX Digital Input/Output Test Panel appears as shown in Figure 6-25.

Figure 6-25
DriverLINX Digital I/O Test Panel



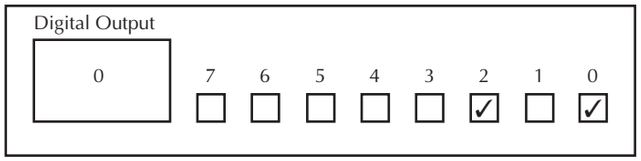
NOTE *In the following steps, clicking on an output check box in the DriverLINX Digital Input/Output Test Panel toggles the outputs of the eight KPCI-1800HC output bits ON or OFF. A check mark (√) in a check box signifies ON. Bits 0, 1, 2,…7 correspond to digital outputs DO0, DO1,…DO7.*

Clicking on input check boxes has no effect; they are read-only. Input check boxes 0, 1, 2, and 3 display the responses of the four KPCI-1800HC digital input bits (DI0/XPCLK, DI1/TGIN, DI2, and DI3). Input check boxes 4, 5, 6, and 7 are inactive.

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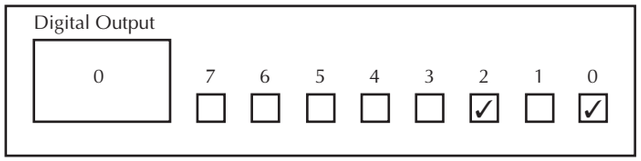
6. Referring back to Table 6-6, set the switch poles connected to your screw terminal accessory to position B.
7. Set the Digital Output check boxes of the Digital Input/Output Test Panel to bit pattern 1, shown in Figure 6-26.

Figure 6-26
Output bit pattern 1 of digital I/O hardware test



8. Click the Write button on the Digital Input/Output Test Panel.
9. Click the Read button on the Digital Input/Output Test Panel.
10. Observe the Digital Input check boxes of the Digital Input/Output Test Panel. Figure 6-27 shows successful results.

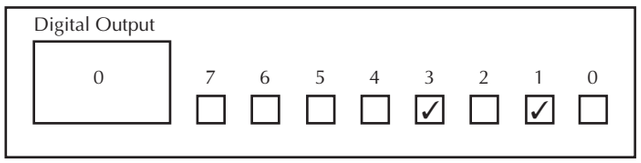
Figure 6-27
Proper input-bit responses to bit pattern 1 of digital I/O hardware test



- If the input bit patterns are not the same as shown in Figure 6-27, the digital I/O is not functioning properly. Stop here, and return to Scheme F in the systematic problem isolation procedure.
- If the input bit patterns are the same as shown in Figure 6-27, continue with step 11.

11. Set the Digital Output check boxes of the Digital Input/Output Test Panel to bit pattern 2, shown in Figure 6-28.

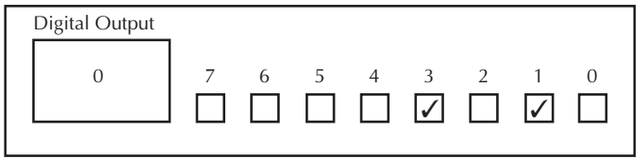
Figure 6-28
Output bit pattern 2 of digital I/O hardware test



12. Click the Write button on the Digital Input/Output Test Panel.
13. Click the Read button on the Digital Input/Output Test Panel.
14. Observe the Digital Input check boxes of the Digital Input/Output Test Panel. Figure 6-29 shows successful results.

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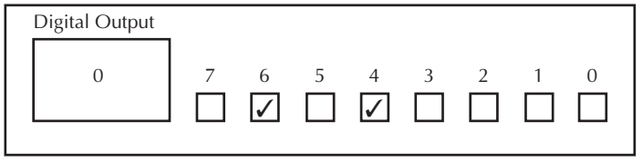
Figure 6-29
Proper input-bit responses to bit pattern 2 of digital I/O hardware test



- If the input bit patterns are not the same as shown in Figure 6-29, the digital I/O is not functioning properly. Stop here, and return to Scheme F in the systematic problem isolation procedure.
- If the input bit patterns are the same as shown in Figure 6-29, continue with step 15.

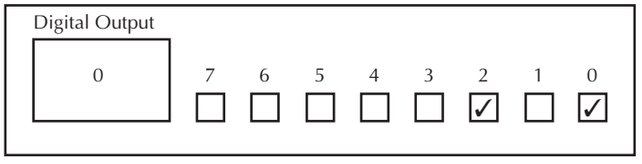
15. Referring back to Table 6-6, now set the switch poles connected to your screw terminal accessory to position A.
16. Set the Digital Output check boxes of the Digital Input/Output Test Panel to bit pattern 3, shown in Figure 6-30.

Figure 6-30
Output bit pattern 3 of digital I/O hardware test



17. Click the Write button on the Digital Input/Output Test Panel.
18. Click the Read button on the Digital Input/Output Test Panel.
19. Observe the Digital Input check boxes of the Digital Input/Output Test Panel. Figure 6-31 shows successful results.

Figure 6-31
Proper input-bit responses to bit pattern 3 of digital I/O hardware test

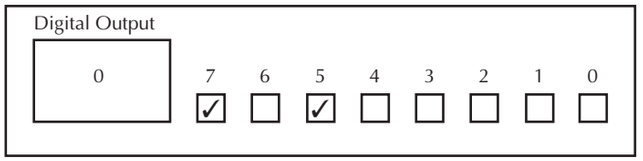


- If the input bit patterns are not the same as shown in Figure 6-31, the digital I/O is not functioning properly. Stop here, and return to Scheme F in the systematic problem isolation procedure.
- If the input bit patterns are the same as shown in Figure 6-31, continue with step 20.

20. Set the Digital Output check boxes of the Digital Input/Output Test Panel to bit pattern 4, shown in Figure 6-32.

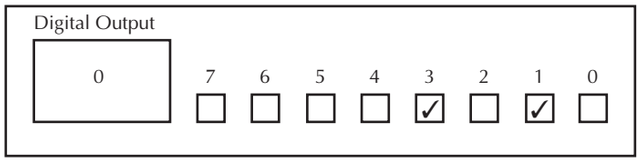
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Figure 6-32
Output bit pattern 4 of digital I/O hardware test



21. Click the Write button on the Digital Input/Output Test Panel.
22. Click the Read button on the Digital Input/Output Test Panel.
23. Observe the Digital Input check boxes of the Digital Input/Output Test Panel. Figure 6-33 shows successful results.

Figure 6-33
Proper input-bit responses to bit pattern 4 digital I/O hardware test



- If the input bit patterns are not the same as shown in Figure 6-33, the digital I/O is not functioning properly.
- If the input bit patterns are the same as shown in Figure 6-33, the digital I/O is functioning properly.

24. Stop here, and return to Scheme F in the systematic problem isolation procedure.

Specified software I/O tests

The tests in this section check whether your application software correctly performs analog and digital I/O tasks. The I/O are tested using a KPCI-1800HC Series board known to work properly, thereby bypassing potential board problems. These tests are intended to be used when specified in the preceding *Systematic problem isolatio*n procedure.

NOTE *During these tests, disconnect all user circuits from the board, except for connections specified in individual test procedures.*

Analog input software test

This basic analog input test checks whether your application software correctly monitors DC analog inputs. You ground channel 0, apply a DC voltage to channel 1, and measure the results.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for analog input connections specified for the test.*

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NOTE *The analog input test is a software function test, not a calibration check, although readings from a properly calibrated board should correspond to a known test voltage within the accuracy specifications of the board. If you wish to check and adjust the accuracy, refer to Section 5, "Calibration."*

The analog input software test is only a basic check of your application software. You are encouraged to perform additional tests that exercise your software more thoroughly.

Equipment for the analog input software test

- The following equipment is needed for the analog input test:
- A voltage source supplying a known voltage at < 5V. Refer to Table 6-7 for more details.
- (Optional) A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) to accurately determine the voltage of the voltage source.
- An STP-100 or STA-1800HC screw terminal accessory wired as shown in Table 6-7. This is the same wiring scheme as used in the analog input hardware tests.

  If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

Table 6-7
Wiring for analog input software test

If you have an STP-100 accessory:		
Connect this test voltage…	**…between this analog input terminal…**	**…and an analog ground terminal.**
0V, via a short between the analog input terminal and ground	P1B-02 (Channel 00)	P1A-01 P1B-01 P1A-35 P1B-35
< +5V from one of the following: • A battery • An isolated power supply • A voltage divider — e.g. 10KΩ or 20KΩ — between +5V board power output (any of terminals labeled P1A-47, P1B-47, P1A-48, or P1B-48) and analog ground *	P1B-04 (Channel 01)	P1A-01 P1B-01 P1A-35 P1B-35

If you have an STA-1800HC accessory:		
Connect this test voltage…	**…between this analog input terminal…**	**…and an analog ground terminal.**
0 V, via a short between the analog input terminal and ground	00HI (Channel 00)	Any terminal labeled A GND
< +5V from one of the following: • A battery • An isolated power supply • A voltage divider — e.g. 10KΩ or 20KΩ — between +5V board power output (terminal labeled +5V) and analog ground *	01HI (Channel 01)	Any terminal labeled A GND

*For example, composed of two 5KΩ or 10KΩ resistors. Observe the following CAUTION .

