KEITHLEY

KPCI-3110 and KPCI-3116

PCI Bus Data Acquisition Boards

User's Manual

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4/02

KPCI-3110 and KPCI-3116 PCI Bus Data Acquisition Boards
User's Manual

Cleveland, Ohio, U.S.A.
Third Printing, January 2002
Document Number: 98180 Rev. C

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number 98180) .... November 1999
Revision B (Document Number 98180) .... August 2000
Revision C (Document Number 98180) .... January 2002

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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.

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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Preface

This manual describes the features of the KPCI-3110 and KPCI-3116 boards, the capabilities of the DriverLINX software, and how to configure the KPCI-3110 and KPCI-3116 board using DriverLINX. Troubleshooting and calibration information is also provided.

Intended audience

This document is intended for engineers, scientists, technicians, or others responsible for using and/or programming the KPCI-3110 and KPCI-3116 boards for data acquisition operations in Microsoft Windows 95, Windows 98, or Windows NT. It is assumed that you have some familiarity with data acquisition principles and that you understand your application.

NOTE *Unless noted otherwise, this manual refers to both models collectively as KPCI-3110.*

This manual focuses primarily on describing the KPCI-3110 boards and their capabilities, setting up the boards and their associated software, making typical hookups, and troubleshooting. There are also sections that discuss calibration and summarize characteristics of DriverLINX test-panel software.

What you should learn from this manual

This manual provides detailed information about the features of the KPCI-3110 and KPCI-3116 boards and the capabilities of the KPCI-3110 and KPCI-3116 Device Driver.

- Section 1 describes the major features of the board, as well as the supported software and accessories for the board.
- Section 2 describes all of the board's features and how to use them in your application.
- Section 3 describes how to install DriverLINX software, install the KPCI-3110 boards, wire accessories, and configure the software to work with the boards.
- Section 4 describes the use of the DriverLINX Analog I/O Panel for testing board functions.
- Section 5 describes how to calibrate the analog I/O circuitry of the board.
- Section 6 provides information that you can use to resolve problems with the board, computer, or DriverLINX should they occur.
- Appendix A lists the specifications of the board and data acquisition subsystems and the associated features accessible using DriverLINX for the KPCI-3110 and KPCI-3116 boards.
- Appendix B shows the pin assignments for the connectors on the board and for the STP300 screw termination panel.
- Appendix C describes how to systematically isolate problems with the board, computer, software, and programming.
- Appendix D provides information on special considerations when using your own screw terminal panel.
- An index completes this manual.

Viewing the KPCI-3110 and KPCI-3116 documentation online

The *DriverLINX Manuals* and this manual have been provided in electronic form (in PDF file format) on the CD-ROM. To view these documents, you need to install Rev 3.01 or later of Adobe Acrobat Reader on your hard drive (refer to DriverLINX for installation instructions).

View the KPCI-3110 and KPCI-3116 documentation by clicking the manual title.

Here are a few helpful hints about using Adobe Acrobat Reader:

- To navigate to a specific section of the document, click a heading from the table of contents on the left side of the document.
- Within the document, click the text shown in blue to jump to the appropriate reference (the pointer changes from a hand to an index finger).
- To go back to the page from which the jump was made, click the right mouse button and **Go Back,** or from the main menu, click **View**, then **Go Back**.
- To print the document, from the main menu, click **File**, then **Print**.
- To increase or decrease the size of the displayed document, from the main menu, click **View**, then **Zoom**.
- By default, text and monochrome images are smoothed in Acrobat Reader, resulting in blurry images. If you wish, you can turn smoothing off by clicking **File**, then **Preferences/ General**, and unchecking **Smooth Text and Monochrome Images**.

Conventions used in this manual

The following conventions are used in this manual:

- Notes provide useful information or information that requires special emphasis, cautions provide information to help you avoid losing data or damaging your equipment, and warnings provide information to help you avoid catastrophic damage to yourself or your equipment.
- Items that you select or type are shown in **bold**.

Related information

Refer to the following documents for more information on using the KPCI-3110 and KPCI-3116 boards:

- *KPCI-3110 and KPCI-3116 Read This First*. This "Quick Start Guide" describes how to install the KPCI-3110 and KPCI-3116 boards and related software.
- DriverLINX Installation and Configuration
- DriverLINX Appendix: Using DriverLINX with your Hardware: Keithley KPCI-3110 and KPCI-3116 installation information)
- DriverLINX Technical Reference Manual
- DriverLINX Analog I/O Programming Guide
- DriverLINX Digital I/O Programming Guide
- DriverLINX Counter/Timer Programming Guide
- *PCI Specification:* PCI Local Bus Specification, PCI Special Interest Group, Portland, OR.
- Microsoft Windows 3.x, Windows 95, Windows 98, and/or Windows NT user manuals.
- Other manuals appropriate to your installation.

Where to get help

Should you run into problems installing or using a KPCI-3110 and KPCI-3116 board, our Technical Support Department is available to provide technical assistance. Refer to Section 6 for more information. If you are outside the U.S. or Canada, call your local distributor, whose number is listed in your Keithley product catalog.

1
Overview

Introduction

This manual is provided for persons needing to understand the installation, interface requirements, functions, and operation of the KPCI-3110 and KPCI-3116 boards. These board types differ in analog I/O resolution, throughput, and D/A filters as shown in Table 1-1.

NOTE *Unless noted otherwise, this manual refers to both models collectively as KPCI-3110.*

This manual focuses primarily on describing the KPCI-3110 boards and their capabilities, setting up the boards and their associated software, making typical hookups, and troubleshooting. There are also sections that discuss calibration and summarize characteristics of DriverLINX test-panel software.

Features

The KPCI-3110 and KPCI-3116 boards are high-speed, multifunction board types for the PCI bus. These board types differ in analog I/O resolution, throughput, and D/A filters as shown in Table 1-1.

Table 1-1
Differences among KPCI-3110 and KPCI-3116 boards

Board Type	Analog I/O Resolution	Output FIFO Size	A/D Throughput (Single Channel)	D/A Throughput (Full Scale)	D/A Filters
KPCI-3110	12 bits	4 kSample	1.25 MSamples/s	200 kSamples/s	-
KPCI-3116	16 bits	4 kSample	250 kSamples/s	100 kSamples/s	0 and 20kHz

All KPCI-3110 and KPCI-3116 boards share the following major features:

- 32 Single-ended or pseudo-differential analog input channels (refer to), or 16 differential analog input channels.
- Programmable bipolar (±10V) and unipolar (0 to 10V) input ranges with gains of 1, 2, 4, and 8.
- Continuously-paced and triggered scan capability.
- A 1024-location channel-gain list that supports sampling analog input channels at the same or different gains in sequential or random order.
- Up to 256 scans per trigger for a total of 262,144 samples per trigger.
- PCI bus mastering for data transfers.
- Pre-, post-, and about-trigger acquisition modes to acquire data relative to an external event using computer memory.
- Internal and external clock sources; one external clock input for the analog input subsystem and one external clock input for the analog output subsystem.
- Analog threshold triggering using either an external analog input or one of the analog input channels; a separate DAC sets the trigger level (8-bit resolution, fixed hysteresis).
- Digital TTL triggering; one external hardware TTL input for the analog input subsystem and one external hardware TTL input for the analog output subsystem.
- Two analog output channels with a ±10V output range.
- Simultaneous analog input and analog output operations running at full speed.
- Software calibration of the analog input and output subsystems.

- Two 8-bit digital ports programmable as inputs or outputs on a per-port basis; digital inputs can be included as part of the analog input channel-gain list to correlate the timing of analog and digital events; digital outputs can drive external solid-state relays.
- Two dynamic, high-speed digital output lines; useful for synchronizing and controlling external equipment, these dynamic digital output lines are programmable as part of the analog input subsystem.
- Four user counter/timers programmable for event counting, frequency measurement, rate generation (continuous pulse output), one-shot pulse output, and repetitive one-shot pulse output.
- Programmable gate types.
- Programmable pulse output polarities (output types) and duty cycles.
- A/D Sample Clock Output and A/D Trigger Output signals, useful for synchronizing and controlling external equipment.

DriverLINX software

The following software is available for use with the KPCI-3110 or KPCI-3116 board:

- **KPCI-3110 and KPCI-3116 standard software package —** Shipped with KPCI-3110 and KPCI-3116 boards. Includes DriverLINX for Microsoft Windows and function libraries for writing application programs under Windows in a high-level language such as C/C++, Visual Basic, Delphi, and Test Point; LabVIEW support files; utility programs; and language-specific example programs.
- **DriverLINX** — the high-performance real-time data-acquisition device drivers for Windows application development includes:
  - *DriverLINX API DLLs* and drivers supporting the KPCI-3110 or KPCI-3116 hardware.
  - *Analog I/O Test Panel* — A DriverLINX program that verifies the operation of your KPCI-3110 or KPCI-3116 board and demonstrates several virtual bench-top instruments.
  - *Learn DriverLINX* — an interactive learning and demonstration program for DriverLINX that includes a Digital Storage Oscilloscope.
  - *Source Code* — for the sample programs.
  - *DriverLINX Application Programming Interface files* — for the KPCI-3110 or KPCI-3116 interfaces.
  - *DriverLINX Calibration Utility* — used to calibrate the ADC and DAC functions of the KPCI-3110 or KPCI-3116 board.
  - *DriverLINX On-line Help System* — provides immediate help as you operate DriverLINX.
  - *Supplemental Documentation* — on DriverLINX installation and configuration; analog and digital I/O programming; counter/timer programming; technical reference; and information specific to the KPCI-3110 or KPCI-3116 hardware.

System requirements

The system capabilities required to run the KPCI-3110 or KPCI-3116 board, and to use the DriverLINX software supplied with the board, are listed in Table 1-2.

Table 1-2
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	16MB or greater RAM when running Windows 95 or 98
	32MB or greater RAM when running Windows NT
Hard disk space	4MB for minimum installation
	50MB 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-3110 or KPCI-3116 board, which draws 1.5A at 5VDC and 0.12A 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-3110 and KPCI-3116 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-3110 or KPCI-3116 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.

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

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

Accessories

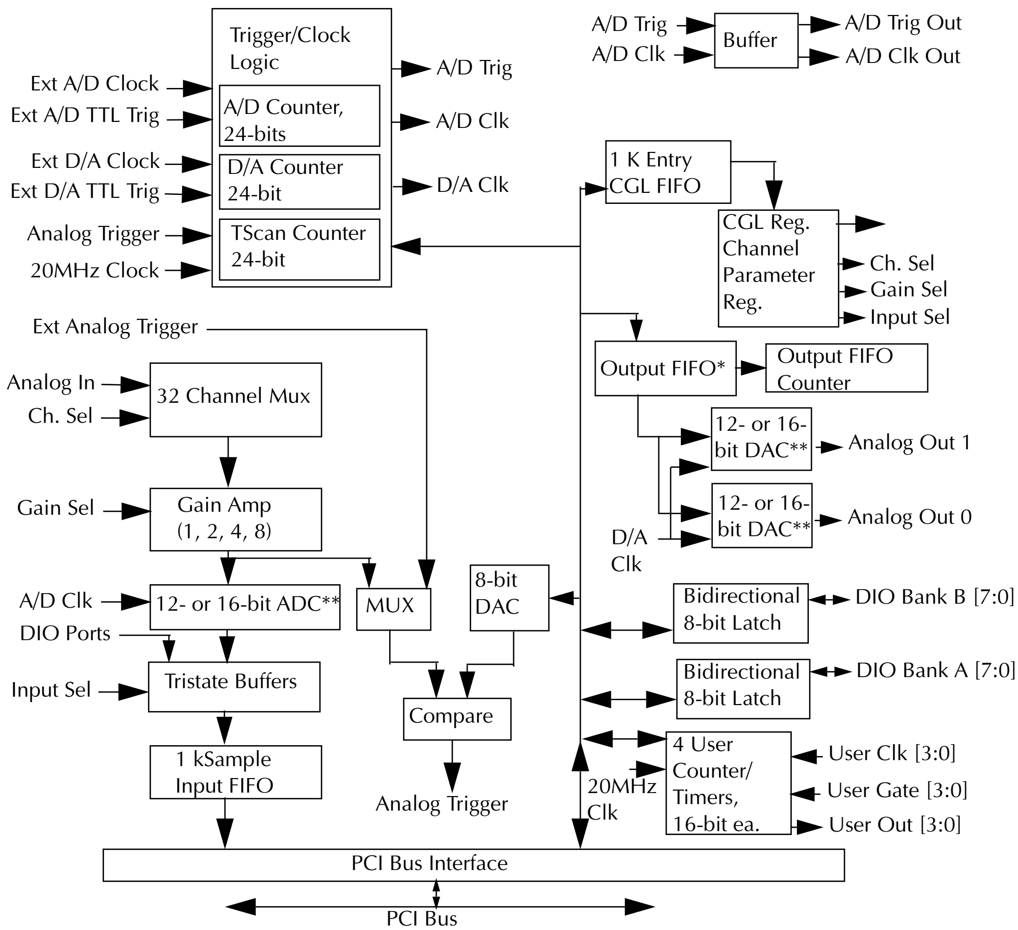
The following optional accessories are available for KPCI-3110 and KPCI-3116 boards:

- **STP-3110 screw terminal panel** — Screw terminal panel with two connectors to accommodate the analog I/O, digital I/O, and counter/timer signals provided by the KPCI-3110 and KPCI-3116 boards.
- **CAB-307 cable** — A 1-meter, twisted-pair, shielded cable that connects the 50-pin analog I/O connector (J1) on the KPCI-3110 or KPCI-3116 board to the J1 connector on the STP-3110 screw terminal panel.
- **CAB-308 cable** — A 1-meter, twisted-pair, shielded cable that connects the 68-pin digital I/O connector (J2) on the KPCI-3110 or KPCI-3116 board to the J2 connector on the STP-3110 screw terminal panel.

2
Functional Description

This section describes the analog input, analog output, digital I/O, counter/timer, and synchronous features of the KPCI-3110 and KPCI-3116 boards. To frame the discussions, refer to the block diagram shown in Figure 2-1. Note that bold entries indicate signals you can access.

Figure 2-1
Block diagram of the KPCI-3110 and KPCI-3116 boards



*The KPCI-3110 and KPCI-3116 have a 4 kSample Output FIFO;
**Only the KPCI-3116 has a 16-bit ADC and 16-bit DACs.

Analog input features

This section describes the features of the analog input (A/D) subsystem, including the following:

- Analog input resolution
- Analog input channels
- Input ranges and gains
- A/D sample clock sources
- Analog input conversion modes
- Trigger sources and trigger acquisition modes
- Data formats and transfer
- Error conditions

Analog input resolution

The KPCI-3110 board has a fixed analog input resolution of 12 bits. The KPCI-3116 board has a fixed resolution of 16 bits. The analog input resolution cannot be changed in software.

Analog input channels

KPCI-3110 and KPCI-3116 boards support 32 single-ended or pseudo-differential analog input channels, or 16 differential analog input channels. Refer to Section 3 for a description of how to wire these signals. You configure the channel type through DriverLINX software.

NOTE *For pseudo-differential inputs, specify single-ended in software; in this case, how you wire these signals determines the configuration.(Refer to* Section 3*, "*Connecting pseudo-differential voltage inputs*.")*

KPCI-3110 and KPCI-3116 boards can acquire data from a single analog input channel or from a group of analog input channels. Channels are numbered 0 to 31 for single-ended and pseudo-differential inputs, and 0 to 15 for differential inputs. Refer to "Using DriverLINX with your hardware: Keithley KPCI-3100 Series" for details of how to specify the channels.

Specifying digital input lines in the analog input channel list

In addition to the analog input channels, you can read the two digital I/O channels (16 lines) of the KPCI-3110 and KPCI-3116 boards using the analog input channel list. This feature is particularly useful when you want to correlate the timing of analog and digital events.

To read these two digital I/O channels, specify channel 0 in the DriverLINX analog input channel list. Specify the special code (2^{13}) in the gain field to indicate that channel 0 is a 16 bit digital channel. See "Analog Input Termination Modes" in "Using DriverLINX with Your Hardware." The hardware-specific gain code is provided in the DriverLINX channel gain list. You can enter channel 0 anywhere in the list and can enter it more than once, if desired. Refer to the *DriverLINX Analog I/O Programming Guide* provided with DriverLINX.