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CAUTION **If you use the +5V board power to energize a voltage divider, ensure that the +5V board power terminal cannot accidentally short to ground. A short to ground can damage one or more of the following: the screw terminal accessory, the board, the computer.**

Procedure for the analog input software test

Perform the analog input test as follows:

1. Turn OFF the host computer.
2. Wire a screw terminal accessory as described under *Equipment for the analog input software test.*
3. Connect the screw terminal accessory, as wired in step 2, to the KPCI-1800HC board I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.
5. Start DriverLINX and your application software.
6. Set your application software to measure and display/report voltages from analog input channels 0 and 1 at a rate suitable for monitoring DC signals. Configure your system as follows:
   - The ±5V input range
   - Single ended input
7. Based on the displayed/reported voltages in step 6, act as follows:
   - If the measured channel 00 voltage is not 0V and/or if the measured channel 01 voltage does not agree with the applied voltage, then there could be a problem with the way your application software program interfaces with DriverLINX or the way it deals with analog input data from the board.
   - If the measured channel 00 voltage is 0V and the measured channel 01 voltage agrees with the applied voltage, then your software is treating DC analog input data correctly.
8. Stop here, and return to Scheme C in the systematic problem isolation procedure.

Analog output software test

This basic analog input test checks whether your application software correctly sets DC analog output voltages. You set zero volts at the two analog outputs, using your application software. The two output voltages are then measured with a digital voltmeter to verify reasonable DAC offsets. Similarly, a mid-range voltage is set for each of the two analog outputs and the procedure is repeated.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for analog input connections specified for the test.*

The analog output software test is a software function test, not a calibration check. If you wish to check and adjust the accuracy, refer to Section 5, "Calibration."

The analog output software test is only a basic check of your application software. You are encouraged to perform additional tests that exercise your software more thoroughly.

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Equipment for the analog output software test

The following equipment is required to perform the analog output test:

- A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) set to the 10V range.
- An STP-100 or STA-1800HC screw terminal accessory, to which you connect the DVM/DMM as indicated in Table 6-8.

  If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

Table 6-8
Screw terminals to which DVM/DMM is connected in analog output software test

To check this analog output…	…the DVM or DMM will be connected to these terminals on an STP-100 accessory.		…the DVM or DMM will be connected to these terminals on an STA-1800HC accessory.	
	Analog output screw terminal	Analog-ground screw terminal (any of those listed below)	Digital output screw terminal	Analog-ground screw terminal
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND
Analog output 1	PIA-36		DAC1OUT	

CAUTION **The following test procedure involves changing DVM/DMM connections while the computer and KPCI-1800HC board are powered. Be careful not to short analog outputs to the adjacent or nearby ground, +5V, +15V, or –15V terminals. Shorting the analog outputs can damage the Digital-to-Analog Converters (DACs). As a precaution, do the following:**

- **Before powering the computer, connect the DVM/DMM negative lead to a ground screw terminal.**
- **After powering the computer, connect the DVM/DMM positive lead to each specified analog output screw terminal by touching the tip of the lead to the screw head of the screw terminal (for example, via a probe).**

Procedure for the analog output software test

1. Turn OFF the host computer.
2. Connect the negative lead of the DVM/DMM to a ground terminal of the screw terminal accessory, as indicated in Table 6-8.
3. Connect the STP-100 or STA-1800HC screw terminal accessory to the KPCI-1800HC I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.
5. Start DriverLINX and your application software.

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6. Set your application software to output 0V at analog outputs 0 and 1.
7. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM, and compare these with levels you set via your application software, as indicated in Table 6-9.

Table 6-9
Test connections and correct readings for zero-voltage analog output

To test this analog output…	… connect the DVM or DMM to these terminals on an STP-100 accessory.		… connect the DVM or DMM to these terminals on an STA-1800HC accessory.		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	Analog-ground screw terminal (any of those listed below)	Analog output screw terminal	Analog ground screw terminal	Level setting in application software	Voltage reading at DVM or DMM
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND	0.0V	0.0V
Analog output 1	PIA-36		DAC1OUT		0.0V	0.0V

8. Set your application software to output 5V at analog outputs 0 and 1.
9. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM, and compare these with levels you set via your application software, as indicated in Table 6-10.

Table 6-10
Test connections and correct readings for mid-range analog output during analog output software tests

To test this analog output…	… connect the DVM or DMM to these terminals on an STP-100 accessory.		… connect the DVM or DMM to these terminals on an STA-1800HC accessory.		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	Analog-ground screw terminal (any of those listed below)	Analog output screw terminal	Analog ground screw terminal	Level setting in application software	Voltage reading at DVM or DMM
Analog output 0	PIB-36	P1A-01 P1B-01 P1A-35 P1B-35	DAC0OUT	Any terminal labeled A GND	5.0V	5.0V
Analog output 1	PIA-36		DAC1OUT		5.0V	5.0V

10. Based on the measured voltages in steps 7 and 9, take action as follows:
    - If the voltages measured with the DVM/DMM do not agree with the application software settings, then there could be a problem with the way your application software program interfaces with DriverLINX or the way it prepares the analog data being sent to the board.
    - If the voltages measured with the DVM/DMM agree with your application software settings, then your software is probably working correctly with the analog outputs. Stop here, and return to the step in which you were directed to do analog output tests.
11. Stop here, and return to Scheme C in the systematic problem isolation procedure.

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Digital I/O software test

This digital I/O software test checks whether your application software is properly performing both digital input and output functions of the board.

Temporarily wire a screw terminal accessory so that the eight digital outputs of the KPCI-1800HC Series board are connected, in groups of four, to the four digital inputs. Then, using a DriverLINX graphical interface, set different output bit patterns and check in each case for corresponding input bit patterns. The bit patterns are chosen to check both for direct ON/OFF response and for shorts between bits. The digital I/O of the board is performing satisfactorily if all bits respond appropriately.

NOTE *During this test, ensure that no user circuits are connected to the KPCI-1800HC Series board, via the required screw terminal accessory, except for connections specified for the test.*

Equipment for the digital I/O software test

All I/O is set and read using your application software, and no instruments are required. You wire an STP-100 or STA-1800HC screw terminal accessory in the loop-back configuration shown in Table 6-11. This is the same configuration used in the digital I/O hardware test.

If possible, use a screw terminal accessory that is reserved for I/O tests. Avoid using a screw terminal accessory that is normally connected to your external circuits. You thereby avoid the extra labor and potential wiring errors involved in disconnecting and later reconnecting your external circuits.

Table 6-11
Wiring for digital I/O software test

If you have an STP-100 accessory:			If you have an STC-1800HC accessory:		
Connect these pairs of digital-output screw terminals, via double-throw switch poles…	**…to these digital input screw terminals**	**Switch pole position**	**Connect these pairs of digital-output screw terminals, via double-throw switch poles…**	**…to these digital input screw terminals**	**Switch pole position**
P1B-43 —o ↔ o— P1A-43 —o o—	P1B-39	B A	DO0 —o ↔ o— DO4 —o o—	DI0/XPCLK	B A
P1B-44 —o ↔ o— P1A-44 —o o—	P1B-40	B A	DO1 —o ↔ o— DO5 —o o—	D11/TGIN	B A
P1B-45 —o ↔ o— P1A-45 —o o—	P1B-41	B A	DO2 —o ↔ o— DO6 —o o—	D12	B A
P1B-46 —o ↔ o— P1A-46 —o o—	P1B-42	B A	DO3 —o ↔ o— DO7 —o o—	D13	B A

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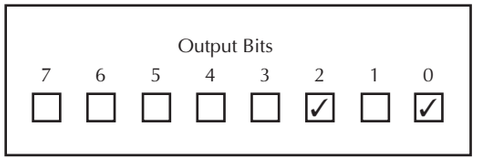
Procedure for the digital I/O software test

NOTE *In all input and output bit patterns called for in this test, a check mark ( ) means that the bit is ON (logic high) and the absence of a check mark means that the bit is off (logic low).*

Perform the digital I/O software test as follows:

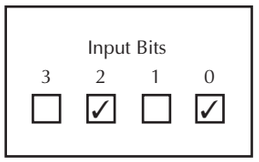
1. Turn OFF the host computer.
2. Wire the screw terminal accessory as described in Table 6-11.
3. Connect the wired screw terminal accessory to the KPCI-1800HC board I/O connector.
4. Turn ON the host computer and boot Windows 95, 98, or NT.
5. Start DriverLINX and your application software.
6. Set up your application software to set and monitor digital I/O bits.
7. Refer back to Table 6-11 and set the switch poles connected to your screw terminal accessory to position B.
8. Using your application software, set the digital outputs of your board to bit pattern 1, shown in Figure 6-34.