NOTE *If channel 0 is programmed with digital capabilities and is the only channel in the channel-gain list, the board can read this channel at a rate of 3 MSamples/s. Refer to the* Using DriverLINX with your Hardware:Keithley KPCI-3100 *manual provided with DriverLINX.*

This channel is treated like any other channel in the analog input channel list; therefore, all the clocking, triggering, and conversion modes supported for analog input channels are supported for these digital I/O lines, if you specify them in this manner.

Performing dynamic digital output operations

Using DriverLINX software, you can enable a synchronous dynamic digital output operation for the A/D subsystem. This feature is particularly useful for synchronizing and controlling external equipment.

Two dynamic digital output lines are provided: 0 and 1. These lines are set to a value of 0 on power up; a reset does not affect the values of the dynamic digital output lines. Note that these lines are provided in addition to the other 16 digital I/O lines. See page 2-21 for more information on the digital I/O features.

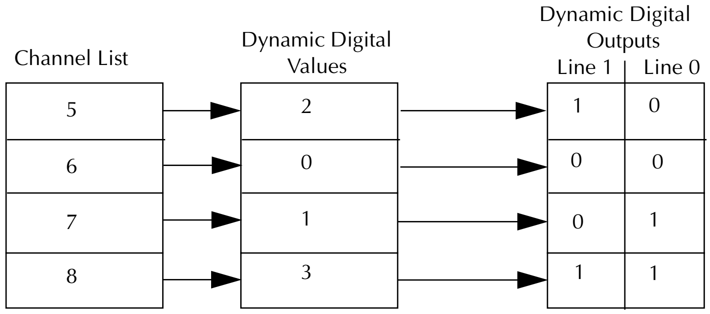
To read these two digital I/O lines, specify channel 0 in the DriverLINX analog input channel list. Specify its digital capabilities in the Digital Capabilities groups of the Logical Device Descriptor (channel, channel characteristics, and timing and start/stop trigger events). The hardware-specific gain code is provided in the DriverLINX channel gain list. You can enter channel 0 anywhere in the list and can enter it more than once, if desired. Refer to the *Using DriverLINX with your Hardware: Keithley KPCI-3100* manual provided with DriverLINX.

NOTE *If channel 0 is programmed with digital capabilities and is the only channel in the channel-gain list, the board can read this channel at a rate of 3 MSamples/s.* Refer to the Using DriverLINX with your Hardware: Keithley KPCI-3100 *manual provided with DriverLINX.*

For KPCI-3110 and KPCI-3116 boards, you can specify the following values for the dynamic digital output lines: 0 (00 in binary format), 1 (01 in binary format), 2 (10 in binary format), or 3 (11 in binary format). Each bit in binary format corresponds to the value to write to the dynamic digital output line. For example, a value of 1 (01 in binary format) means that a value of 1 is output to dynamic digital output line 0 and value of 0 is output to dynamic output line 1. Similarly, a value of 2 (10 in binary format) means that a value of 0 is output to dynamic digital output line 0 and value of 1 is output to dynamic output line 1.

For example, assume that the analog input channel list contains channels 5, 6, 7, 8; that dynamic digital output operations are enabled; and that the values to write to the dynamic digital output lines are 2, 0, 1, 3. Figure 2-2 shows this configuration.

Figure 2-2
An example using dynamic digital outputs



As analog input channel 5 is read, 1 is output to dynamic digital output line 1, and 0 is output to dynamic output line 0 (since 2 in binary format is 10). As analog input channel 6 is read, 0 is output to both dynamic digital output lines. As analog input channel 7 is read, 0 is output to dynamic digital output line 1, and 1 is output to dynamic output line 0 (since 1 in binary format is 01). As analog input channel 8 is read, 1 is written to both dynamic digital output lines.

NOTE *Expansion accessories use some of the dynamic digital output signals. Therefore, you cannot use this feature and an expansion channel in the same task.*

Input ranges and gains

Each channel on the KPCI-3110 or KPCI-3116 board can measure unipolar and bipolar analog input signals. A unipolar signal is always positive (0 to 10V on KPCI-3110 and KPCI-3116 boards), while a bipolar signal extends between the negative and positive peak values (±10V on KPCI-3110 and KPCI-3116 boards).

Through DriverLINX software, specify the range as 0 to 10V for unipolar signals or –10V to +10V for bipolar signals. Note that the range applies to the entire analog input subsystem, not to a specific channel.

KPCI-3110 and KPCI-3116 boards also provide gains 1, 2, 4, and 8, which are programmable per channel. Table 2-1 lists the effective ranges supported by KPCI-3110 and KPCI-3116 boards using these gains.

Table 2-1
Gains and effective ranges

Gain	Unipolar Analog Input Range	Bipolar Analog Input Range
1	0 to 10V	±10V
2	0 to 5V	±5V
4	0 to 2.5V	±2.5V
8	0 to 1.25V	±1.25V

For each channel, choose the gain that has the smallest effective range that includes the signal you want to measure. For example, if the range of your analog input signal is ±1.5V, specify a range of –10V to +10V for the board and use a gain of 4 for the channel; the effective input range for this channel is then ±2.5V, which provides the best sampling accuracy for that channel.

The way you specify gain depends on how you specified the channels, as described in the following subsections.

Specifying the gain for a single channel

The simplest way to specify gain for a single channel is to specify the gain for a single value analog input operation using software. Refer to page 2-7 for more information on single value operations.

You can also specify the gain for a single channel using an analog input gain list as described in the next section.

Specifying the gain for one or more channels

On the KPCI-3110 Series, you can specify the gain for one or more analog input channels using an analog input gain list. Using software, set up the gain list by specifying the gain for each entry in the analog input channel-gain list. The gain list parallels the channel list. (The two lists together are often referred to as the channel-gain list.)

For example, assume the analog input channel list contains three entries: channels 5, 6, and 7; the gain list might look like this: 2, 4, 1, where a gain of 2 corresponds to channel 5, a gain of 4 corresponds to channel 6, and a gain of 1 corresponds to channel 7.

A/D sample clock sources

KPCI-3110 and KPCI-3116 boards provide two clock sources for pacing analog input operations in continuous mode:

- An internal A/D sample clock that uses the 24-bit A/D counter on the board
- An external A/D sample clock that you can connect to the screw terminal panel

The A/D sample clock paces the acquisition of each channel in the channel-gain list. This clock is also called the A/D pacer clock.

NOTE *If you specify Digital Capabilities for channel 0 in the channel-gain list, the A/D sample clock (internal or external) also paces the acquisition of the 16 digital input lines. Refer to the* DriverLINX Analog I/O Programming Guide *provided with DriverLINX.*

The following subsections describe the internal and external A/D sample clocks in more detail.

Internal A/D sample clock

The internal A/D sample clock uses a 20MHz time base. Conversions start on the falling edge of the counter output; the output pulse is active low.

Using software, specify the clock source as internal and the clock frequency at which to pace the operation. The minimum frequency supported is 1.2Hz (1.2 Samples/s). For the KPCI-3110 boards, the maximum frequency supported is 1.25MHz (1.25 MSamples/s). For the KPCI-3116 board, the maximum frequency supported is 250kHz (250 kSamples/s).

According to sampling theory (Nyquist Theorem), specify a frequency that is at least twice as fast as the input's highest frequency component. For example, to accurately sample a 20kHz signal, specify a sampling frequency of at least 40kHz. Doing so avoids an error condition called *aliasing*, in which high frequency input components erroneously appear as lower frequencies after sampling.

NOTE *You can access the output signal from the A/D sample clock using screw terminal 79 on the STP-3110 screw terminal panel (pin 4 on connector J2).*

External A/D sample clock

The external A/D sample clock is useful when you want to pace acquisitions at rates not available with the internal A/D sample clock or when you want to pace at uneven intervals.

Connect an external A/D sample clock to screw terminal 76 on the STP-3110 screw terminal panel (pin 7 on connector J2). Conversions start on the falling edge of the external A/D sample clock input signal.

Using DriverLINX, specify the clock source as external (refer to *DriverLINX Analog I/O Programming Guide* furnished with DriverLINX). For KPCI-3110 and KPCI-3116 boards, the clock frequency is always equal to the frequency of the external A/D sample clock input signal that you connect to the board through the screw terminal panel.

Analog input conversion modes

KPCI-3110 and KPCI-3116 boards support the following conversion modes:

- **Single value polled operations** are the simplest to use but offer the least flexibility and efficiency. Use software to specify the range, gain, and analog input channel (among other parameters); acquire the data from that channel; and convert the result. The data is returned immediately. For a single value operation, you cannot specify a clock source, trigger source, trigger acquisition mode, scan mode, or buffer.

  Single value operations stop automatically when finished; you cannot stop a single value operation.
- **Scan mode** takes full advantage of the capabilities of the KPCI-3110 and KPCI-3116 boards. In a scan, you can specify a channel-gain list, clock source, trigger source, trigger acquisition mode, buffering, and timing. Refer to "Using DriverLINX with Your Hardware: KPCI-3100 Series" for details on specifying these parameters.

  Using DriverLINX software, you can stop a scan when the hardware fills the host buffer you specified or when your application issues a stop command.

Continuously-paced scan mode (rate generation: internal clock)

Use continuously-paced scan mode if you want to accurately control the period between conversions of individual channels in a scan.

When it detects an initial trigger, the board cycles through the channel-gain list, acquiring and converting the value for each entry in the channel list. This process is defined as the scan. The board then wraps to the start of the channel-gain list and repeats the process continuously until either the specified samples are taken or you stop the operation. Refer to page 2-15 for more information on buffers.

The conversion rate is determined by the frequency of the A/D sample clock. Refer to page 2-6 for more information on the A/D sample clock. The sample rate, which is the rate at which a single entry in the channel-gain list is sampled, is determined by the frequency of the A/D sample clock divided by the number of entries in the channel-gain list.

NOTE *An A/D Trigger Out signal is provided for your use. This signal is high when the A/D subsystem is waiting for a trigger and low when a trigger occurs. In continuously-paced scan mode, this signal goes low when the trigger occurs and stays low until you stop the operation.*

Triggered scan mode

KPCI-3110 and KPCI-3116 boards support two triggered scan (burst) modes: internally-clocked and externally-clocked. These modes are described in the following subsections.

Internally-retriggered scan mode (internal clock: burst mode)

Use internally-retriggered scan mode if you want to accurately control both the period between conversions of individual channels in a scan and the period between each scan. This mode is useful when synchronizing or controlling external equipment, or when acquiring a buffer of data on each trigger or retrigger. Using this mode, you can acquire up to 262,144 samples per trigger (256 times per trigger x 1024-location channel-gain list).

When it detects an initial trigger, the board scans the channel-gain list a specified number of times (up to 256), then waits for an internal retrigger to occur. When the board detects an internal retrigger, the board scans the channel-gain list the specified number of times, then waits for another internal retrigger to occur. The process repeats continuously until either the specified samples are taken or you stop the operation.

The sample rate is determined by the frequency of the A/D sample clock divided by the number of entries in the channel-gain list. Refer to page 2-6 for more information on the A/D sample clock. The conversion rate of each scan is determined by the frequency of the internal retrigger clock. The internal retrigger clock is the Triggered Scan Counter, a 24-bit counter with a 20MHz clock located on the board.

Using DriverLINX software, specify the frequency of the internal retrigger clock. The minimum retrigger frequency is 1.2Hz. For KPCI-3110 boards, the maximum retrigger frequency is 357.14kHz (357.14 kSamples/s); for KPCI-3116 boards, the maximum retrigger frequency is 166.67kHz (166.666 kSamples/s).

Specify the *retrigger frequency* as follows:

$$\text{Min. Retrigger Period} = \left(\frac{\text{No. of CGL entries} \times \text{No. of CGLs per trigger}}{\text{A/D sample clock frequency}} + 2\mu s\right)$$

$$\text{Max. Retrigger} = \frac{1}{\text{Frequency Min. Retrigger Period}}$$

For example, if you are using 512 channels in the channel-gain list (CGL), scanning the channel-gain list 256 times every trigger or retrigger, and using an A/D sample clock with a frequency of 1MHz, set the maximum retrigger frequency to 7.62Hz, since:

$$7.62\text{Hz} = \frac{1}{\left(\frac{(512 \times 256)}{\text{MHz}} + 2\mu s\right)}$$

To select internally-retriggered scan mode, use software to specify the following parameters:

- The dataflow as continuous, continuous pre-trigger, or continuous about-trigger.
- Triggered scan mode usage as enabled.
- The retrigger mode as internal.
- The number of times to scan per trigger or retrigger (also called the multiscan count).
- The frequency of the retrigger clock.

The initial trigger source depends on the trigger acquisition mode selected. Refer to page 2-10 for more information on the supported trigger acquisition modes and trigger sources.

NOTE *An A/D Trigger Out signal is provided for your use. This signal is high when the A/D subsystem is waiting for a trigger and low when a trigger occurs. In internally-retriggered scan mode, this signal stays low until the desired number of samples have been acquired, then goes high until the internal retrigger is generated.*

Externally-retriggered scan mode (external clock: burst mode)

Use externally-retriggered scan mode if you want to accurately control the period between conversions of individual channels and retrigger the scan based on an external event. Like internally-retriggered scan mode, this mode allows you to acquire 262,144 samples per trigger (256 times per trigger x 1024-location channel-gain list).

NOTE *Use externally-retriggered scan mode with continuous post-trigger acquisitions only. Refer to page 2-11 for more information on post-trigger acquisitions.*

When a KPCI-3110 or KPCI-3116 board detects an initial trigger (post-trigger source only), the board scans the channel-gain list up to 256 times, then waits for an external retrigger to occur. Specify any supported post-trigger source as the initial trigger. For the retrigger, specify either an external digital (TTL) trigger or an external analog threshold trigger.

When the retrigger occurs, the board scans the channel-gain list the specified number of times, then waits for another external retrigger to occur. The process repeats continuously until either the allocated buffers are filled or you stop the operation. Refer to page 2-15 for more information on buffers.

The conversion rate of each channel is determined by the frequency of the A/D sample clock. Refer to page 2-6 for more information on the A/D sample clock. The conversion rate of each scan is determined by the period between external retriggers; therefore, it cannot be accurately controlled. The board ignores external triggers that occur while it is acquiring data. Only external retrigger events that occur when the board is waiting for a retrigger are detected and acted on.

To select externally-retriggered scan mode, use software to specify the following parameters:

- The dataflow as continuous (post-trigger).
- Triggered scan mode as enabled.
- The retrigger mode as an external retrigger.
- The number of times to scan per trigger or retrigger (also called the multiscan count).
- The retrigger source as the external digital (TTL) trigger or an external analog threshold trigger.

Triggers

A trigger is an event that occurs based on a specified set of conditions. KPCI-3110 and KPCI-3116 boards support a number of trigger sources and trigger acquisition modes, described in the following subsections.

Trigger sources

KPCI-3110 and KPCI-3116 boards support the following trigger sources:

- Software trigger
- External digital (TTL) trigger
- Analog threshold trigger

This subsection describes these trigger sources in more detail.

Software trigger

A software trigger event occurs when you start the analog input operation (the computer issues a write to the board to begin conversions). Specify the software trigger source in software.

External digital (TTL) trigger

For analog input operations, an external digital trigger event occurs when the KPCI-3110 or KPCI-3116 board detects either a rising or falling edge on the external A/D TTL trigger input signal connected to screw terminal 77 on the STP-3110 screw terminal panel (pin 6 of connector J2). The trigger signal is TTL-compatible.

Using software, specify the trigger source as a rising-edge external digital trigger or a falling-edge external digital trigger.

Analog threshold trigger

For analog input operations, an analog trigger event occurs when the KPCI-3110 or KPCI-3116 detects a transition from above a threshold level to below a threshold level (falling edge), or a transition from below a threshold level to above a threshold level (rising edge). The following analog threshold trigger sources are available:

- **External Analog Trigger input signal** is connected to screw terminal TB107 (Analog Trigger) on the STP-3110 screw terminal panel (pin 34 on connector J2). Using software, perform the following steps to configure a scan triggered by an external analog trigger input signal:

1. Specify the trigger source as either a rising-edge or falling-edge analog threshold trigger.
2. Specify channel 0 as the trigger channel. To distinguish this channel from analog input channel 0, set the special gain code of &H8000 to indicate the use of the dedicated Analog Trigger line.

When channel 0 is scanned, the analog trigger signal at TB107 is detected to start the acquisition process.

- **One of the analog input channels** after gain is applied (also called the output of the programmable gain amplifier (PGA). Using software, specify the trigger source as either a positive threshold trigger or negative threshold trigger.

Using DriverLINX software, specify the analog input channel used as the analog threshold trigger as the first channel in the channel list; refer to page 2-3 for more information.

On KPCI-3110 and KPCI-3116 boards, the threshold level is set using a dedicated 8-bit DAC; the hysteresis is fixed at 50mV. Using software, program the threshold level by writing a voltage value to this DAC; this value can range from −10V to +10V.

NOTE *If you are using an analog threshold trigger to trigger both the A/D and the D/A subsystems, ensure that you use the same analog trigger type for both subsystems (either external or one of the analog input channels).*

Trigger acquisition modes

KPCI-3110 and KPCI-3116 boards can acquire data in post-trigger mode, pre-trigger mode, or about-trigger mode. These trigger acquisition modes are described in more detail in the following subsections.

Post-trigger acquisition

Use post-trigger acquisition mode (continuous mode) when you want to acquire data when a post-trigger or retrigger, if using triggered scan mode, occurs.

Using DriverLINX software, specify the following parameters:

- The dataflow as continuous.
- The trigger source to start the post-trigger acquisition (the post-trigger source) as any of the supported trigger sources.

Refer to page 2-7 for more information on the supported conversion modes. Refer to page 2-10 for information on the supported trigger sources.

Post-trigger acquisition starts when the board detects the post-trigger event and stops when the specified number of post-trigger samples has been acquired, or when you stop the operation.

If you are using triggered scan mode, the board continues to acquire post-trigger data using the specified retrigger source to clock the operation. Refer to page 2-8 for more information on triggered scan mode.

Figure 2-3 illustrates continuous post-trigger mode using a channel-gain list with three entries: channel 0, channel 1, and channel 2. Triggered scan mode is disabled. In this example, post-trigger analog input data is acquired on each clock pulse of the A/D sample clock. The board wraps to the beginning of the channel-gain list and repeats continuously (continuously-paced scan mode).

Figure 2-3
Continuous post-trigger mode without triggered scan

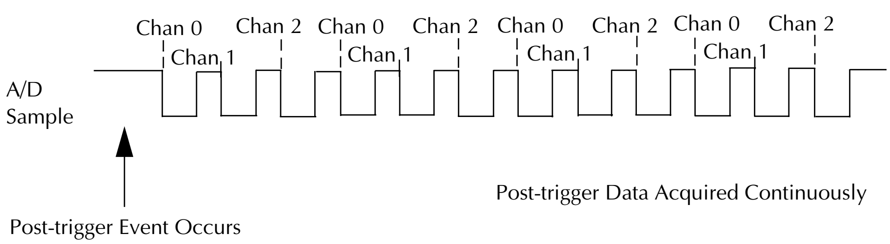
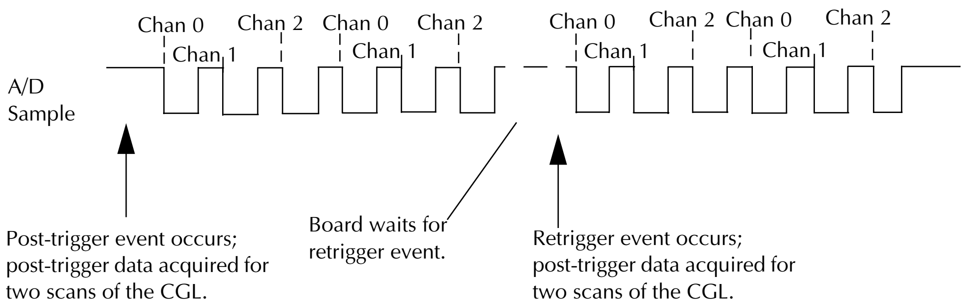


Figure 2-4 illustrates the same example using triggered scan mode (either internally- or externally-retriggered). The multiscan count is 2 indicating that the channel-gain list will be scanned twice per trigger or retrigger. In this example, post-trigger analog input data is acquired on each clock pulse of the A/D sample clock until the channel-gain list has been scanned twice; then, the board waits for the retrigger event. When the retrigger event occurs, the board scans the channel-gain list twice more, acquiring data on each pulse of the A/D sample clock. The process repeats continuously with every specified retrigger event.

Figure 2-4
Continuous post-trigger mode with triggered scan



Pre-trigger Acquisition

Use pre-trigger acquisition mode (continuous pre-trigger mode) when you want to acquire data before a specific external event occurs.

Using software, specify the following parameters:

- The dataflow as continuous pre-trigger
- The pre-trigger source as the software trigger
- The post-trigger source as the external digital (TTL) trigger or the external analog threshold trigger
- If you are using triggered scan mode, the retrigger mode as the internal retrigger

Refer to page 2-7 for more information on the supported conversion modes. Refer to page 2-10 for information on the supported trigger sources.

When using pre-trigger acquisition, you cannot use an external retrigger in triggered scan mode. Refer to page 2-8 for more information on triggered scan mode.

Pre-trigger acquisition starts when you start the operation and stops when the board detects the selected post-trigger source, indicating that the first post-trigger sample was acquired (this sample is ignored).

If you are using internally-retriggered scan mode and the post-trigger event has not occurred, the board continues to acquire pre-trigger data using the internal retrigger clock to clock the operation. When the post-trigger event occurs, the operation stops. Refer to page 2-8 for more information on internally-retriggered scan mode.

Figure 2-5 illustrates continuous pre-trigger mode using a channel-gain list of three entries: channel 0, channel 1, and channel 2. In this example, pre-trigger analog input data is acquired on each clock pulse of the A/D sample clock. The board wraps to the beginning of the channel-gain list and the acquisition repeats continuously until the post-trigger event occurs. When the post-trigger event occurs, acquisition stops.

Figure 2-5
Continuous pre-trigger mode

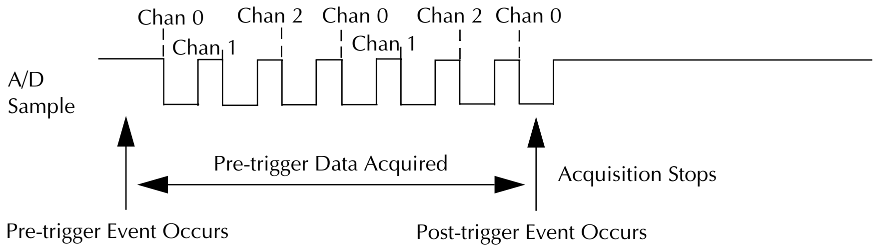
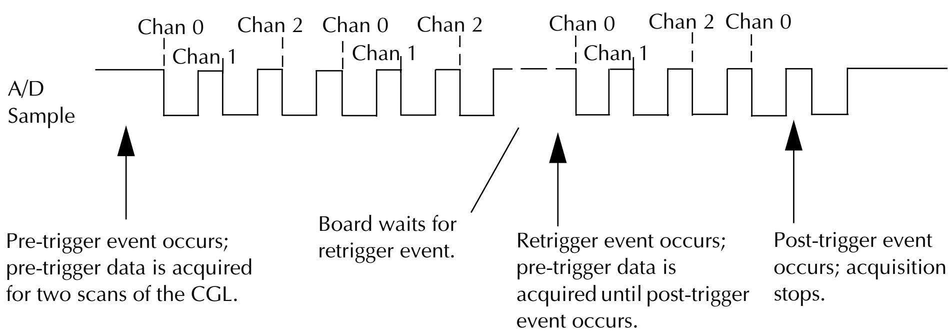


Figure 2-6 illustrates the same example using internally-retriggered triggered scan mode. The multiscan count is 2 indicating that the channel-gain list will be scanned twice per trigger or retrigger. In this example, pre-trigger analog input data is acquired on each clock pulse of the A/D sample clock until the channel-gain list has been scanned twice; then, the board waits for the internal retrigger event. When the internal retrigger occurs, the process repeats. The process stops when the post-trigger event occurs.

Figure 2-6
Continuous pre-trigger mode with triggered scan



About-trigger acquisition

Use about-trigger acquisition mode (continuous about-trigger mode) when you want to acquire data both before and after a specific external event occurs. This operation is equivalent to doing both a pre-trigger and a post-trigger acquisition.

Using software, specify the following parameters:

- The dataflow as continuous about-trigger
- The pre-trigger source as the software trigger
- The post-trigger source as the external digital (TTL) trigger or the external analog threshold trigger
- If you are using triggered scan mode, the retrigger mode as the internal retrigger

Refer to page 2-7 for more information on the supported conversion modes. Refer to page 2-10 for information on the supported trigger sources.

When using about-trigger acquisition, you cannot use an external retrigger in triggered scan mode. Refer to page 2-8 for more information on triggered scan mode.

The about-trigger acquisition starts when you start the operation. When the board detects the selected post-trigger event, the board stops acquiring pre-trigger data and starts acquiring post-trigger data.

If you are using internally-retriggered scan mode and the post-trigger event has not occurred, the board continues to acquire pre-trigger data using the internal retrigger clock to clock the operation. If, however, the post-trigger event has occurred, the board continues to acquire post-trigger data using the internal retrigger clock to clock the operation.

The about-trigger operation stops when the specified number of post-trigger samples has been acquired, or when you stop the operation. Refer to page 2-8 for more information on internally-retriggered scan mode.

Figure 2-7 illustrates continuous about-trigger mode using a channel list of two entries: channel 0 and channel 1. In this example, pre-trigger analog input data is acquired on each clock pulse of the A/D sample clock, scanning the channel list continuously, until the post-trigger event occurs. When the post-trigger event occurs, post-trigger analog input data is acquired continuously on each clock pulse of the A/D sample clock.

Figure 2-7
Continuous about-trigger mode

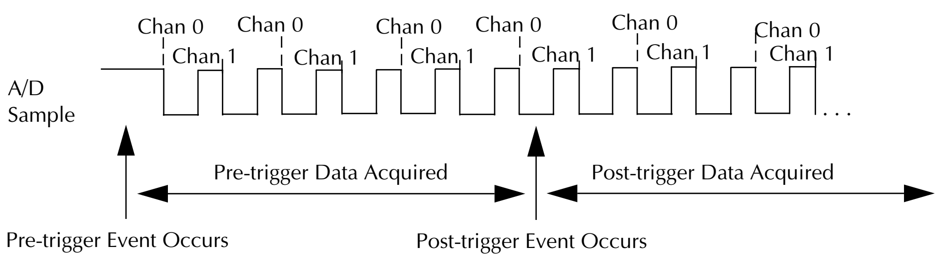
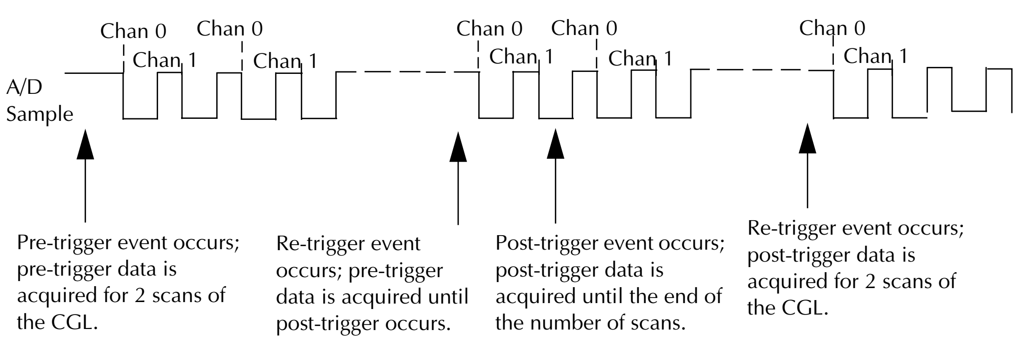


Figure 2-8 illustrates the same example using internally-retriggered triggered scan mode. The multiscan count is 2 indicating that the channel-gain list will be scanned twice per trigger or retrigger. In this example, pre-trigger analog input data is acquired on each clock pulse of the A/D sample clock for two scans; then, the board waits for the internal retrigger event. When the internal retrigger occurs, the board begins acquiring pre-trigger data until the post-trigger event occurs. Then, the board finishes scanning the channel-gain list the specified number of times, but acquires the data as post-trigger samples. On all subsequent internal retriggers, post-trigger data is acquired.

Figure 2-8
Continuous about-trigger mode with triggered scan



Data format and transfer

KPCI-3110 and KPCI-3116 boards use offset binary data encoding to represent signals. In DriverLINX software, the analog input value is returned as a code or voltage depending on user input. DriverLINX provides single-value and buffer methods to convert between voltages and analog codes. The single-value functions are Volts2Code and Code2Volts. Refer to DriverLINX manuals provided with DriverLINX for more information.

To represent unipolar signals, KPCI-3110 and KPCI-3116 boards use straight binary data encoding, such as 000 (for 12-bit boards) or 0000 (for 16-bit boards) to represent 0V, and FFFh (for 12-bit boards) or FFFFh (for 16-bit boards) to represent full-scale. To represent bipolar signals, KPCI-3110 and KPCI-3116 boards use offset binary data encoding, such as 000 (for 12-bit boards) or 0000 (for 16-bit boards) to represent negative full-scale, and FFFh (for 12-bit boards) or FFFFh (for 16-bit boards) to represent positive full-scale. Use software to specify the data encoding as binary.

DriverLINX transfers data to the controlling (your program) application in buffers that the application has allocated. The size and number of buffers that your application should allocate is a function of Windows' message processing and the type of stop event you have specified.

Guidance on specifying buffers

If using 'Stop on terminal count,' data transfer stops automatically after the specified buffer is filled. Only a single buffer of adequate length is needed.

If using 'Stop on trigger' (analog or digital) or 'Stop on command,' the data transfer will continue indefinitely until the stop condition occurs, with buffers being used and reused to keep up with incoming transfers. In this case, allocate enough buffers for one second's worth of data, plus two extras to provide a margin for recycling of used buffers. (The total number of buffers available should equal [(Sampling Frequency / Buffer Size) + 2].)

A Windows message will be sent each time a buffer is filled. For example, at a rate of 100Hz and a buffer of 100 samples, a buffer filled message will be sent once per second. A buffer message rate in the range of 1 – 10 per second is recommended to avoid overloading Windows with too many messages.

Error conditions

KPCI-3110 and KPCI-3116 boards can report the following analog input error conditions to the host computer:

- **A/D Over Sample** — Indicates that the A/D sample clock rate is too fast. This error is reported if a new A/D sample clock pulse occurs while the ADC is busy performing a conversion from the previous A/D sample clock pulse. The host computer can clear this error. To avoid this error, use a slower sampling rate.
- **Input FIFO Overflow** — Indicates that the analog input data is not being transferred fast enough from the Input FIFO across the PCI bus to the host computer. This error is reported when the Input FIFO becomes full; the board cannot get access to the PCI bus fast enough. The host computer can clear this error, but the error will continue to be generated if the Input FIFO is still full. To avoid this error, close other applications that may be running while you are acquiring data. Also check if bus mastering is evaluated in B105. If this has no effect, try using a computer with a faster processor or reduce the sampling rate.
- **Host Block Overflow** — Indicates that the host computer is not handling data from the board fast enough. This error is reported if the board completes the transfer of a block of input data to the circular buffer in the host computer before the host computer has finished reading the last block of data.

If any of these error conditions occurs, the board stops acquiring and transferring data to the host computer.

NOTE *DriverLINX reports any of these errors as a "DATA LOST" message.*

Analog output features

Two analog output (D/A) subsystems are provided on KPCI-3110 and KPCI-3116 boards. The first D/A subsystem contains the majority of analog output features. The second is dedicated to threshold triggering only (refer to page 2-18 for information on analog threshold triggering).