Figure 6-34
Output bit pattern 1 of digital I/O software test



9. Using your application software, observe the digital input bits. Figure 6-35 shows successful results.

Figure 6-35
Proper input-bit responses to bit pattern 1 of digital I/O software test

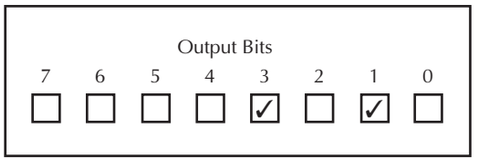


- If the input bit pattern is not the same as shown in Figure 6-35, the digital I/O part of your software is not functioning properly. Stop here, and return to Scheme C of the systematic problem isolation procedure.
- If the input bit pattern is the same as shown in Figure 6-35, continue with step 10.

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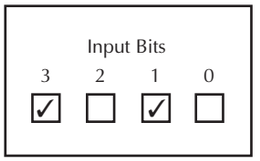
10. Using your application software, set the digital outputs of your board to bit pattern 2, shown in Figure 6-36.

Figure 6-36
Output bit pattern 2 of digital I/O software test



11. Using your application software, observe the digital input bits. Figure 6-37 shows successful results.

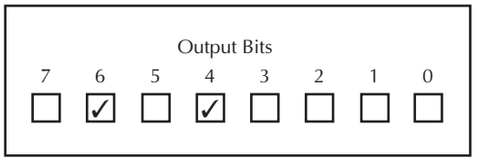
Figure 6-37
Proper input-bit responses to bit pattern 2 of digital I/O software test



- If the input bit pattern is not the same as shown in Figure 6-37, the digital I/O part of your software is not functioning properly. Stop here, and return to Scheme C of the systematic problem isolation procedure.
- If the input bit pattern is the same as shown in Figure 6-37, continue with step 12.

12. Refer back to Table 6-11 and set the switch poles connected to your screw terminal accessory to position A.
13. Using your application software, set the digital outputs of your board to bit pattern 3, shown in Figure 6-38.

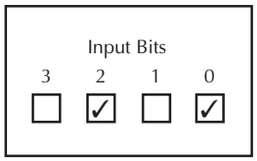
Figure 6-38
Output bit pattern 3 of digital I/O software test



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14. Using your application software, observe the digital input bits. Figure 6-39 shows successful results.

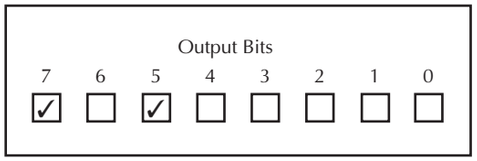
Figure 6-39
Proper input-bit responses to bit pattern 3 of digital I/O software test



- If the input bit pattern is not the same as shown in Figure 6-39, the digital I/O part of your software is not functioning properly. Stop here, and return to Scheme C of the systematic problem isolation procedure.
- If the input bit pattern is the same as shown in Figure 6-39, continue with step 15.

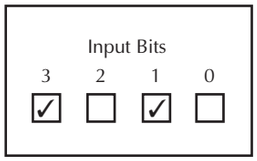
15. Using your application software, set the digital outputs of your board to bit pattern 4, shown in Figure 6-40.

Figure 6-40
Output bit pattern 4 of digital I/O software test



16. Using your application software, observe the digital input bits. Figure 6-41 shows successful results.

Figure 6-41
Proper input-bit responses to bit pattern 4 of digital I/O software test



- If the input bit pattern is not the same as shown in Figure 6-41, the digital I/O part of your software is not functioning properly.
- If the input bit pattern is the same as shown in Figure 6-41, the digital I/O part of your software is functioning properly.

17. Stop here, and return to Scheme C of the systematic problem isolation procedure.

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Technical support

Before returning any equipment for repair, call Keithley for technical support at:

(440) 248-0400
Monday - Friday, 8:00 A.M. - 6:00 P.M., Eastern Time

An applications engineer will help you diagnose and resolve your problem over the telephone. Please make sure that you have a record of any diagnostic tests that you have performed and the following information available before you call:

KPCI-1800HC series board configuration	Model	_____
	Serial #	_____
	Revision code	_____
	Number of channels	_____
	Input (S.E. or Diff.)	_____
	Mode (unipolar. or bipolar.)	_____
	No. of SSH-8s connected	_____
Computer	Manufacturer	_____
	CPU type	_____
	Clock speed (MHz)	_____
	MB of RAM	_____
	Video system	_____
	BIOS type	_____
Operating system	DOS version	_____
	Windows version	_____
		_____
Software package	Name	_____
	Serial #	_____
	Version	_____
	Invoice/Order #	_____
Compiler (if applicable)	Language	_____
	Manufacturer	_____
	Version	_____
Accessories	Type	_____
	Type	_____
	Type	_____
	Type	_____
	Type	_____
	Type	_____
	Type	_____
	Type	_____

If a telephone resolution is not possible, the applications engineer will issue you a Return Material Authorization (RMA) number and ask you to return the equipment. Include the RMA number with any documentation regarding the equipment.

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When returning equipment for repair, include the following information:

- Your name, address, and telephone number.
- The invoice or order number and date of equipment purchase.
- A description of the problem or its symptoms.
- The RMA number on the **outside** of the package.

Repackage the equipment, using the original anti-static wrapping, if possible, and handle it with ground protection. Ship the equipment to:

ATTN: RMA #_____
Repair Department
Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

Telephone (440) 248-0400
FAX (440) 248-6168

NOTE *If you are submitting your equipment for repair under warranty, you must include the invoice number and date of purchase.*

To enable Keithley to respond as quickly as possible, you must include the RMA number on the outside of the package.

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A
Specifications

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KPCI-1801HC specifications

Analog Inputs, KPCI-1801HC

Number of channels

32 differential or 64 single-ended; software configurable

A/D FIFO buffer size

2048 samples

Channel gain queue length

64 entries

A/D resolution

12 bits

Input Gain and Range

Gain	Range (bipolar)	Range (unipolar)
1	±5V	0 to 5V
5	±1V	0 to 1V
50	±100mV	0 to 100mV
250	±20mV	0 to 20mV

Input range selection

Software selectable via channel gain queue entry

Input overvoltage

±15V continuous, powered or unpowered

Input bias current

±40nA maximum at 25°C; ±60nA maximum over operating range

Input impedance

>100MΩ or greater in parallel with 90pF or less, all gains.

Single channel throughput

333 kS/s

Scanning throughput (multiple channels scanned at the same gain)

Gain	Throughput in bipolar mode	Throughput in unipolar mode
1	312.5 kS/s	312.5 kS/s
5	312.5 kS/s	312.5 kS/s
50	312.5 kS/s	200 kS/s
250	75 kS/s	60 kS/s

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Linearity

Integral: ±1 LSB maximum
Differential: ±1 LSB maximum

Accuracy at 25˚C

±0.02% Reading ±1 LSB maximum for gains < 250
±0.03% Reading ±1 LSB maximum for gain = 250

Accuracy at other temperatures; noise

Accuracies listed below are based on averages of 50 samples. For a single sample, add noise to get the maximum uncertainty.

Range	Resolution	Accuracy over temperature range				Noise, counts	
		Over 25˚C ±5˚C, sum of following:		Over 25˚C ±25˚C, sum of following:			
		% of full scale	% of reading	% of full scale	% of reading	p-p	rms
±5V	0.00244V	0.051%	0.030%	0.060%	0.070%	1	0.1
0 to 5V	0.00122V	0.027%	0.030%	0.036%	0.070%	1	0.1
±1V	0.000488V	0.055%	0.030%	0.080%	0.070%	1	0.1
0 to 1V	0.000244V	0.031%	0.030%	0.056%	0.070%	1	0.1
±100mV	4.88E-05V	0.100%	0.035%	0.305%	0.095%	4	0.5
0 to 100mV	2.44E-05V	0.076%	0.035%	0.281%	0.095%	6	0.9
±20mV	9.77E-06V	0.300%	0.048%	1.305%	0.118%	8	1.0
0 to 20mV	4.88E-06V	0.276%	0.048%	1.281%	0.118%	9	1.4

Temperature coefficients

Offset, unipolar mode: ±10µV/˚C ±(14µV/˚C ÷ Gain) maximum
Offset, bipolar mode: ±10µV/˚C ±(12µV/˚C ÷ Gain) maximum
Gain, at gain < 50: ±20 ppm/˚C maximum
Gain, at gain = 50: ±30 ppm/˚C maximum
Gain, at gain = 250: ±35 ppm/˚C maximum

Common mode rejection

Gain	Common mode rejection ratio (CMRR)
1	74 dB at 60Hz
5	80 dB at 60Hz
≥50	100 dB at 60Hz

Data transfer modes

DMA (PCI bus master), Interrupt (target-mode transfer), Polled (target-mode transfer)

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Analog Outputs, KPCI-1801HC

Number of Channels
Two

Resolution
12 Bits

Range
±10V

Accuracy
±5mV maximum

Output current
±5mA maximum

Maximum capacitive load
100µF

Glitch energy
2nV sec typical

Data transfer modes
DMA (PCI bus master), Interrupt (target-mode transfer), Polled (target-mode transfer)

D/A FIFO buffer size
16 Samples

Clock/Timer, KPCI-1801HC

Internal pacer clock rate
333kHz maximum
0.0012Hz minimum

External pacer clock rate
333kHz maximum

External pacer clock pulse width
10ns, minimum

Burst clock rate
333kHz maximum

Triggers
External digital: pre-trigger, post-trigger, about-trigger modes
Internal software: start, stop, pre-trigger, post-trigger, about-trigger modes

External trigger pulse width
10ns, minimum

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Digital I/O, KPCI-1801HC

Number of input bits

Two general purpose and two configurable by software as either general purpose or external pacer-clock and trigger inputs.

Input-low signal

V_{IL} = 0.8V maximum; I_{IL} = –0.2mA maximum

Input high signal

V_{IH} = 2.0V minimum; I_{IH} = 20µA maximum

Number of output bits

Eight, with strobe

Output low signal

V_{OL} = 0.5V maximum; I_{OL} = 8mA maximum

Output high signal

V_{OH} = 2.7V minimum; I_{OH} = –400µA maximum

Strobe (DOSTB) signal pulse width

300ns typical; data latched on rising edge

Data transfer mode

Target mode

Power, KPCI-1801HC

Power input

+5V; 430mA typical, 870mA maximum
+12V; 400mA typical, 550mA maximum

Power output

+5V at 1.0A maximum (May also be limited by computer or bus capability.)
±15V at 30mA maximum

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Environment, KPCI-1801HC

Temperature, operating

0˚ to 50˚C

Temperature, nonoperating

–20˚ to 70˚C

Humidity

0 to 95% relative (non-condensing), operating or nonoperating

Dimensions

8 in. L × 4.25 in. H × 0.75 in. D

Accessories, KPCI-1801HC

Termination

STP-100
CONN-1800HC
STA-1800HC

Sample/hold

SSH-8

Signal Conditioning/expansion

EXP-1800
MB-Series

Cables

CAB-1800
CAB-1801
CAB-1802
CAB-1800/S (Shielded cable, as required for CE emissions test)
CAB-1801/S (Shielded cable, as required for CE emissions test)
CAB-1802/S (Shielded cable, as required for CE emissions test)

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KPCI-1802HC specifications

Analog Inputs, KPCI-1802HC

Number of channels

32 differential or 64 single-ended; software configurable

A/D FIFO buffer size

2048 samples

Channel gain queue length

64 entries

A/D resolution

12 bits

Input Gain and Range

Gain	Range (bipolar)	Range (unipolar)
1	±10V	0 to 10V
2	±5V	0 to 5V
4	±2.5V	0 to 2.5V
8	±1.25V	0 to 1.25V

Input range selection

Software selectable via channel gain queue entry

Input overvoltage

±15V continuous, powered or unpowered

Input bias current

±40nA maximum at 25˚C; ±60nA maximum over operating range

Input impedance

>100MΩ or greater in parallel with 90pF or less, all gains

Single channel throughput

333 kS/s

Scanning throughput (multiple channels scanned at the same gain)

Gain	Throughput in bipolar mode	Throughput in unipolar mode
1	312.5 kS/s	312.5 kS/s
2	312.5 kS/s	312.5 kS/s
4	312.5 kS/s	312.5 kS/s
8	312.5 kS/s	312.5 kS/s

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Linearity

Integral: ±1 LSB maximum
Differential: ±1 LSB maximum

Accuracy at 25˚C

±0.02% Reading ±1 LSB maximum for gains < 250

Accuracy at other temperatures; noise

Accuracies listed below are based on averages of 50 samples. For a single sample, add noise to get the maximum uncertainty.

Range	Resolution	Accuracy over temperature range				Noise, counts	
		Over 25˚C ±5˚C, sum of following:		Over 25˚C ±25˚C, sum of following:			
		% of full scale	% of reading	% of full scale	% of reading	p-p	rms
±10V	0.004883V	0.050%	0.030%	0.054%	0.070%	1	0.1
0 to 10V	0.002441V	0.026%	0.030%	0.030%	0.070%	1	0.1
±5V	0.002441V	0.050%	0.030%	0.057%	0.070%	1	0.1
0 to 5V	0.001221V	0.026%	0.030%	0.033%	0.070%	1	0.1
±2.5V	0.001221V	0.051%	0.030%	0.062%	0.070%	1	0.1
0 to 2.5V	0.00061V	0.027%	0.030%	0.038%	0.070%	1	0.1
±1.25V	0.00061V	0.053%	0.030%	0.072%	0.070%	1	0.1
0 to 1.25V	0.000305V	0.029%	0.030%	0.048%	0.070%	1	0.1

Temperature coefficients

Offset, unipolar mode: ±10µV/˚C ±(14µV/˚C ÷ Gain) maximum
Offset, bipolar mode: ±10µV/˚C ±(12µV/˚C ÷ Gain) maximum
Gain: < 50: ±20 ppm/˚C maximum

Common mode rejection

Gain	Common mode rejection ratio (CMRR)
1	74 dB at 60Hz
2, 4	80 dB at 60Hz
8	86 dB at 60Hz

Data transfer modes

DMA (PCI bus master), Interrupt (target-mode transfer), Polled (target-mode transfer)

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Analog Outputs, KPCI-1802HC

Number of Channels
Two

Resolution
12 Bits

Range
±10V

Accuracy
±5mV maximum

Output current
±5mA maximum

Maximum capacitive load
100µF

Glitch energy
2nV sec typical

Data transfer modes
DMA (PCI bus master), Interrupt (target-mode transfer), Polled (target-mode transfer)

D/A FIFO buffer size
16 samples

Clock/Timer, KPCI-1802HC

Internal pacer clock rate
333kHz maximum
0.0012Hz minimum

External pacer clock rate
333kHz maximum

External pacer clock pulse width
10ns, minimum

Burst clock rate
333kHz maximum

Triggers
External digital: pre-trigger, post-trigger, about-trigger modes
Internal software: start, stop, pre-trigger, post-trigger, about-trigger modes

External trigger pulse width
10ns, minimum

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Digital I/O, KPCI-1802HC

Number of input bits

Two general purpose and two configurable by software as either general purpose or external pacer-clock and trigger inputs.

Input-low signal

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Input high signal

V_{IH} = 2.0V minimum; I_{IH} = 20µA maximum

Number of output bits

Eight, with strobe

Output low signal

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Strobe (DOSTB) signal pulse width

300ns typical; data latched on rising edge

Data transfer mode

Target mode

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+12V; 400mA typical, 550mA maximum

Power output

+5V at 1.0A maximum (May also be limited by computer or bus capability.)
±15V at 30mA maximum

Environment, KPCI-1802HC

Temperature, operating

0˚ to 50˚C

Temperature, nonoperating

–20˚ to 70˚C

Humidity

0 to 95% relative (non-condensing), operating or nonoperating

Dimensions

8 in. L × 4.25 in. H × 0.75 in. D

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Accessories, KPCI-1802HC

Termination

STP-100
CONN-1800HC
STA-1800HC

Sample/hold

SSH-8

Signal Conditioning/expansion

EXP-1800
MB-Series

Cables

CAB-1800
CAB-1801
CAB-1802
CAB-1800/S (Shielded cable, as required for CE emissions test)
CAB-1801/S (Shielded cable, as required for CE emissions test)
CAB-1802/S (Shielded cable, as required for CE emissions test)