This section describes the following features of the first D/A subsystem:

- Analog output resolution
- Analog output channels
- Output ranges and gains
- Output filters
- D/A output clock sources
- Trigger sources
- Analog output conversion modes
- Data formats and transfer
- Error conditions

Analog output resolution

KPCI-3110 boards have a fixed analog output resolution of 12 bits. The KPCI-3116 boards have a fixed analog output resolution of 16 bits. The analog output resolution cannot be changed in software.

Analog output channels

KPCI-3110 and KPCI-3116 boards support two differential analog output channels (DAC0 and DAC1). Refer to Section 3 for information on how to wire analog output signals to the board using the screw terminal panel.

Within each DAC, the digital data is double buffered to prevent spurious outputs, then output as an analog signal. Both DACs power up to a value of 0V ±10mV. Note that resetting the board does not clear the values in the DACs.

KPCI-3110 and KPCI-3116 boards can output data from a single analog output channel or from two analog output channels. The following subsections describe how to specify the channels.

Specifying a single channel

The simplest way to output data to a single analog output channel is to specify the channel for a single value analog output operation using software; refer to page 2-19 for more information on single value operations.

You can also specify a single analog output channel using an analog output channel list, described in the next section.

Specifying one or more channels

You can specify one or two analog output channels in the analog output channel list, either starting with DAC 0 or with DAC 1.

Values are output simultaneously to the entries in the channel list.

Output filters

On the KPCI-3116 board only, each DAC supports a software-selectable, single-pole, filter of 20kHz. Specifying a 20kHz filter is useful if you want to smooth the output values of the DAC.

On power-up or reset, no filter is used. *Refer to DriverLINX manuals for more information on filters.*

Output ranges and gains

Each DAC on the KPCI-3110 or KPCI-3116 board can output bipolar analog output signals in the range of ±10V.

In DriverLINX software, specify a gain of -1 for bipolar analog output operations. This sets both range and gain.

If you are using an analog output channel list, the subsystem defaults to a gain of 1 for each channel; therefore, you do not have to specify the gain.

D/A output clock sources

KPCI-3110 and KPCI-3116 boards provide two clock sources for pacing the output of each channel in the analog output channel-gain list:

- An internal D/A output clock that uses the 24-bit D/A Counter on the board.
- An external D/A output clock that you can connect to the screw terminal panel

The following subsections describe the internal and external D/A output clocks in more detail.

Internal D/A output clock

The internal D/A output clock uses a 20MHz time base. Conversions start on the falling edge of the counter output; the output pulse is active low.

Through software, specify the clock source as internal and the clock frequency at which to pace the analog output operation. The minimum frequency supported is 1.2Hz (1.2 Samples/s). For KPCI-3110 boards, the maximum frequency supported is 500kHz (500 kSamples/s). For KPCI-3116 boards, the maximum frequency supported is 200kHz (200 kSamples/s). See page 2-19 for more information on these conversion modes.

External D/A output clock

The external D/A output clock is useful when you want to pace analog output operations at rates not available with the internal D/A output clock, if you want to pace at uneven intervals, or if you want to start pacing when an external event occurs.

Connect an external D/A output clock to screw terminal 74 on the STP-3110 screw terminal panel (pin 9 on connector J2). Conversions start on the falling edge of the external D/A output clock signal.

Using software, specify the clock source as external. For KPCI-3110 and KPCI-3116 boards, the clock frequency is always equal to the frequency of the external D/A output clock input signal that you connect to the board through the screw terminal panel.

Trigger sources

A trigger is an event that occurs based on a specified set of conditions. KPCI-3110 and KPCI-3116 boards support the following trigger sources for analog output operations:

- Software trigger
- External digital (TTL) trigger
- Analog threshold trigger

This subsection describes these trigger sources in more detail.

Software trigger

A software trigger event occurs when you start the analog output operation (the computer issues a write to the board to begin conversions). Specify the software trigger source in software.

External digital (TTL) trigger

For analog output operations, an external digital trigger event occurs when the KPCI-3110 or KPCI-3116 board detects either a rising or falling edge on the External D/A TTL Trigger input signal connected to screw terminal 75 on the STP-3110 screw terminal panel (pin 8 on connector J2). The trigger signal is TTL-compatible.

Using software, specify the trigger source as either a rising-edge external digital trigger or falling-edge external digital trigger.

Analog threshold trigger

For analog output operations, an analog trigger event occurs when the KPCI-3110 or KPCI-3116 board detects a transition from above a threshold level to below a threshold level (falling edge), or a transition from below a threshold level to above a threshold level (rising edge). The following analog threshold trigger sources are available:

- **External Analog Trigger input signal** connected to screw terminal 104 on the STP-3110 screw terminal panel (pin 34 on connector J2). Using software, specify the trigger source as either a rising-edge or falling-edge analog threshold trigger.
- **One of the analog input channels** after gain is applied. Using software, specify the trigger source as either a positive threshold trigger or a negative threshold trigger.

Using software, specify the analog input channel used as the analog threshold trigger as the first channel in the analog input channel list; refer to page 2-3 for more information.

On KPCI-3110 and KPCI-3116 boards, the threshold level is set using a dedicated 8-bit DAC (the second analog output subsystem); the hysteresis is fixed at 50mV. Using software, program the threshold level by writing a voltage value to the DAC of the second analog output subsystem; this value can range from −10V to +10V.

NOTE *If you are using an analog threshold trigger to trigger both the A/D and the D/A subsystems, ensure that you use the same analog trigger type for both subsystems (either external or one of the analog input channels).*

Analog output conversion modes

KPCI-3110 and KPCI-3116 boards support the following conversion modes:

- **Single value (polled) operations** are the simplest to use but offer the least flexibility and efficiency. Use software to specify the range, gain, and analog output channel (among other parameters), and output the data from that channel. For a single value operation, you cannot specify a clock source, trigger source, or buffer.

  Single value operations stop automatically when finished; you cannot stop a single value operation.
- **Continuous analog output operations** take full advantage of the capabilities of the KPCI-3110 and KPCI-3116 boards. In this mode, you can specify an analog output channel-gain list, clock source, trigger source, buffer, and buffer wrap mode. Two continuous analog output operations are supported: continuously-paced and waveform generation mode. These modes are described in the following subsections.

  Using DriverLINX software, you can stop a scan when the hardware fills the host buffer you specified or when your application issues a stop command.

Continuously-paced analog output

Use continuously-paced analog output mode if you want to accurately control the period between conversions of individual analog output channels in the analog output channel list.

The host computer transfers digital values to write to the DACs from allocated circular buffers in computer memory to the Output FIFO on the board. KPCI-3110 and KPCI-3116 boards have a 4 kSample Output FIFO. Use software to allocate the number of buffers and to specify the values.

When it detects a trigger, the board outputs the values in the Output FIFO to the DACs at the same time. Even samples (0, 2, 4, and so on) are written to entry 0 in the channel list; odd samples (1, 3, 5, and so on) are written to entry 1 in the channel list. The operation repeats continuously until either all the data is output from the buffers (if buffer wrap mode is none) or if you stop the operation (if buffer wrap mode is multiple). Refer to page 2-20 for more information on buffers.

Ensure that the host computer transfers data to the Output FIFO fast enough so that the Output FIFO does not empty completely; otherwise, an Output FIFO Underrun error results. Note that the Output FIFO Counter increments each time the host loads a value into the Output FIFO and decrements each time the DAC reads a value from the Output FIFO; the counter is reset to 0 when the Output FIFO is reset. To avoid the Output FIFO Underrun error in continuously-paced mode, the host computer can read the Output FIFO Counter to determine how many samples remain in the Output FIFO, and transfer more data before the Output FIFO empties.

The conversion rate is determined by the frequency of the D/A output clock. For KPCI-3110 boards, the maximum throughput rate in this mode is 500 (500 kSamples/s) in 100mV steps. For KPCI-3116 boards, the maximum throughput rate in this mode is 200kHz (200 kSamples/s) in 100mV steps. Note that rate is system dependent. Refer to page 2-17 for more information on the D/A output clock.

Waveform generation

Use waveform generation mode if you want to output waveforms repetitively.

Before this process can begin, the host computer must transfer the entire waveform pattern to output to the DACs from computer memory into the Output FIFO on the board.

For the KPCI-3110 and KPCI-3116 boards, if you are using a single DAC, the waveform pattern can range from 2 to 4,096 samples. If you are using two DACs, the waveform pattern can range from 2 to 2,048 samples.

When it detects a trigger, the board cycles through the analog output channel-gain list, converting and outputting the specified waveform for the specified DACs. When the Output FIFO empties, the board issues a retransmit pulse to the Output FIFO. This allows the board to output the same pattern continuously to the DACs without having to reload the Output FIFOs. Refer to page 2-20 for more information on buffers.

The conversion rate is determined by the frequency of the D/A output clock. For KPCI-3110 boards, the maximum throughput rate in this mode is 500kHz (500 kSamples/s) in 100mV steps. For the KPCI-3116 boards, the maximum throughput rate in this mode is 200kHz (200 kSamples/s) in 100mV steps. Refer to page 2-17 for more information on the D/A output clock.

To select waveform generation mode, refer to the "Using DriverLinx with your hardware: KPCI-3100 Series" manual.

Data format and transfer

Data from the host computer must use offset binary data encoding for analog output signals. DriverLINX converts this "native format" to a hardware-independent format so that applications can use the numeric operations that are intrinsic to most high-level languages. A DriverLINX Service Request may be used for several types of data conversion (such as VOLTS2CODE conversion that converts analog voltage to D/A code). Because the data values depend on the selected gain at the time of the data transfer, you should use DriverLINX to convert the data, as it takes the gain properties of the Service Request into account.

NOTE *Refer to the DriverLINX Analog I/O Programming Guide and the "Using DriverlINX with your Hardware" manuals furnished with DriverLINX.*

Error conditions

KPCI-3110 and KPCI-3116 boards can report an Output FIFO Underflow error to the host computer. This error indicates that the analog output data was not being transferred fast enough across the PCI bus from the host computer to the Output FIFO on the board.

If the D/A output clock occurs while the Output FIFO is empty, an error is not reported since the most likely cause is that the host computer has no more data to output. In this case, the last value received from the host computer is output by the specified DACs continuously until the board is powered down or new data becomes available. If, however, the host does an additional write to the Output FIFO (after the D/A output clock occurred while the Output FIFO was empty), the data is written to the DACs and the Output FIFO Underflow error is reported. This error has no effect on board operation; the host computer can clear this error.

To avoid this error, ensure that the host computer provides data to the Output FIFO faster than the DACs are converting the data. You can read the value of the Output FIFO Counter to determine how many samples are in the Output FIFO.

If this error condition occurs, the board stops acquiring and transferring data to the host computer.

NOTE *DriverLINX reports this error as a "DATA LOST" message.*

Digital I/O features

This section describes the following features of the digital I/O subsystem:

- Digital I/O lines
- Digital I/O resolution
- Digital I/O operation modes

Digital I/O lines

KPCI-3110 and KPCI-3116 boards support 16 digital I/O lines through the digital input (DIN) and output (DOUT) subsystems; both subsystems use the same digital I/O lines. These lines are divided into two banks of eight: Bank A, lines 0 to 7; and Bank B, lines 0 to 7. You can use each bank as either an input port or an output port; all eight lines within a bank have the same configuration. For example, if you use Bank A as an input port (port 0), lines 0 to 7 of Bank A are configured as inputs. Likewise, if you use Bank B as an output port (port 1), lines 0 to 7 of Bank B are configured as outputs.

Specify the digital I/O line to read or write in a single value digital I/O operation. Refer to page 2-22 for more information on single value operations.

On power up or reset, no digital data is output from the board.

DriverLINX lets you dynamically reconfigure digital I/O ports at run time using a "Digital Setup Event." Refer to *DriverLINX Digital I/O Programming Guide* for information and limitations of this function.

Digital I/O operation modes

DriverLINX uses the Digital I/O Subsystem for single value outputs. For continuous digital input, DriverLINX uses the Analog I/O subsystem (see "Specifying digital input lines in the analog input channel list" on page 2-4. Single value operations stop automatically when finished; you cannot stop a single value operation

- **Continuous digital input** takes full advantage of the capabilities of the KPCI-3110 or KPCI-3116 board. Program the digital input lines as Analog Input Channel 0; enter the inputs through the DriverLINX A/D subsystem. You will assign a special gain code to this channel to distinguish it as digital. You can specify parameters such as clock source, scan mode, and trigger source for the digital input operation. Refer to page 2-4 for more information on specifying digital input lines for a continuous digital input operation. Refer to *DriverLINX Analog I/O Programming Guide* and *Using DriverLINX with your Hardware* manuals that accompany DriverLINX.
- **Dynamic digital output** is useful for synchronizing and controlling external equipment and allows you to output data to two dynamic digital output lines each time an analog input value is acquired. This mode is programmed through the A/D subsystem; refer to page 2-4 for more information.

NOTE *Expansion accessories use some of the dynamic digital output signals. Therefore, you cannot use this feature and an expansion channel in the same task.*

Counter/timer features

The counter/timer circuitry on the board provides the clocking circuitry used by the A/D and D/A subsystems as well as several user counter/timer features. This section describes the following user counter/timer features:

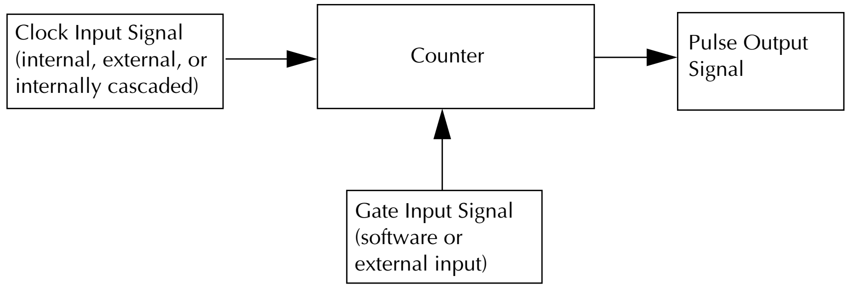
- Units
- C/T clock sources
- Gate types
- Pulse types and duty cycles
- Counter/timer operation modes

Units

KPCI-3110 and KPCI-3116 boards support four user 16-bit counter/timer units (called counters); counters are numbered 0, 1, 2, and 3.

Each counter accepts a clock input signal and gate input signal and outputs a clock output signal (also called a pulse output signal), as shown in Figure 2-9.

Figure 2-9
Counter/timer channel



C/T clock sources

The following clock sources are available for the user counters:

- Internal C/T clock
- External C/T clock
- Internally cascaded clock

Refer to the following subsections for more information on these clock sources.

Internal C/T clock

The internal C/T clock uses a 20MHz time base. Counter/timer operations start on the rising edge of the clock input signal.

Through software, specify the clock source as internal and the frequency at which to pace the counter/timer operation (this is the frequency of the clock output signal). The maximum frequency that you can specify for the clock output signal is 10MHz. The minimum frequency that you can specify for the clock output signal is 305.18Hz.

External C/T clock

The external C/T clock is useful when you want to pace counter/timer operations at rates not available with the internal C/T clock or if you want to pace at uneven intervals. The rising edge of the external C/T clock input signal is the active edge.

Using DriverLINX, specify the clock source as external and the clock divider used to determine the frequency at which to pace the operation (this is the frequency of the clock output signal). The minimum clock divider that you can specify is 2.0; the maximum clock divider that you can specify is 65,536. For example, if you supply an external C/T clock with a frequency of 5MHz and specify a clock divider of 5, the resulting frequency of the external C/T clock output signal is 1MHz. The resulting frequency of the external C/T clock output signal must not exceed 2.5MHz.

Connect the external C/T clock to the board through the STP-3110 screw terminal panel. Table 2-2 lists the screw terminals that correspond to the external C/T clock signals of each counter/timer.