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B
Connector pin assignments

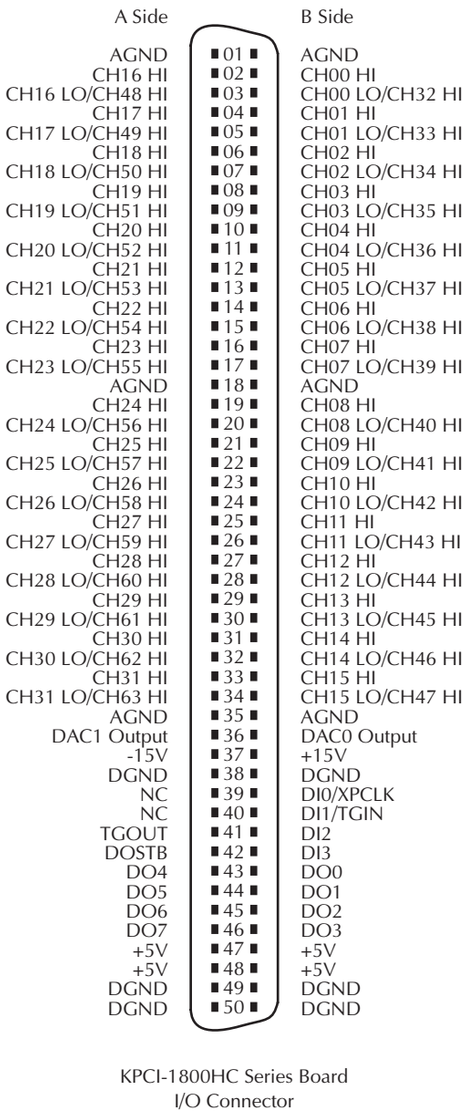
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This appendix contains pin layouts and assignments for I/O connectors of the KPCI-1800HC Series boards and the STA-1800HC, STP-100, and CONN-1800HC accessories and for the four 37-pin D connectors of the STA-1800HC accessory.

Pin assignments for KPCI-1800HC Series I/O connector

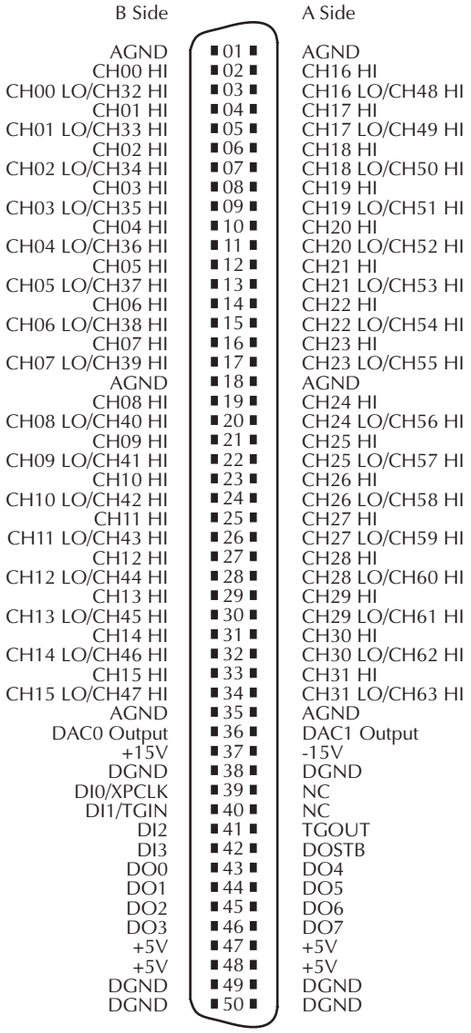
The I/O connectors for the KPCI-1800HC Series boards, the STA-1800HC, STP-100, and CONN-1800HC each contain 100 pins arranged in two banks of 50: bank A and bank B. All are female connectors. The STA-1800HC, STP-100 and CONN-1800HC connectors are a mirror image of the KPCI-1800HC Series board connector. Figure B-1 shows pin assignments for the main I/O connector of KPCI-1800HC Series boards; Figure B-2 shows pin assignments for the main I/O connectors of the STA-1800HC, STP-100, and CONN-1800HC accessories.

Figure B-1
Pin assignments for the main I/O connector of KPCI-1800HC Series boards



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Figure B-2
Pin assignments for the main I/O connectors of the STA-1800HC, STP-100, and CONN-1800HC



STA-1800HC, STP-100, and CONN-1800HC
I/O Connectors

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Pin assignments for STA-1800HC and CONN-1800HC 37-pin D connectors

The STA-1800HC and CONN-1800HC each contain four 37-pin, male, D connectors: J1, J2, J3, and J4 to connect external accessories. Pin layouts and assignments for these connectors are shown in Figure B-3, Figure B-4, Figure B-5, and Figure B-6.

Figure B-3
Connector J1

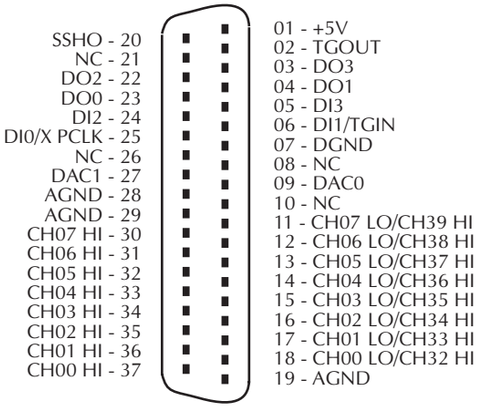
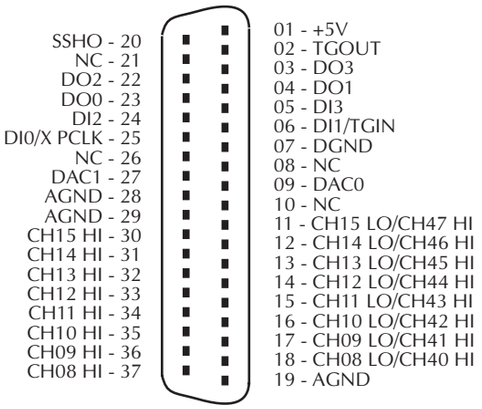


Figure B-4
Connector J2



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Figure B-5
Connector J3

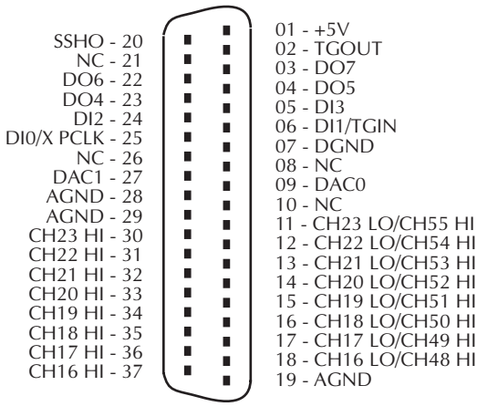
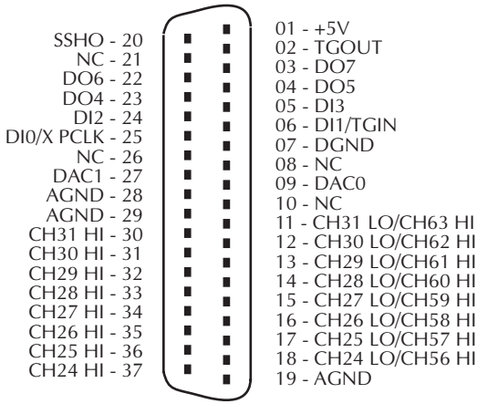


Figure B-6
Accessory Connector J4



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C
Glossary

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About-trigger acquisition mode
A data acquisition triggering mode in which the data acquisition is started by an internal or external trigger, then continues after a trigger event until a specified number of samples has been acquired. *See also* Trigger (data acquisition) *and* Trigger modes.

Absolute accuracy
A measure of the uncertainty of an instrument reading compared to that of a primary standard having absolute traceability to the National Institute of Standards and Technology. Accuracy is often separated into gain and offset terms. *See also* Rated accuracy.

Active edge
The positive, rising edge of a trigger signal or the negative, falling edge. Data acquisition systems typically may be configured to interpret specifically a positive edge or specifically a negative edge, as a trigger event. *See also* Trigger *and* Trigger polarity.

Acquisition time
In general, the minimum amount of time that an analog signal must be present at the input of an analog-to-digital (A/D) converter for an A/D conversion to take place. For a sampling A/D converter, which contains a sample-and-hold (SH) front end, the acquisition time specifies the time that the analog signal must be present at the SH front end before the A/D conversion starts. Acquisition time is also referred to as Aperture time and Sample window. *See also* Analog-to-digital converter, Sampling analog-to-digital converter, Sample-and-hold.

A/D converter
See Analog-to-digital converter.

ADC
See Analog-to-digital converter.

Address[1]
A number specifying a location in memory where data is stored.

Analog-to-digital converter
An electronic device, often an integrated circuit, that converts an analog voltage to a digital value. All digital instruments use analog-to-digital converters to convert the input signals into digital information. Sometimes called an A/D converter or an ADC.