Table 2-2
External C/T clock signals

Counter/Timer	Screw Terminal on STP-3110	Pin on Connector J2
0	TB58	17
1	TB62	15
2	TB66	13
3	TB70	11

Internally cascaded clock

You can also internally route the clock output signal from one user counter to the clock input signal of the next user counter to internally cascade the counters. In this way, you can create a 32-bit counter without externally connecting two counters together. KPCI-3110 and KPCI-3116 boards support software cascading on counters 0 and 1, 1 and 2, and 2 and 3.

Specify internal cascade mode in software. The rising edge of the clock input signal is active.

To specify internal cascading, use DriverLINX software to set the internal cascade mode, then specify the clock input and gate input for the first counter in the cascaded pair. Specify the clock source of the second counter as C/T_{N-1}. The clock output signal from the first counter is the clock input signal of the second counter. For example, if counters 1 and 2 are cascaded, specify the clock input and gate input for counter 1.

The maximum frequency that you can specify for the clock output signal is 10MHz. For a 32-bit cascaded counter, the minimum frequency that you can specify for the clock output signal is 0.00465Hz, which corresponds to a rate of once every 215 seconds.

Gate types

The active edge or level of the gate input to the counter enables counter/timer operations. The operation starts when the clock input signal is received. KPCI-3110 and KPCI-3116 boards provide the following gate input types:

- **None** — A software command enables any specified counter/timer operation immediately after execution. This gate type is useful for all counter/timer modes.
- **Logic-low level external gate input** — Enables a counter/timer operation when the external gate signal is low, and disables the counter/timer operation when the external gate signal is high. Note that this gate type is used only for event counting, frequency measurement, and rate generation; refer to page 2-26 for more information on these modes.
- **Logic-high level external gate input** — Enables a counter/timer operation when the external gate signal is high, and disables a counter/timer operation when the external gate signal is low. Note that this gate type is used only for event counting, frequency measurement, and rate generation; refer to page 2-26 for more information on these modes.
- **Falling-edge external gate input** — Enables a counter/timer operation on the transition from the high level to the low level (falling edge). In software, this is called a low-edge gate type. Note that this gate type is used only for one-shot and repetitive one-shot mode; refer to page 2-34 for more information on these modes.

- **Rising-edge external gate input** — Enables a counter/timer operation on the transition from the low level to the high level (rising edge). In software, this is called a high-edge gate type. Note that this gate type is used only for one-shot and repetitive one-shot mode; refer to page 2-34 for more information on these modes.

Specify that gate type in software.

Table 2-3 lists the screw terminals that correspond to the gate input signals of each counter/timer.

Table 2-3
Gate input signals

Counter/Timer	Screw Terminal on STP-3110	Pin on Connector J2
0	TB60	50
1	TB64	48
2	TB68	46
3	TB72	44

Pulse output types and duty cycles

The KPCI-3110 and KPCI-3116 boards can output pulses from each counter/timer. Table 2-4 lists the screw terminals that correspond to the pulse output signals of each counter/timer.

Table 2-4
Pulse output signals

Counter/Timer	Screw Terminal on STP-3110	Pin on Connector J2
0	TB59	16
1	TB63	14
2	TB67	12
3	TB71	10

KPCI-3110 and KPCI-3116 boards support the following pulse output types on the clock output signal:

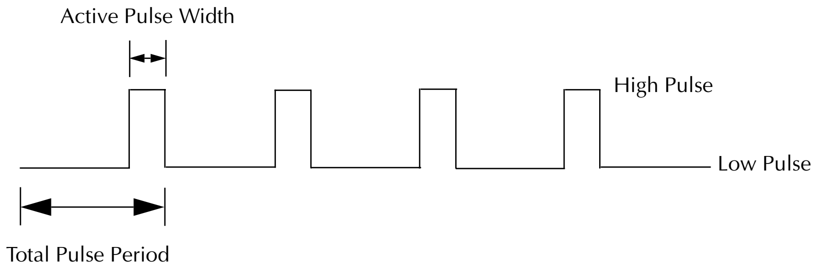
- **High-to-low transitions** — The low portion of the total pulse output period is the active portion of the counter/timer clock output signal.
- **Low-to-high transitions** — The high portion of the total pulse output period is the active portion of the counter/timer pulse output signal.

You specify the pulse output type in software.

The duty cycle (or pulse width) indicates the percentage of the total pulse output period that is active. A duty cycle of 50, then, indicates that half of the total pulse is low and half of the total pulse output is high. You specify the duty cycle in software.

Figure 2-10 illustrates a low-to-high pulse with a duty cycle of approximately 30%.

Figure 2-10
Example of a low-to-high pulse output type



Counter/timer operation modes

KPCI-3110 and KPCI-3116 boards support the following counter/timer operation modes:

- Event counting
- Frequency measurement
- Rate generation
- One-shot
- Repetitive one-shot

The following subsections describe these modes in more detail.

Event counting

Use event counting mode to count events from the counter's associated clock input source.

If you are using one counter, you can count a maximum of 65,536 events before the counter rolls over to 0 and starts counting again. If you are using a cascaded 32-bit counter, you can count a maximum of 4,294,967,296 events before the counter rolls over to 0 and starts counting again.

In event counting mode, use an external C/T clock source; refer to page 2-23 for more information on the external C/T clock source.

Using DriverLINX software, specify the counter/timer mode as event counting (count), the C/T clock source as external, and the gate type that enables the operation. Refer to page 2-25 for information on gates.

Ensure that the signals are wired appropriately. Figure 2-11 shows one example of connecting an event counting application to the STP-3110 screw terminal panel using user counter 0. In this example, rising clock edges are counted while the gate is active.

Figure 2-11
Connecting event counting signals (shown for Clock Input 0 and External Gate 0)

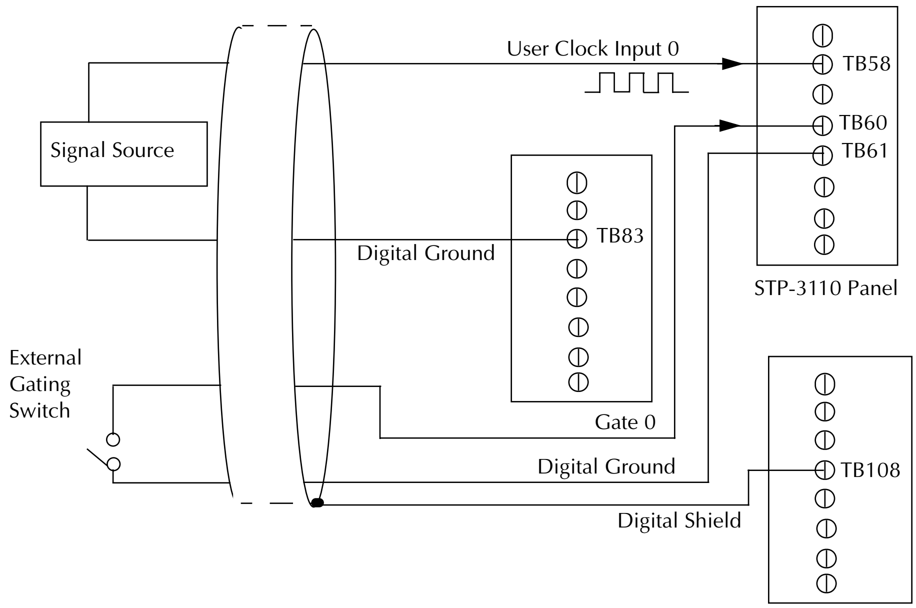
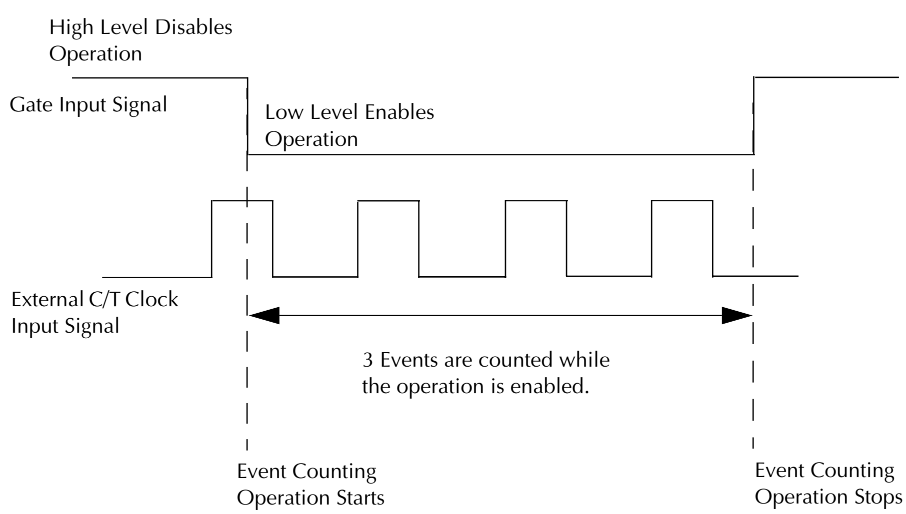


Figure 2-12 shows an example of an event counting operation. In this example, the gate type is low level.

Figure 2-12
Example of event counting

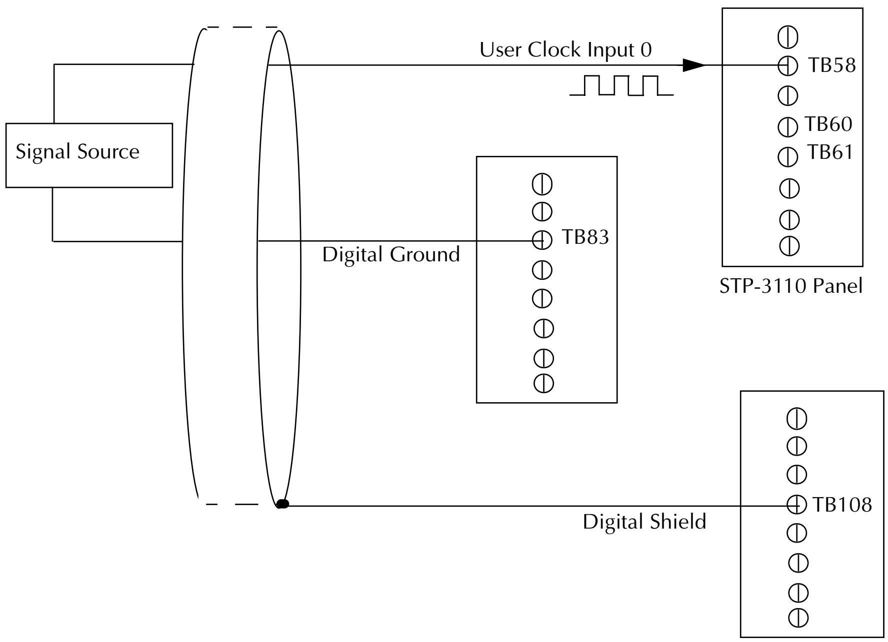


Frequency measurement

Use frequency measurement mode to measure the frequency of the signal from counter's associated clock input source over a specified duration. In this mode, use an external C/T clock source; refer to page 2-23 for more information on the external C/T clock source.

One way to perform a frequency measurement is to use the same wiring as an event counting application that does not use an external gate signal, as shown in Figure 2-13.

Figure 2-13
Connecting frequency measurement signals without an external gate input (shown for Clock Input 0)

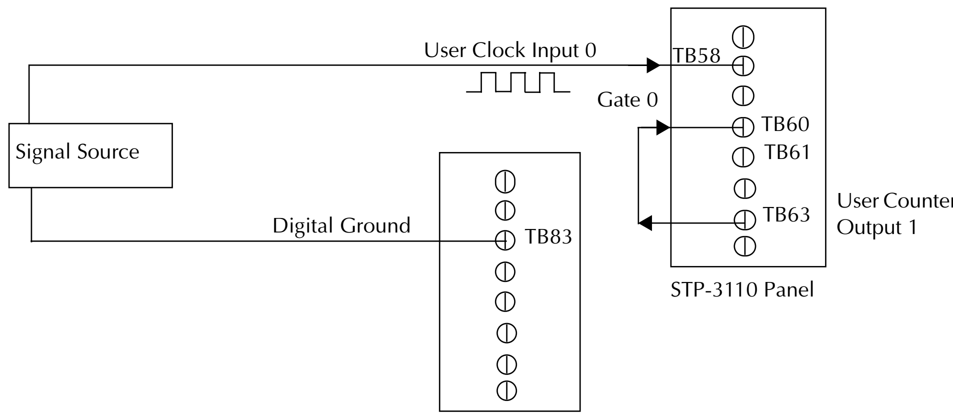


In this configuration, use software to specify the counter/timer mode as frequency measurement or event counting, and the duration of the Windows timer over which to measure the frequency. (The Windows timer uses a resolution of 1ms.) In this configuration, frequency is determined using the following equation:

$$\text{Frequency Measurement} = \frac{\text{Number of Events}}{\text{Duration of the Windows Timer}}$$

If you need more accuracy than the Windows timer provides, you can connect a pulse of a known duration (such as a one-shot output of another user counter) to the external gate input, as shown in Figure 2-14.

Figure 2-14
Connecting frequency measurement signals (shown for Clock Input 0 and External Gate 0)



In this configuration, use software to set up the counter/timers as follows:

1. Set up one of the counter/timers for one-shot mode, specifying the clock source, clock frequency, gate type, type of output pulse (high or low), and pulse width.
2. Set up the counter/timer that will measure the frequency for event counting mode, specifying the clock source to count, and the gate type (this should match the pulse output type of the counter/timer set up for one-shot mode).
3. Start both counters (events are not counted until the active period of the one-shot pulse is generated).
4. Read the number of events counted. (Allow enough time to ensure that the active period of the one-shot occurred and that events have been counted.)
5. Determine the measurement period using the following equation:

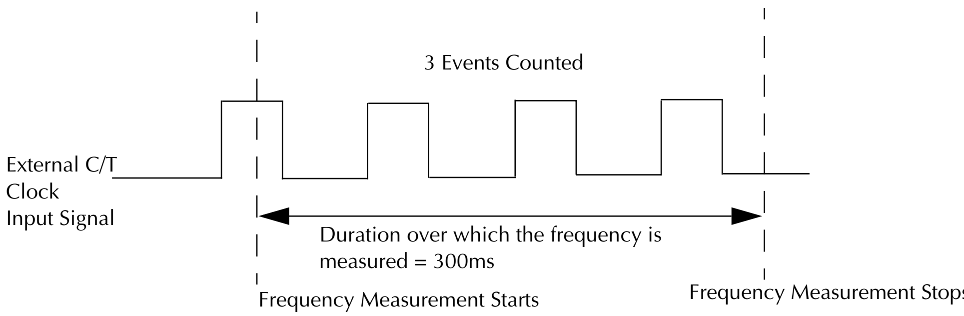
$$\text{Measurement period} = \frac{1}{\text{Clock Frequency}} \times \text{""}ActivePulseWidth$$

   Determine the frequency of the clock input signal using the following equation:

$$\text{Frequency Measurement} = \frac{\text{Number of Events}}{\text{Measurement Period}}$$

Figure 2-15 shows an example of a frequency measurement operation. In this example, three events are counted during a duration of 300ms. The frequency, then, is 10Hz, since 10Hz = 3/(.3 s).

Figure 2-15
Example of frequency measurement



Rate generation

Use rate generation mode to generate a continuous pulse output signal from the counter. This mode is sometimes referred to as continuous pulse output or pulse train output. You can use this pulse output signal as an external clock to pace other operations, such as analog input, analog output, or other counter/timer operations.

While the pulse output operation is enabled, the counter outputs a pulse of the specified type and frequency continuously. As soon as the operation is disabled, rate generation stops.

The period of the output pulse is determined by the clock input signal and the external clock divider. If you are using one counter (not cascaded), you can output pulses using a maximum frequency of 10MHz (this is the frequency of the clock output signal). In rate generation mode, either the internal or external C/T clock input source is appropriate depending on your application. Refer to page 2-23 for more information on the C/T clock source.

Using DriverLINX software, specify the counter/timer mode as rate generation (rate), the C/T clock source as either internal or external, the polarity of the output pulses (high-to-low transitions or low-to-high transitions), the duty cycle of the output pulses, and the gate type that enables the operation. Refer to page 2-25 for more information on pulse output signals and to page 2-24 for more information on gate types.