Analog trigger
An event that occurs at a user-selected point on an analog input signal. The polarity, sensitivity, and hysteresis of the analog trigger can often be programmed. S*ee also* Trigger, Trigger conditions, Trigger hysteresis, Trigger mode, Trigger polarity, Trigger sensitivity.

Aperture delay
The time delay between when an analog-to-digital converter receives a conversion command and when it starts the conversion process. *See also* Analog-to-digital converter, aperture jitter.

Aperture time
See acquisition time.

Aperture jitter
The short-term variation of aperture delay. Also called Aperture uncertainty. *See also* Aperture delay.

Aperture uncertainty
See aperture jitter.

API
See Application Programming Interface.

Application programming interface[1]
A set of routines used by an application program to direct the performance of a procedure by the computer's operating system.

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Base address
An I/O address that is the starting address for programmable registers. All subsequent registers are accessed by adding to the base address.

Bias current (in differential amplifier)
A small but finite current drawn through an input terminal of a differential amplifier to the corresponding input transistor. Depending on the design of the amplifier, the bias current flows into the base of a bipolar transistor, the gate of a junction field effect transistor, or the biased protective diodes in front of a MOS field effect transistor. Ideally, the bias current through the input-high terminal of the amplifier is identical to the bias current through the input-low terminal. Because bias currents flow through the resistance of the signal source and through the resistance between the signal source and ground, compensation techniques are sometimes employed to minimize input errors caused by the resulting voltage drops.

Bipolar
An analog signal range that includes both positive and negative values.

Burst clock
For a data acquisition board operating in the burst mode, a pulse-emitting circuit that determines the analog data conversion rate. *See also* Burst mode *and* Conversion rate.

Burst clock rate
The rate at which timing pulses are emitted from a pacer clock. *See also* Burst clock, Burst mode.

Burst clock frequency
See burst clock rate.

Burst conversion mode
A data acquisition mode in which a group of analog input channels are scanned at a rate determined by the pacer clock and each channel within the group is converted at a higher rate determined by the burst clock. This mode minimizes the skew between channels. *See also* Burst clock, Pacer clock.

Bus mastering
On a microcomputer bus such as the PCI bus, the ability of an expansion board to take control of the bus and transfer data to memory at high speed, independently of the CPU. Replaces direct memory access (DMA).

Bus
An interconnection system that allows each part of a computer to communicate with the other parts.

Byte
A group of eight bits.

Channel
On a data acquisition board, one of several input or output paths on the board. Multiple analog input channels are commonly connected to one analog-to-digital converter, one at a time, using a multiplexer. *See also* Multiplexer *and* Analog-to-digital converter.

Channel-gain queue
A user-defined scan sequence in a data acquisition device that specifies both the position in the sequence and the gain at which each channel is scanned. It can also specify whether the input modes are bipolar or unipolar and single-ended or differential. *See also* Channel *and* Scan.

CMRR
See Common Mode Rejection Ratio (CMRR).

Cold junction
The junction in a thermocouple circuit that is held at a stable, known temperature. Also known as a reference junction.

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Cold-junction compensation
A method of compensating for ambient temperature variations in thermocouple circuits.

Common Mode Rejection Ratio (CMRR)
The ability of a differential input to reject interference from a voltage common to both its input terminals with respect to ground—the common mode voltage. Numerically,

$$\text{CMRR} = \frac{\text{Common mode voltage}}{\text{Common mode error, the part of common mode voltage not rejected}}$$

The CMRR is usually expressed in decibels [i.e. as $20\log_{10}(\text{CMRR})$], at a specified frequency. *See also* Common mode voltage *and* Differential input.

Common mode voltage
A voltage between input low and chassis ground of an instrument. A differential input "sees" the common mode voltage as a common component of the voltages at both the input-high and input-low terminals and rejects all but a small fraction. *See also* Common Mode Rejection Ratio (CMRR) *and* Differential input.

Contact bounce
The intermittent and undesired opening of relay contacts during closure, or the intermittent and undesired closing of relay contacts during opening.

Conversion rate
The rate at which sampled analog data is converted to digital data or at which digital data is converted to analog data.

Conversion time
The time required to complete an analog-to-digital conversion or a digital-to-analog conversion.

Crosstalk
The coupling of a signal from one input to another (or from one channel to another channel or to the output) by conduction or radiation. Crosstalk is expressed in decibels at a specified load and up to a specific frequency.

D/A converter
See Digital-to-analog converter.

DAC
See Digital-to-analog converter.

Darlington
A high-gain current amplifier composed of two bipolar transistors, typically integrated in a single package.

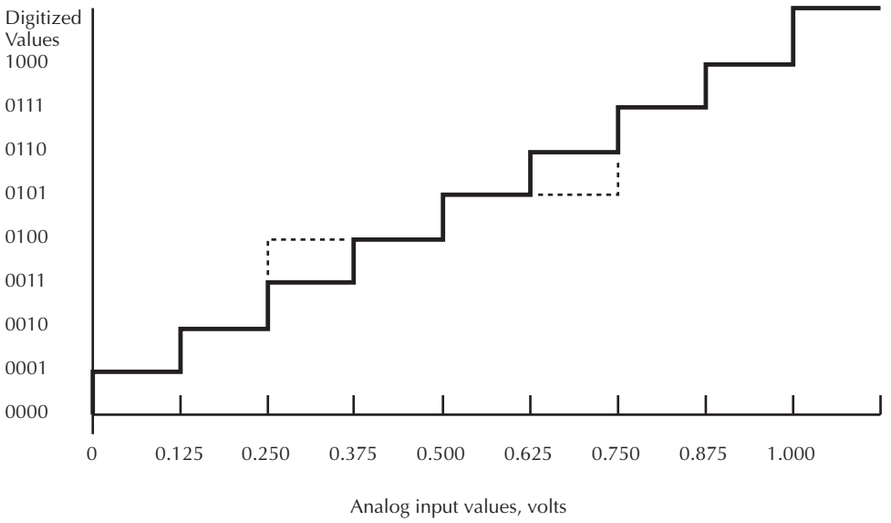
Differential amplifier
An amplifier that measures the difference between the voltages at two input terminals, input-high and input-low, each of which is referenced to a common ground. A differential amplifier rejects the common mode voltage — the common voltage relative to ground, as measured at the input low terminal — to an extent limited by the common-mode rejection ratio of the amplifier.

Differential input
An analog input circuit that measures the difference between the voltages at two input terminals — input high and input low, each of which is referenced to a common ground. A differential input rejects the common mode voltage — the common voltage relative to ground, as measured at the input low terminal — to an extent limited by the common-mode rejection ratio of the circuit. *See also* Common mode voltage, Common-mode rejection ratio (CMRR) *and* Single-ended input.

Differential linearity
See Differential Nonlinearity (DNL).

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Differential Nonlinearity (DNL)
The maximum deviation of a real digitized step width or height from the ideal digitized step width or height. The input range of a data acquisition board is divided into a series of discrete steps, each step ideally having a height of one least significant bit (LSB). For a 4 bit analog-to-digital converter, the solid curve below illustrates ideal digitized steps over an entire 1 V input range, resulting in a differential nonlinearity of 0 LSB. The dashed curve illustrates deviations from ideality resulting in a differential nonlinearity of ±1.0 LSB. *See also* Least Significant Bit (LSB), and Analog-to-digital converter.



Digital-to-analog converter[1]
A device that translates digital data to an analog signal. A digital-to-analog converter takes a succession of discrete digital values as input and creates an analog signal whose amplitude, moment by moment, corresponds to each digital value. *Compare* Analog to digital converter.

Digital trigger
An event that occurs at a user-selected point on a digital input signal. The polarity and sensitivity of the digital trigger can often be programmed. *See also* trigger, trigger conditions, trigger polarity, *and* trigger sensitivity.

DLL
See Dynamic Link Library.

DMA (Direct Memory Access) channels
ISA bus PCs offer eight parallel channels for DMA mode data transfers. Several of these are reserved for exclusive use by the computer. The remainder are available for use by user-supplied I/O options, such as plug-in data acquisition cards. Also called DMA levels. *See also* DMA mode.

DMA (Direct Memory Access) levels
See DMA (Direct Memory Access) channels

DMA (Direct Memory Access) mode
A mode in which data transfers directly between an I/O device and computer memory, bypassing the CPU. In the most general sense, PCI bus mastering is a DMA mode. More commonly, however, DMA mode refers to data transfers across the ISA bus, using special circuitry on the computer motherboard. *See also* Bus mastering.

Direct Memory Access (DMA)
See DMA (Direct Memory Access) mode.

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DNL
See Differential Nonlinearity.

Drift
A gradual change of a reading or an amplifier output over time with no changes in the input signal or operating conditions.