Ensure that the signals are wired appropriately. Figure 2-16 shows one example of connecting a pulse output operation to the STP-3110 screw terminal panel using user counter 0. In this example, a software gate type is used.

Figure 2-16
Connecting rate generation signals (shown for Counter Output 0; a software gate is used)

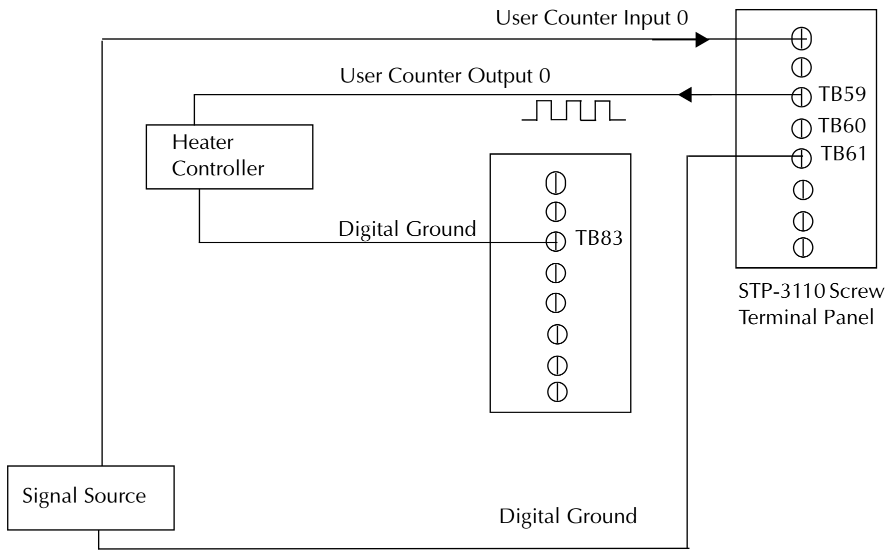


Figure 2-17 shows an example of an enabled rate generation operation using an external C/T clock source with an input frequency of 4kHz, a clock divider of 4, a low-to-high pulse type, and a duty cycle of 75%. (The gate type does not matter for this example.) A 1kHz square wave is the generated output. Figure 2-18 shows the same example using a duty cycle of 25%.

Figure 2-17
Example of rate generation mode with a 75% duty cycle

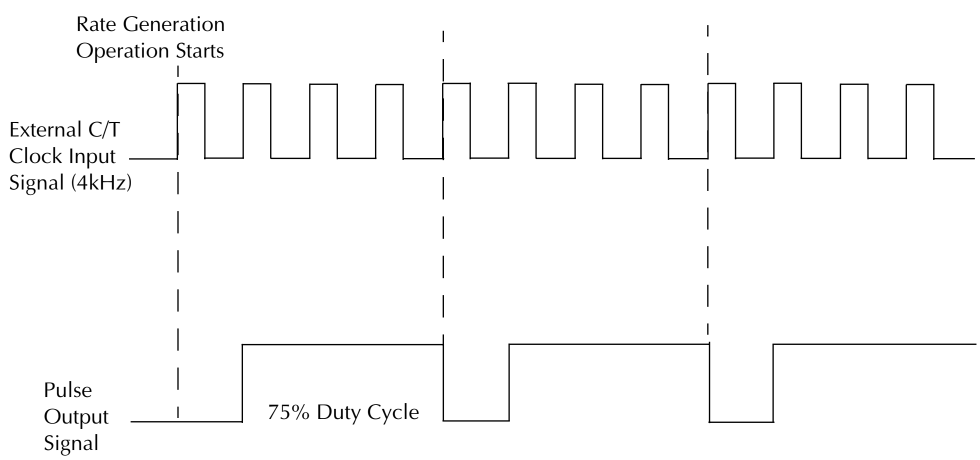
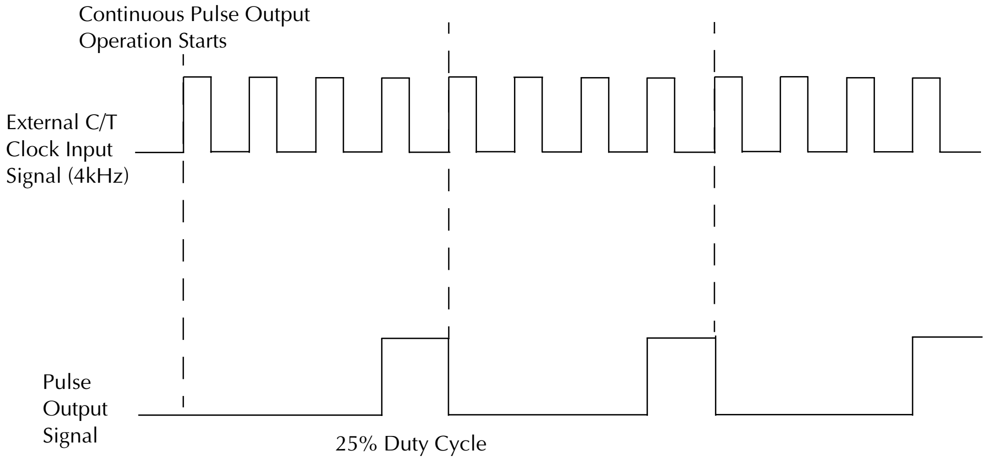


Figure 2-18
Example of rate generation mode with a 25% duty cycle



One-shot

Use one-shot mode to generate a single pulse output signal from the counter when the operation is triggered (determined by the gate input signal). You can use this pulse output signal as an external digital (TTL) trigger to start other operations, such as analog input or analog output operations.

When the one-shot operation is triggered, a single pulse is output; then, the one-shot operation stops. All subsequent clock input signals and gate input signals are ignored.

The period of the output pulse is determined by the clock input signal. In one-shot mode, the internal C/T clock source is more useful than an external C/T clock source; refer to page 2-23 for more information on the internal C/T clock source.

Using DriverLINX software, specify the counter/timer mode as one-shot, the clock source as internal, the polarity of the output pulse (high-to-low transition or low-to-high transition), the duty cycle of the output pulse, and the gate type to trigger the operation. Refer to page 2-25 for more information on pulse output types and to page 2-24 for more information on gate types.

In the case of a one-shot operation, use a duty cycle as close to 100% as possible to output a pulse immediately. Using a duty cycle closer to 0% acts as a pulse output delay.

Ensure that the signals are wired appropriately. Figure 2-19 shows one example of connecting a pulse output operation to the STP-3110 screw terminal panel using user counter 0.

Figure 2-19
Connecting one-shot signals (shown for Counter Output 0 and Gate 0)

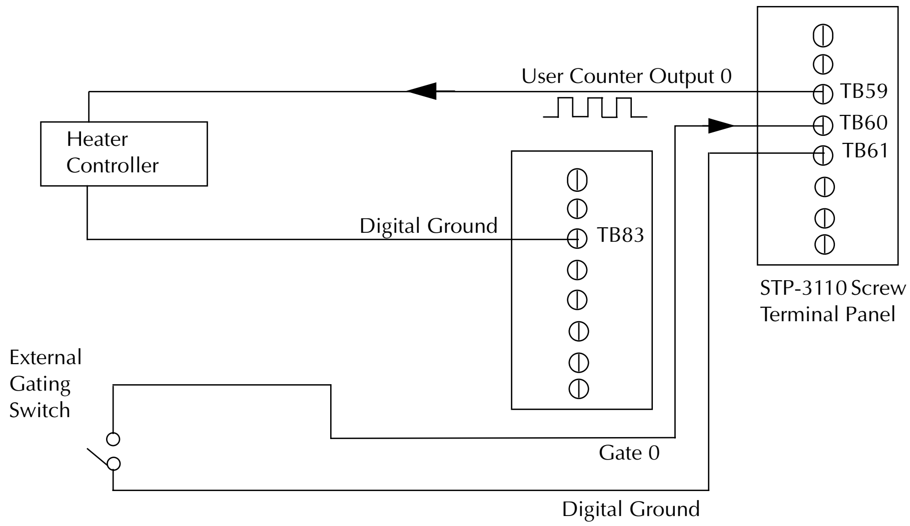


Figure 2-20 shows an example of a one-shot operation using an external gate input (rising edge), a clock output frequency of 1kHz (pulse period of 1ms), a low-to-high pulse type, and a duty cycle of 99.99%. Figure 2-21 shows the same example using a duty cycle of 50%.

Figure 2-20
Example of one-shot mode using a 99.99% duty cycle

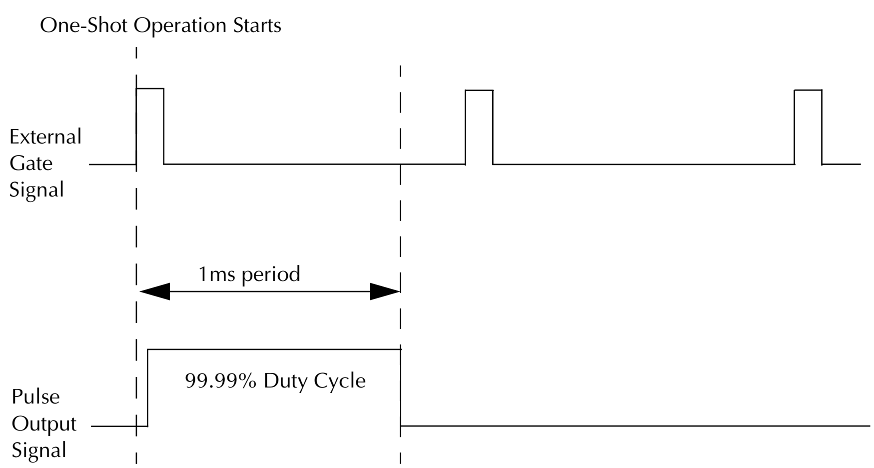
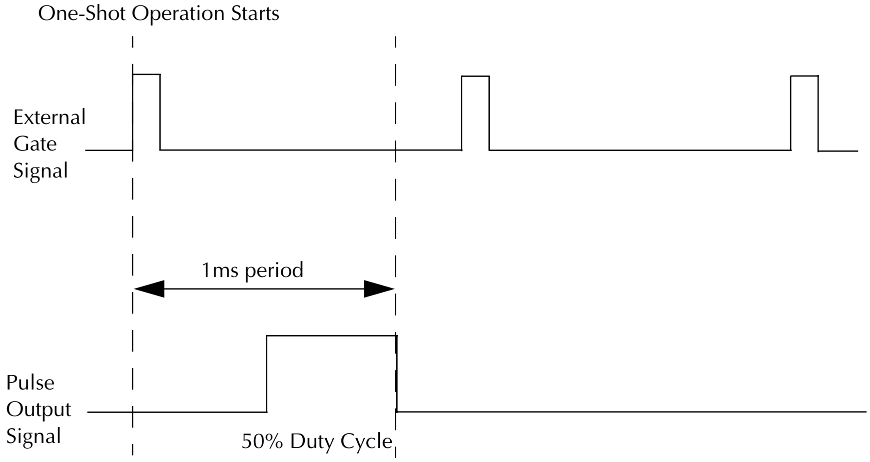


Figure 2-21
Example of one-shot mode using a 50% duty cycle



Repetitive one-shot

Use repetitive one-shot mode to generate a pulse output signal each time the board detects a trigger (determined by the gate input signal). You can use this mode to clean up a poor clock input signal by changing its pulse width, then outputting it.

In repetitive one-shot mode, the internal C/T clock source is more useful than an external C/T clock source. Refer to page 2-23 for more information on the internal C/T clock source.

Use DriverLINX software to specify the counter/timer mode as repetitive one-shot, the polarity of the output pulses (high-to-low transitions or low-to-high transitions), the duty cycle of the output pulses, the C/T clock source, and the gate type to trigger the operation. Refer to page 2-25 for more information on pulse output types and to page 2-24 for more information on gates.

In the case of a one-shot operation, use a duty cycle as close to 100% as possible to output a pulse immediately. Using a duty cycle closer to 0% acts as a pulse output delay.

When the one-shot operation is triggered (determined by the gate input signal), a pulse is output. When the board detects the next trigger, another pulse is output. This operation continues until you stop the operation.

NOTE *Triggers that occur while the pulse is being output are not detected by the board.*

Figure 2-22 shows an example of a repetitive one-shot operation using an external gate (rising edge); a clock output frequency of 1kHz (one pulse every 1ms), a low-to-high pulse type, and a duty cycle of 99.99%. Figure 2-23 shows the same example using a duty cycle of 50%.

Figure 2-22
Example of repetitive one-shot mode using a 99.99% duty cycle

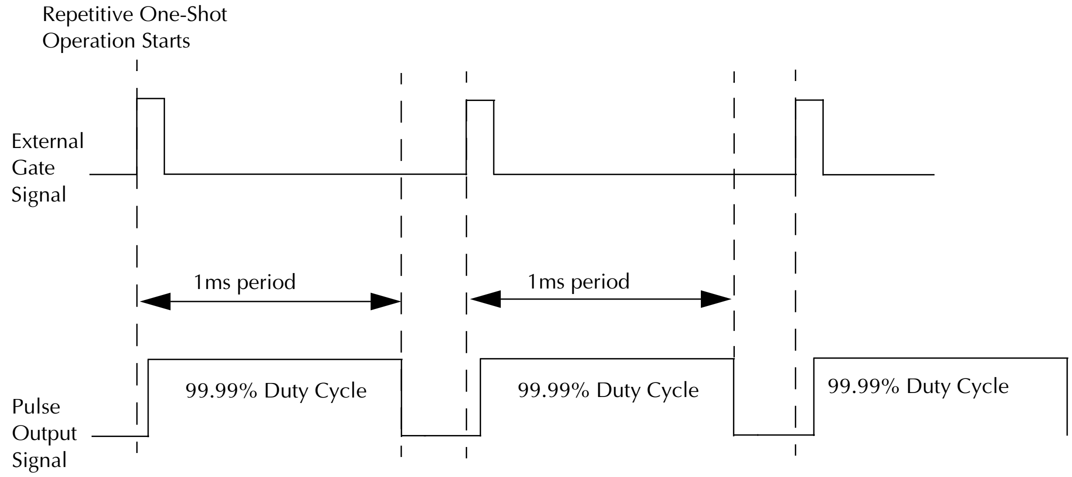
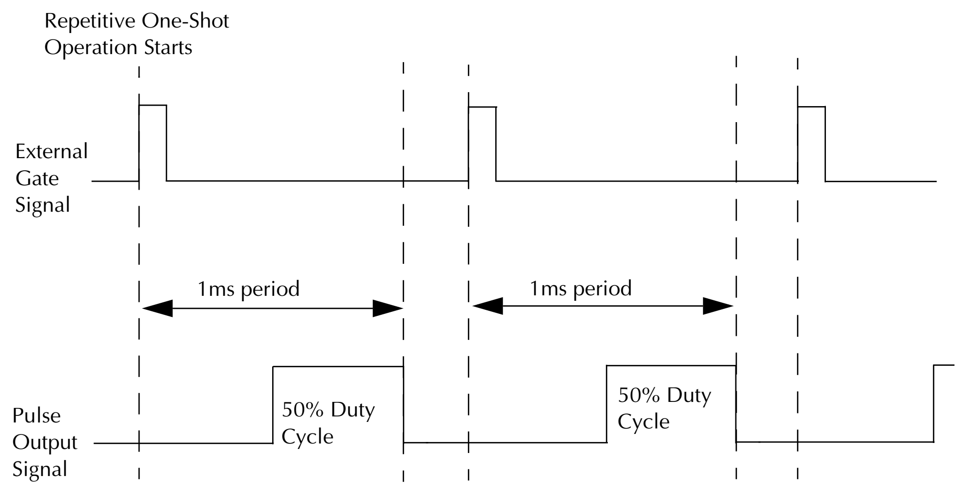


Figure 2-23
Example of repetitive one-shot mode using a 50% duty cycle



Synchronizing A/D and D/A subsystems

You can synchronize the operation of the A/D and D/A subsystems providing that they are not performing single value operations. Refer to page 2-7 and page 2-19 for more information on single value operations.

You can synchronize the A/D and D/A subsystems in two ways: by applying the same external trigger or by applying the same external clock. This section describes these two methods.

Synchronizing the triggers

You can synchronize the triggers of the A/D and D/A subsystems as follows:

- **External digital (TTL) trigger** — Using software, specify the trigger source for the A/D and D/A subsystems as the external digital (TTL) trigger and specify start type as digital trigger. Then, wire an external digital TTL trigger to both the A/D subsystem and the D/A subsystem. When armed, both subsystems are triggered simultaneously when the external digital event occurs.

Synchronizing the clocks

You can synchronize the clocks of the A/D and D/A subsystems as follows:

- **External Sample Clocks** — Using software, specify the clock source as the external A/D sample clock for the A/D subsystem and as the external D/A output clock for the D/A subsystem. When started, both subsystems are clocked simultaneously.

3
Installation and Configuration

Unpacking

Open the shipping box and remove the wrapped KPCI-3110 or KPCI-3116 board.

CAUTION **Keep the board in its protective antistatic bag until you are ready to install it; this minimizes the likelihood of electro-static damage.**

Verify that the following items are present:

- KPCI-3110, or KPCI-3116 data acquisition board
- KPCI-3110 and KPCI-3116 DriverLINX Software and Documentation CD-ROM

If an item is missing or damaged, call Keithley at:

1-888-KEITHLEY
Monday - Friday, 8:00 a.m. - 5:00 p.m., Eastern Time

An application engineer will guide you through the appropriate steps for replacing missing or damaged items.

Installing the software

NOTE *Install the DriverLINX software before installing the KPCI-3110 or KPCI-3116 board. Otherwise, the device drivers will be more difficult to install.*

Software options

Users of KPCI-3110 and KPCI-3116 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-3110 or KPCI-3116 board has fully functional driver support for use under Windows 95/98/NT/2000.

NOTE *The DriverLINX Installation and Configuration Guide, explains the DriverLINX installation process. To display this manual from your DriverLINX KPCI-3110 and KPCI-3116 CD-ROM, open the Windows Explorer, then double click on X:\Drvlinx4\Docs\Instconf.pdf, where X = the letter of the CD-ROM drive. Acrobat Reader must already be installed on the other system. If necessary, you can first install Acrobat Reader directly from the CD-ROM by double clicking X:\Acrobat\setup.exe.*

DriverLINX driver software for Windows 95/98/NT/2000

DriverLINX software, supplied by Keithley with the KPCI-3110 or KPCI-3116 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 on-line 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

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.

TestPoint interfaces with your KPCI-3110 or KPCI-3116 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-3110 or KPCI-3116 board through DriverLINX. The needed driver is provided on your DriverLINX CD-ROM or may be obtained by download at www.keithley.com.

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.

You can install TestPoint application software at any time—before or after installing DriverLINX and the KPCI-3110 or KPCI-3116 board. For TestPoint installation instructions, consult the manual provided by with TestPoint.

NOTE *Before using TestPoint with the KPCI-3110 version of DriverLINX, check with Keithley 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 with LabVIEW for installation instructions.

Installing the board

To install the board, check the system requirements, set up the computer, select an available 32-bit or 64-bit PCI expansion slot, and insert the board into the slot. The following subsections describe how to perform these steps.

To install the board, perform the following steps:

- Check the system requirements, described in Section 1, "Overview."
- Set up the computer, described on page 3-5.
- Select an expansion slot, described on page 3-5.
- Insert the board into any available 32-bit or 64-bit PCI expansion slot in your computer, described on page 3-6.

NOTE *The KPCI-3110 and KPCI-3116 boards are factory-calibrated and require no further adjustment prior to installation. If you decide later to recalibrate the board, refer to Section 5, "Calibration," for instructions.*

Setting up the computer

CAUTION **To prevent electro-static damage that can occur when handling electronic equipment, use a ground strap or similar device when performing this installation procedure.**

1. Turn off the computer.
2. Turn off all peripherals (printer, modem, monitor, and so on) connected to the computer.
3. Unplug the computer and all peripherals.
4. Remove the cover from you computer. Refer to your computer's user manual for instructions.

Selecting an expansion slot

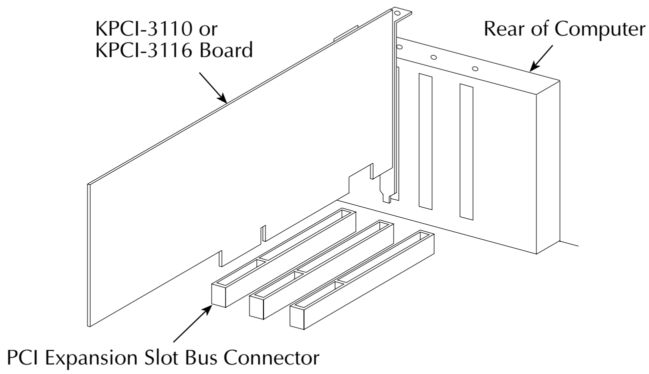
1. Select a 32-bit or 64-bit PCI expansion slot.

   PCI slots are shorter than ISA or EISA slots and are usually white or ivory. Commonly, three PCI slots (one of which may be a shared ISA/PCI slot) are available. If an ISA board exists in the shared slot, you cannot use the slot for a PCI board; likewise if a PCI board exists in the shared slot, you cannot use the slot for an ISA board.
2. Remove the cover plate from the selected expansion slot. Retain the screw that held it in place; you will use it later to install the board.

Inserting the board in the computer

1. To discharge any static electricity, hold the wrapped board in one hand while placing your other hand firmly on a metal portion of the computer chassis.
2. Carefully remove the anti-static packing material from the board. (Save the original packing material in the unlikely event that your board requires servicing in the future.)
3. Hold the board by its edges and do not touch any of the components on the board.
4. Position the board so that the cable connectors are facing the rear of the computer, as shown in Figure 3-1.

Figure 3-1
Inserting a KPCI-3110 or KPCI-3116 board in the computer



5. Carefully lower the board into the PCI expansion slot using the card guide to properly align the board in the slot. When the bottom of the board contacts the bus connector, gently press down on the board until it clicks into place.

CAUTION **Do not force the board into place. Moving the board from side to side during installation may damage the bus connector. If you encounter resistance when inserting the board, remove the board and try again.**

6. Secure the board in place at the rear panel of the system unit using the screw removed from the slot cover.

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 restart the Wizard from a batch file, as follows:

1. Open the Windows Explorer.
2. Double click on X:\DrvLINX4\Help\kcpi3110.bat, where X = the letter of the drive on which you installed DriverLINX.
3. The Wizard appears.

NOTE *You can also start this batch file directly from the CD-ROM by double clicking on Y:\DrvLINX4\Help\kpci3110.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. Refer to Section 4, "Testing the Board" and the DriverLINX manuals.

Try starting the DriverLINX Analog I/O Panel. Proceed 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.
4. If a KPCI-3110 or KPCI-3116 board is the only board in your computer installed under DriverLINX or if the DriverLINX Analog I/O Panel lists the **KPCI3110** board under **Driver Selection,** then DriverLINX and your board are installed properly and are working together.
5. If you cannot initially run the Analog I/O Panel, refer to Section 6, "Troubleshooting."

After DriverLINX and your board are installed properly and working together, continue with installation and wiring.

Attaching the STP-3110 screw terminal panel

Before you can wire signals, you first need to attach the STP-3110 screw terminal panel to the KPCI-3110 or KPCI-3116 board. Connector J1 on the screw terminal panel brings out all of the analog signals from connector J1 on the KPCI-3110 or KPCI-3116 board; cable CAB-307 connects connector J1 on the screw terminal panel to the KPCI-3110 or KPCI-3116 board. Connector J2 on the screw terminal panel brings out all of the digital and counter/timer signals from connector J2 on the KPCI-3110 or KPCI-3116 board; cable CAB-308 connects connector J2 on the screw terminal panel to the KPCI-3110 or KPCI-3116 board.

Figure 3-2 illustrates how to attach the STP-3110 screw terminal panel to the KPCI-3110 or KPCI-3116 board.

Figure 3-2
Attaching the STP-3110 screw terminal panel to the KPCI-3110 or KPCI-3116 board

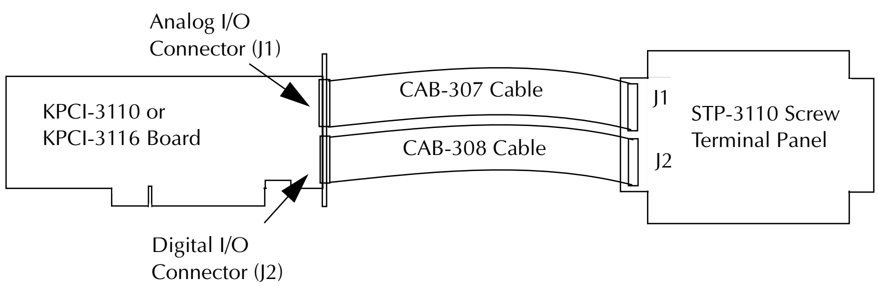
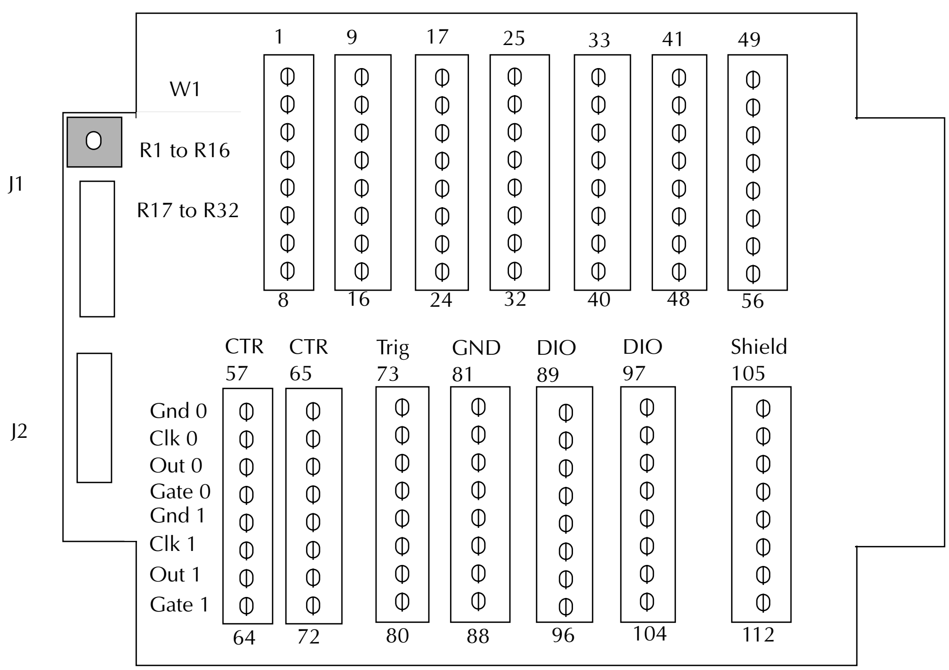


Figure 3-3 shows the layout of the STP-3110 screw terminal panel.

Figure 3-3
Layout of the STP-3110 screw terminal panel



Size

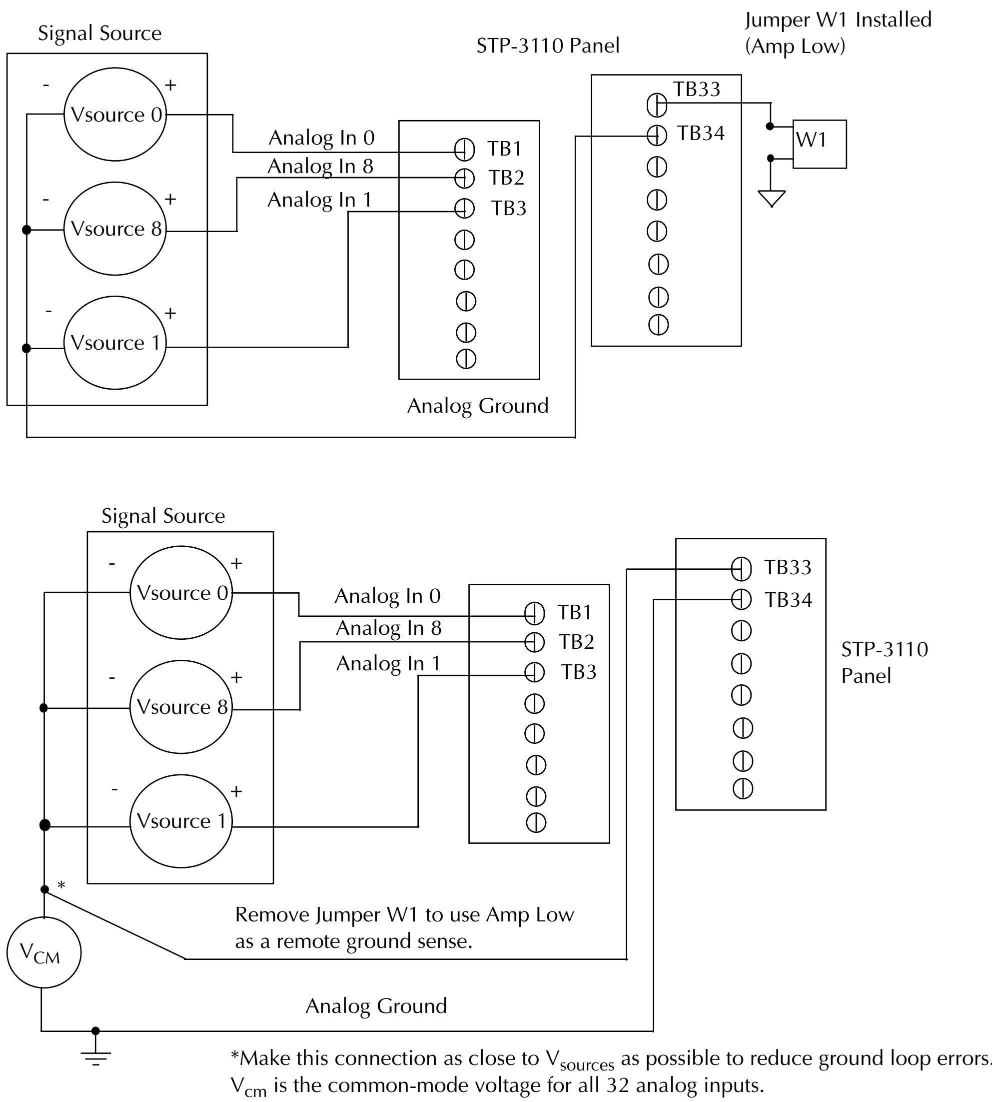
The STP-3110 panel is designed to fit inside a standard 4-inch wide by 8-inch long plastic enclosure. Note, that the grayed area on the STP-3110, shown in Figure 3-3, indicates where to connect a single ground point for shielded enclosures.

Jumper W1 - common ground sense

When shipped from the factory, jumper W1 connects the low side of the input amplifier (Amp Low) on the KPCI-3110 or KPCI-3116 board to analog ground.

When using pseudo-differential analog inputs, remove jumper W1 and connect Amp Low to a remote common-mode voltage to reject offset voltages common to all 32 input channels. Refer to Figure 3-4 for an example of using jumper W1.

Figure 3-4
Removal of Jumper W1 for remote ground sensing



Resistors R1 to R16 - bias return

Resistor locations R1 to R16 connect the low side of analog input channels to analog ground. These resistor locations are typically used when connecting differential inputs to analog input channels 0 to 15, where R1 corresponds to analog input channel 0, and R16 corresponds to analog input channel 15.

The high side of the corresponding analog input channels returns the source input impedance through the bias return resistors to the low side of the channels, then to analog ground. Typical resistor values are 1kΩ to 100kΩ depending on the application. Refer to Figure 3-7 for an example of using bias return resistors.

Resistors R17 to R32 - current shunt

Resistor locations R17 to R32 are typically used to convert current to voltage on channels 0 to 15, where R17 corresponds to analog input channel 0, and R32 corresponds to analog input channel 15.