Driver
Software that controls a specific hardware device, such as a data acquisition board.

Dynamic Link Library (DLL)
A software module in Microsoft Windows containing executable code and data that can be called or used by Windows applications or other DLLs. DLL functions and data are loaded and linked at run time when they are referenced by a Windows application or other DLLs.

Expansion slot[1]
A socket in a computer designed to hold expansion boards and connect them to the system bus (data pathway).

External pacer clock source
A source of pulses that is connected externally to a data acquisition board and is used to pace or time events such as analog-to-digital conversions, digital-to-analog conversions, data sampling, interrupt generation, digital I/O transfers, etc.

External trigger
An analog or digital hardware event from an external source that starts an operation. *See also* Internal trigger.

Floating
Refers to a signal source that is either totally ungrounded (a battery, for example) or is not connected either directly or indirectly to the building ground or analog signal ground. (Real floating signal devices do have a finite, though very small, coupling to ground due to finite insulation resistance and other sources of current leakage.)

Foreground task
An operation, such as a task that occurs in the single or synchronous mode, that cannot take place while another program or routine is running.

Field-Programmable Gate Array (FPGA)
A gate array in which the logic network can be programmed into the device after its manufacture. An FPGA consists of an array of logic elements, either gates or lookup table RAMs, flip-flops, and programmable interconnect wiring. Most FPGAs are reprogrammable, because their logic functions and interconnects are defined by RAM cells. Others can only be programmed once, by closing "antifuses," and retain their programming permanently. In one type, part of the array can be reprogrammed while other parts are active.

FPGA designs are prepared using CAD software tools, usually provided by the chip vendor, to do technology mapping, partitioning and placement, routing, and binary output. The resulting binary can be programmed into a ROM connected to the FPGA or downloaded from a computer connected to the FPGA.

FIFO
First-In/First-Out memory buffer. The first data into the buffer is the first data out of the buffer. On a data acquisition board, a FIFO allows data collection to continue while the board waits for data transfer access to the host computer.

FPGA
See Field-Programmable Gate Array (FPGA).

Gain
The factor by which an incoming signal is multiplied by an amplifier.

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Gate (signal)
A signal that in the active state enables an operation and in the inactive state inhibits the operation.

Glitch energy
A glitch is an unwanted transient superimposed on the output of a digital-to-analog converter. Glitch energy is a measure of this transient. A simple figure of merit is an integral of the transient voltage with time. Also called glitch charge or glitch impulse.

GPIB
Abbreviation for General Purpose Interface Bus, also referred to as the IEEE-488 bus. It is a standard for parallel interfaces.

Ground loop
A current loop created when a signal source and a signal measurement device are grounded at two separate points on a ground bus through which noise currents and/or currents from other devices flow. Due to the finite resistance of the bus, these currents generate voltage drops between the two ground connection points, which can cause errors and noise in the signal measurement.

IEEE-488
See GPIB.

Input bias current
The current that flows at the input of an analog measurement circuit due to internal circuitry and bias voltage. Also, at conditions of zero input signal and offset voltage, the current that must be supplied to the input-high measuring terminal to reduce the output indication to zero. The input bias current is drawn through the source resistance of a signal source. Therefore, in critical and/or low-level measurements, bias current compensation or attention to source resistance may be required to minimize errors.

Input/Output (I/O)
The process of transferring data to and from a computer-controlled system using its communication channels, operator interface devices, data acquisition devices, or control interfaces. Also refers to the electrical inputs and outputs for data signals. For example, one may say that a data acquisition board provides both "digital and analog I/O," meaning "digital and analog inputs and outputs."

Input/output port[1]
A channel through which data is transferred between an input or output device and the processor.

Instrumentation amplifier
A high-performance differential amplifier having high input impedance at both the input high and input low terminals and typically characterized by high common mode rejection ratio (CMRR) and low drift. An instrumentation amplifier normally operates either at a fixed gain or, in the case of a Programmable Gain Instrumentation Amplifier (PGIA at a gain set using a digital control signal. *See also* Differential amplifier, Differential input, Drift, Common Mode Rejection Ratio (CMRR).

Internal pacer clock
See Pacer clock.

Integral linearity
See Linearity.

Internal trigger
A software-generated event that starts an operation. *See also* External trigger.

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Interrupt
For a data acquisition board, a signal to the CPU indicating that the board detected a condition or event calling for special processing. An interrupt causes the CPU to temporarily stop the current processing task, complete the special processing task, and then return to the original processing task. *See also* Interrupt level, Interrupt-mode operation, Interrupt Service Routine (ISR).

Interrupt level
A specific priority that ensures that high priority interrupts are serviced before low priority interrupts.

Interrupt-mode operation
Mode in which a data acquisition board acquires or generates samples using an Interrupt Service Routine (ISR).

Interrupt Service Routine (ISR)
A software program that handles interrupts.

ISA Bus
Industry Standard Architecture. A 16-bit wide bus architecture used in most MS-DOS and Windows computers. Sometimes called the AT bus.

Least Significant Bit (LSB)
The lowest order bit, usually the rightmost bit, in the binary representation of a digital quantity. Measurement precision or accuracy is sometimes specified in terms of *multiple* Least Significant Bits (LSBs). In that case, the precision or accuracy is represented by the binary number that results from *counting* the specified number of least significant bits. For example, the binary number that results from counting 3 LSBs is 0011 (0001 + 0001 + 0001 = 0011). Therefore, a 12-bit number precise to within 3 LSBs is precise to within (0011)/(1111 1111 1111) = 3/4096 = 0.07% of full scale.

Linearity
For a curve relating instrument readings to known inputs, the maximum deviation of readings from a straight line drawn between readings at zero and full range.

LSB
See Least Significant Bit.

Map[1]
Any representation of the structure of an object. For example, a memory map describes the lay-out of objects in an area of memory, and a symbol map lists the association between symbol names and memory addresses in a program.

Multiplexing
A technique whereby multiple signals are sent to one input, one signal at a time in a specified sequence.

Multiplexer (MUX)
A circuit that switches multiple signals into one input, one signal at a time in a specified sequence.

MUX
See Multiplexer.

Negative-edge triggering
Digital trigger mode in which the triggering action starts on the falling edge of the signal. *See also* Trigger polarity *and* Digital trigger.

Noise
An undesirable electrical signal from an external source such as an AC power line, motors, generators, transformers, fluorescent lights, CRT displays, computers, and radio transmitters.

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OCX
Abbreviation for OLE Custom Control. Also referred to as ActiveX control.

Paced mode
A data-acquisition analog-to-digital conversion mode in which one sample is converted following each pulse of a pacer clock. That is, the conversion rate equals the pacer clock rate. *See also* Pacer clock, Conversion rate, Sample rate, and Analog-to-digital converter.

Pacer clock
An internal (on-board) or external clock that emits pulses that are used to pace or time events such as analog-to-digital conversions, digital-to-analog conversions, data sampling, interrupt generation, digital I/O transfers, etc.

p-p
See peak-to-peak.

Peak
The highest magnitude, either positive or negative. For a signal that is symmetrical about zero, peak = ½ *See also* peak-to-peak.

Peak-to-peak
The difference between the minimum value and maximum value of an alternating signal.

Pacer clock rate
The rate at which timing pulses are emitted from a pacer clock. *See also* Pacer clock *and* Paced mode.

Pass-through operation
See Target mode.

PCI
Abbreviation for Peripheral Component Interconnect. It is a standard for a local bus.

PGIA
See Instrumentation amplifier.

Plug and Play[1]
A set of specifications developed by Intel that allows a PC to configure itself automatically to work with peripherals such as monitors, modems, and printers. A user can "plug" in a peripheral and "play" it without manually configuring the system. A Plug and Play PC requires both a BIOS that supports Plug and Play and a Plug and Play expansion card.

PnP
See Plug and Play.

Port
See input/output port.

Port group
For digital I/O emulating the I/O of an 8255 programmable peripheral interface chip, a group of three 8 bit ports, commonly labeled PA, PB, and PC. Digital I/O that emulates multiple 8255 chips is typically divided into multiple port groups.

Port I/O call
A software program statement that assigns bit values to an I/O port or retrieves bit values from an I/O port. Examples include a C/C++ statement containing an `inp` or `outp` function or a Basic statement containing a `peek` or `poke` function.

Positive-edge triggering
A digital trigger mode in which the triggering action starts on the rising edge of the signal. *See also* Trigger polarity, Digital trigger.

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Post-trigger acquisition mode
A data acquisition triggering mode in which the data acquisition starts after an internal or external trigger event and continues until a specified number of samples has been acquired or until the operation is stopped by software. *See also* Trigger (data acquisition) *and* Trigger modes.

Pre-trigger acquisition mode
A data acquisition triggering mode in which the data acquisition is started before an internal or external trigger occurs. *See also* Trigger (data acquisition), Trigger modes.

Programmable Gain Instrumentation Amplifier (PGIA)
See Instrumentation amplifier.

Pseudo-Simultaneous Sample and Hold
Emulating Simultaneous Sample and Hold (SSH) by scanning a group of data acquisition channels at the highest practical rate while repeating scans at a much slower rate. This is commonly done in the burst data-conversion mode, by running the burst clock at a rate close to maximum throughput while running the pacer clock at a much slower rate. Typically used when multiple parameters must be compared at essentially the same instant in time but slight timing variations are acceptable. *See also* Burst clock, Burst mode, Pacer clock, Simultaneous Sample and Hold (SSH), Scan, Throughput.

Pseudo-SSH
See Pseudo-Simultaneous Sample and Hold.

Pulse duration
See Pulse width.

Pulse width
The time interval between the rising and falling edges of a pulse, specified at a certain percentage of the peak amplitude—commonly 50% for a rectangular pulse. Also referred to as pulse duration.

QRAM
Queue RAM. Onboard memory on a data acquisition board that holds information about the channel number and gain, and sometimes other settings, for each position in the channel-gain queue. *See also* Channel-gain queue.

Range
A continuous band of signal values that can be measured or sourced. In bipolar instruments, range includes positive and negative values.

Rated accuracy
The limit that errors will not exceed when an instrument is used under specified operating conditions. It is expressed as a percentage (of input or output) plus a number of counts. *See also* Absolute accuracy.

Register[1]
A set of bits of high-speed memory within a microprocessor or other electronic device used to hold data for a particular purpose.

Resolution
The smallest increment of a signal that can be measured, sourced, or displayed. Also called sensitivity or minimum resolvable quantity. For a digitized signal, resolution is typically expressed in bits or digits. By contrast, sensitivity is expressed in engineering units.

Ringing (in digital-to-analog converter)
A transient oscillation in the output of a Digital-to-Analog Converter (DAC) that follows an abrupt change in input, analogous to the decaying vibrations of a clapped bell. Susceptibility to ringing in a DAC is caused by excessive capacitance in the driven load.

rms (or RMS)
See Root-mean-square (rms).

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Root-mean-square (rms)
The rms value of an alternating signal equals the square root of the time average of the square of that signal. A sinusoidal alternating current having a particular rms value and a DC current having that same value produce the same joule heating when connected to a given resistor. Sometimes referred to by standard deviation.

S
Abbreviation for the Sample or Samples unit. *See* Sample (data acquisition).

Sample (data acquisition)
A single value that is read from or written to one channel. *See also* Channel.

Sample and Hold (SH)
An operation, or electronic circuit, in which an analog input signal is stored briefly as a voltage on a capacitor, typically until it can be digitized by an analog-to-digital converter. *See also* Simultaneous sample and hold *and* Analog-to-digital converter.

Sample rate
The rate at which a continuous-time signal is sampled. The sample rate is frequently expressed in units of samples/second (S/s), kilosamples/second (kS/s), or megasamples/second (MS/s).

Sampling analog-to-digital converter
An analog-to-digital converter containing a sample-and-hold circuit at the front end, which captures the incoming analog signal and holds it for the duration of the analog-to-digital conversion process. *See also* Analog-to digital converter, Sample-and-Hold (SH).

Saturation (amplifier)
Amplifier condition in which an increase of the input signal produces no further increase in the output signal.

Scan (data acquisition)
To sample a group of input channels once at a specified acquisition rate, either in numerical sequence or in the sequence specified in a channel-gain queue. *See also* Channel-gain queue.

Scan rate
The rate at which a group of channels is sampled, measured from the start of one scan to the start of the next scan.

Scatter-gather
A very high speed, direct memory access data transfer method under PCI bus mastering. Data written to memory may be "scattered" into noncontiguous memory blocks. When reading data, the memory block locations are first supplied to the bus master, and then data is rapidly "gathered" from the noncontiguous memory blocks.

Settling time (data acquisition)
The time needed for the output of a digital-to-analog converter or a combined input amplifier/analog-to-digital converter to stabilize, within a specified error, following an abrupt change in input.

SH
See Sample and Hold.

Shielding
A metal enclosure for a circuit being measured or a metal sleeve surrounding wire conductors to lessen interference, interaction, or current leakage. The shield is usually grounded.

Simultaneous Sample and Hold (SSH)
An operation, or electronic circuit, in which multiple analog input signals are simultaneously sampled and stored, typically as voltages on capacitors, until sequentially read by a scanning analog-to-digital converter system. *See also* Analog-to-digital converter. Typically used when multiple parameters must be compared at exactly the same instant in time.

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Single-ended input (data acquisition)
An analog input circuit that measures the voltage at one input terminal relative to a common ground. *See also* Differential input.

Software trigger
A programmed event that starts an operation such as data acquisition.

SSH
See Simultaneous Sample and Hold.

Strobe[1]
A timing signal that initiates and coordinates the passage of data, typically through an input or output device interface.

Target mode
A PCI bus mode in which data from a data acquisition board is transferred indirectly to the computer memory in the foreground, via the host computer CPU, instead of directly, via Bus mastering. Sometimes referred to as pass-through operation. *See also* bus mastering and foreground task.

Temperature coefficient
A change in the value of a measured or sourced signal with a change in temperature. The temperature coefficient is commonly expressed as an absolute or relative change — or both — per degree C or degree F.

Thermal emfs
Temperature-dependent voltages that develop across junctions of dissimilar metals. In an ideal measurement circuit, all such junctions would be wired to high and low differential inputs as identical pairs at identical temperatures, resulting in cancellation of the thermal emfs. Practically, however, temperature differences across the circuit and imperfect metal-to-metal junctions result in net voltage errors, which must be minimized when measuring low-level signals.

Throughput
The maximum rate at which a data conversion system can perform repetitive conversions within a specified accuracy. It is determined by summing the various times required for each part of the conversion system and then calculating the inverse of this time. The throughput rate takes into account the total time required to process a signal and store the value in either on-board or system memory.

Trap[1] **(*verb*)**
To intercept an action or event before it occurs, usually in order to do something else. Trapping is commonly used by debuggers to allow interruption of program execution at a given spot.

Trigger conditions
Refers to trigger sensitivity, polarity, etc.

Trigger (data acquisition)
An event that starts or stops an operation. A trigger can be a specific analog, digital, or software condition. *See also* analog trigger *and* digital trigger.

Trigger hysteresis
Applies only to analog triggers. A specified voltage change, opposite in polarity to the trigger polarity, through which an analog trigger signal must move before triggering can occur. For positive-edge triggering to occur, the signal must first fall below the specified trigger voltage by at least the amount of the hysteresis value. For negative-edge triggering to occur, the signal must rise above the specified trigger voltage level by at least the amount of the hysteresis value. Trigger hysteresis helps prevent false triggering due to noise. *See also* Analog trigger, Trigger polarity.

Trigger jitter
The short-term variation in trigger latency. *See also* Trigger latency.

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Trigger latency
The fixed time offset between the trigger event and the first sample point.

Trigger mode
Refers to when data acquisition begins and ends in relationship to the trigger. Trigger modes include normal-trigger, pre-trigger, about-trigger, post-trigger, trigger-to-trigger, and trigger-to-about-trigger. *See also* Pre-trigger acquisition mode, About-trigger acquisition mode, Post-trigger acquisition mode.

Trigger polarity
For edge-sensitive triggers, trigger polarity defines whether the trigger occurs when the signal is rising (positive direction) or when the signal is falling (negative direction). For level-sensitive triggers, trigger polarity defines whether the trigger occurs when the signal is above a level (positive) or below a level (negative).

Trigger sensitivity
Refers to the edge and/or level of a trigger. For analog triggers, trigger sensitivity defines whether the trigger occurs on a transition across a specified value (edge) or whether the trigger occurs when it is above or below a specified value (level). For digital triggers, trigger sensitivity defines whether the trigger occurs on a transition from one state to another state (edge) or whether the trigger occurs when it is at a specified value (level).

TTL
Abbreviation for Transistor-Transistor-Logic. A popular logic circuit family that uses multiple-emitter transistors. A low signal state is defined as a signal 0.8V and below. A high signal state is defined as a signal +2.0V and above.

Unipolar
An analog signal range that is always positive (above zero).

2's complement[1]
A number in the base-2 (binary) system that is the true complement of another number. A 2's complement is usually derived by reversing the digits in a binary number (changing 1s to 0s and 0s to 1s) and adding 1 to the result. When 2's complements are used to represent negative numbers, the most significant (leftmost) digit is always 1.

[1]*Microsoft Press® Computer Dictionary, Third Edition*. Refer to "Sources" below.

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