These resistor locations connect the high side to the low side of the corresponding channels, thereby acting as shunts. If, for example, you add a 250Ω resistor to location R17, and connect a 4 to 20mA current loop input to channel 0, the input range is converted to 1 to 5V. Note that, depending on your application, you may need to use resistors R1 to R16 with resistors R17 to R32 for proper operation. Refer to Figure 3-9 for an example of using current shunt resistors.

Screw terminals

Screw terminals TB1 to TB56 correspond to the analog I/O channels from the KPCI-3110 or KPCI-3116 board. Screw terminals TB57 to TB112 correspond to the digital I/O signals from the KPCI-3110 or KPCI-3116 board.

Screw terminals TB37 (+15V) and TB39 (−15V) are available for low-current signal conditioning applications. The supply on the KPCI-3110 or KPCI-3116 board is current-limited through a 10Ω resistor and is specified for a maximum load current of ±3mA.

Screw terminal TB49 (+5.0V reference) is also current-limited through a 10Ω resistor and is provided for applications that require a reference less than 1mA.

Screw terminal TB112 (+5V output) is current-limited through a series 10Ω resistor and supports loads up to 100mA. Note that you must take the drop (current [I] multiplied by resistance [R]) across the series 10Ω resistor (1V at 100mA) into consideration.

To provide maximum signal integrity, screw terminals TB35, TB36, and TB51 to TB56 have been reserved for external shield connections from the J1 connector. Screw terminals TB105 and TB108 have been reserved for external shield connections from the J2 connector. In addition, multiple ground connections have been allocated for all the digital and clock signals for proper shielding and current capacity.

NOTE *If you connect a high-speed clock to the STP-3110, it is recommended that you connect the return to the adjacent ground screw terminal.*

Table 3-1 lists the screw terminal assignments for connector J1 on the STP-3110 screw terminal panel. Table 3-2 lists the screw terminal assignments for connector J2 on the STP-3110 screw terminal panel.

Table 3-1
Screw terminal assignments for connector J1on the STP-3110 screw terminal panel

TB #	J1 Pin #	Description	TB #	J1 Pin #	Description
1	25	Analog In 0/0	2	50	Analog In 8/0 Return
3	24	Analog In 1/1	4	49	Analog In 9/1 Return
5	23	Analog In 2/2	6	48	Analog In 10/2 Return
7	22	Analog In 3/3	8	47	Analog In 11/3 Return
9	21	Analog In 4/4	10	46	Analog In 12/4 Return
11	20	Analog In 5/5	12	45	Analog In 13/5 Return
13	19	Analog In 6/6	14	44	Analog In 14/6 Return
15	18	Analog In 7/7	16	43	Analog In 15/7 Return
17	17	Analog In 16/8	18	42	Analog In 24/8 Return
19	16	Analog In 17/9	20	41	Analog In 25/9 Return
21	15	Analog In 18/10	22	40	Analog In 26/10 Return
23	14	Analog In 19/11	24	39	Analog In 27/11 Return
25	13	Analog In 20/12	26	38	Analog In 28/12 Return
27	12	Analog In 21/13	28	37	Analog In 29/13 Return
29	11	Analog In 22/14	30	36	Analog In 30/14 Return
31	10	Analog In 23/15	32	35	Analog In 31/15 Return
33	9	Amp Low	34	34	Analog Ground
35	8	Analog Shield Ground	36	33	Analog Shield Ground
37	7	+15V Output	38	32	Power Ground
39	6	–15V Output	40	31	Reserved
41	5	Analog Output 0+	42	30	Analog Output 0 Return
43	4	Analog Output 1+	44	29	Analog Output 1 Return
45	3	Reserved	46	28	Reserved
47	2	Reserved	48	27	Reserved
49	1	+5V Reference Out	50	26	Analog Ground
51	-	Analog Shield Ground	52	-	Analog Shield Ground
53	-	Analog Shield Ground	54	-	Analog Shield Ground
55	-	Analog Shield Ground	56	-	Analog Shield Ground

NOTE *For analog input channels (TB1-32), two values are shown. The value before the slash is the assignment in single-ended and pseudo-differential configurations when 32 channels are available. The value after the slash applies to differential configurations, when 16 channels are available and each channel has a separate return.*

In particular, be aware that when changing to/from differential configuration, the high side of channels 8-15 must be moved to a different terminal.

Table 3-2
Screw terminal assignments for connector J2 on the STP-3110 screw terminal panel

TB #	J2 Pin #	Description	TB #	J2 Pin #	Description
57	51, 52	Digital Ground	58	17	User Clock Input 0
59	16	User Counter Output 0	60	50	External Gate 0
61	49	Digital Ground	62	15	User Clock Input 1
63	14	User Counter Output 1	64	48	External Gate 1
65	47	Digital Ground	66	13	User Clock Input 2
67	12	User Counter Output 2	68	46	External Gate 2
69	45	Digital Ground	70	11	User Clock Input 3
71	10	User Counter Output 3	72	44	External Gate 3
73	43	Digital Ground	74	9	External D/A Sample Clock In
75	8	External D/A TTL Trigger	76	7	External A/D Sample Clock In
77	6	External A/D TTL Trigger	78	5	A/D Trigger Out
79	4	A/D Sample Clock Out	80	3	Reserved
81	23, 28, 42	Digital Ground	82	39, 41, 57, 62	Digital Ground
83	18, 38, 40, 63, 64	Digital Ground	84	65	Reserved
85	31	Reserved	86	37	Reserved
87	30	Dynamic Digital Output 0	88	29	Dynamic Digital Output 1
89	27	Digital I/O Bank A 0	90	26	Digital I/O Bank A 1
91	25	Digital I/O Bank A 2	92	24	Digital I/O Bank A 3
93	61	Digital I/O Bank A 4	94	60	Digital I/O Bank A 5
95	59	Digital I/O Bank A 6	96	58	Digital I/O Bank A 7
97	22	Digital I/O Bank B 0	98	21	Digital I/O Bank B 1
99	20	Digital I/O Bank B 2	100	19	Digital I/O Bank B 3
101	56	Digital I/O Bank B 4	102	55	Digital I/O Bank B 5
103	54	Digital I/O Bank B 6	104	53	Digital I/O Bank B 7
105	33	Digital Shield Ground	106	68	Analog Ground
107	34	Analog Trigger	108	67	Digital Shield Ground
109	32	Reserved	110	66	Reserved
111	35, 36	Digital Ground	112	1, 2	+5V Out

Wiring signals

This section describes how to wire signals to the STP-3110 screw terminal panel.

CAUTION **To avoid electrical damage, ensure that power is turned off to the computer and to any attached devices before wiring signals to the STP-3110 screw terminal panel.**

TIP *When first installing the board, try wiring a function generator or a known voltage source to analog input channel 0 (use the differential configuration), an oscilloscope or voltage meter to analog output channel 0, a digital input to digital I/O Port A, and an external clock or scope to counter/timer channel 0. Then, run DriverLINX Analog I/O Panel to verify that the board is operating properly. Once you have determined that the board is operating properly, wire the signals according to your application's requirements.*

Keep the following recommendations in mind when wiring signals to the STP-3110 screw terminal panel:

- Use individually shielded twisted-pair wire (size 14 to 26 AWG) when using the KPCI-3110 or KPCI-3116 board in high electrical noise environments.
- Separate power and signal lines by using physically different wiring paths or conduits.
- To avoid noise, do not locate the STP-3110 screw terminal panel and cabling next to sources that produce high electromagnetic fields, such as large electric motors, power lines, solenoids, and electric arcs, unless the signals are enclosed in a metal shield.
- Connect the analog shield to screw terminals TB35 and TB36, and to TB51 through TB56 on the STP-3110 screw terminal panel.
- Connect the digital shield to screw terminals TB105 and TB108 on the screw terminal panel.
- Connect the analog and digital shields to one end only (either at the STP-3110 or at the signal source).

Connecting analog input signals

The STP-3110 screw terminal panel supports both voltage and current loop inputs. You can connect analog input voltage signals to the STP-3110 in the following configurations:

- **Single-ended** — Choose this configuration when you want to measure high-level signals, noise is not significant, the source of the input is close to the STP-3110 screw terminal panel, and all the input signals are referred to the same common ground. When you choose the single-ended configuration, all 32 analog input channels are available.
- **Pseudo-Differential** — Choose this configuration when noise or common-mode voltage (the difference between the ground potentials of the signal source and the ground of the STP-3110 screw terminal panel or between the grounds of other signals) exists and the differential configuration is not suitable for your application. This option provides less noise rejection than the differential configuration; however, all 32 analog input channels are available.
- **Differential** — Choose this configuration when you want to measure low-level signals (less than 1V), you are using an A/D converter with high resolution (> 12 bits), noise is a significant part of the signal, or common-mode voltage exists. When you choose the differential configuration, 16 analog input channels are available.

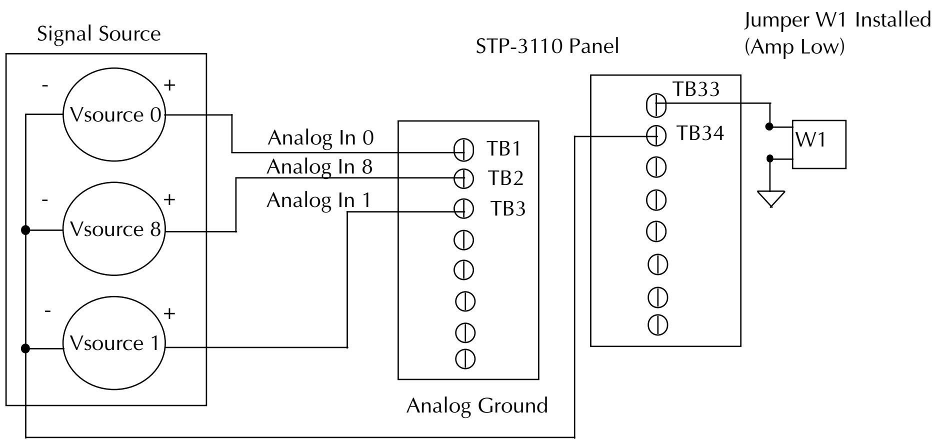
NOTE *It is recommended that you connect all unused analog input channels to analog ground.*

This section describes how to connect single-ended, pseudo-differential, and differential voltage inputs, as well as current loop inputs to the STP-3110 screw terminal panel.

Connecting single-ended voltage inputs

Figure 3-5 shows how to connect single-ended voltage inputs (channels 0, 1, and 8, in this case) to the STP-3110 screw terminal panel.

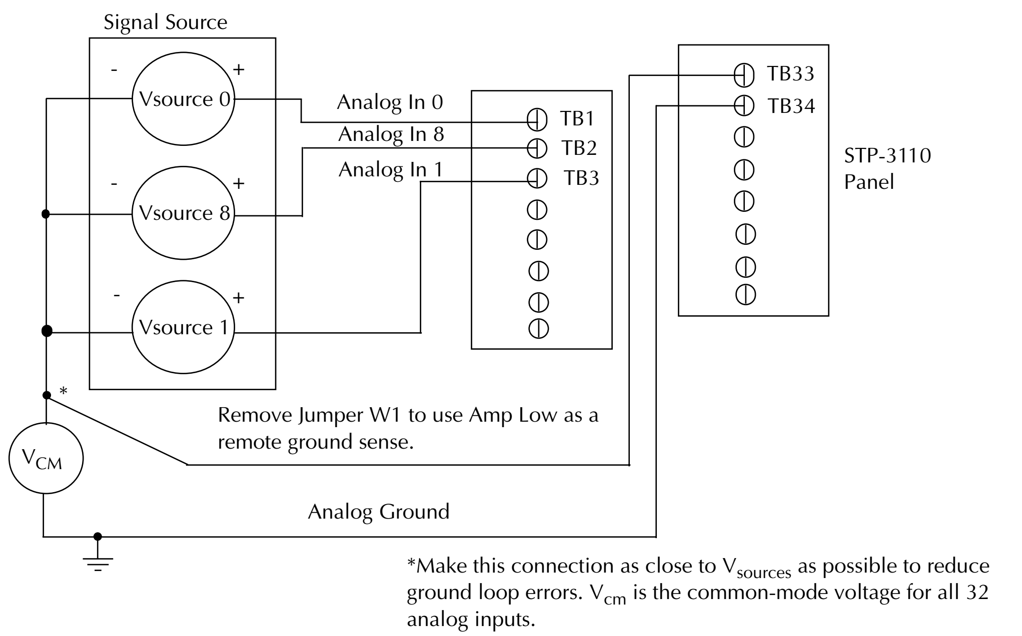
Figure 3-5
Connecting single-ended voltage inputs (shown for Channels 0, 1, and 8)



Connecting pseudo-differential voltage inputs

Figure 3-6 shows how to connect pseudo-differential voltage inputs (channels 0, 1, and 8, in this case) to the STP-3110 screw terminal panel.

Figure 3-6
Connecting pseudo-differential voltage inputs (shown for Channels 0, 1, and 8)



Connecting differential voltage inputs

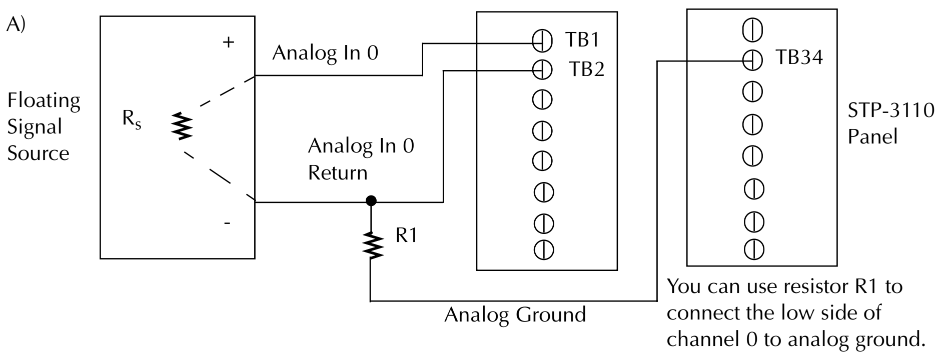
Figure 3-7A illustrates how to connect a floating signal source to the STP-3110 screw terminal panel using differential inputs. (A floating signal source is a voltage source that has no connection with earth ground.) For floating signal sources, you need to provide a bias return path by adding resistors R1 to R16 for channels 0 to 15, respectively.

If the input signal is +10V, then the common-mode voltage could be 1V. Theoretically, the resistor value (R_b) should be 1V divided by the input bias current (20nA) or 50mΩ. However, when you add noise from external sources to the high impedance, a resistor value of 100Ω to 100kΩ is more practical.

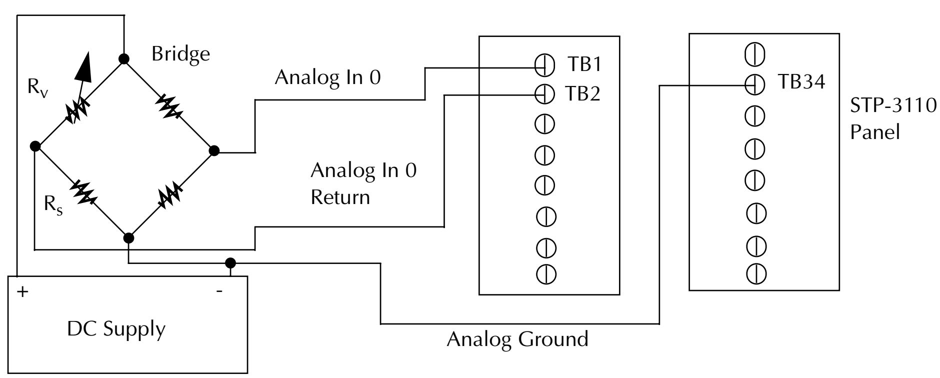
In Figure 3-7B, the signal source itself provides the bias return path; therefore, you do not need to use bias return resistors. R_s is the signal source resistance while R_v is the resistance required to balance the bridge. Note that the negative side of the bridge supply must be returned to analog ground.

Figure 3-7
Connecting differential voltage inputs (shown for Channel 0)

A)

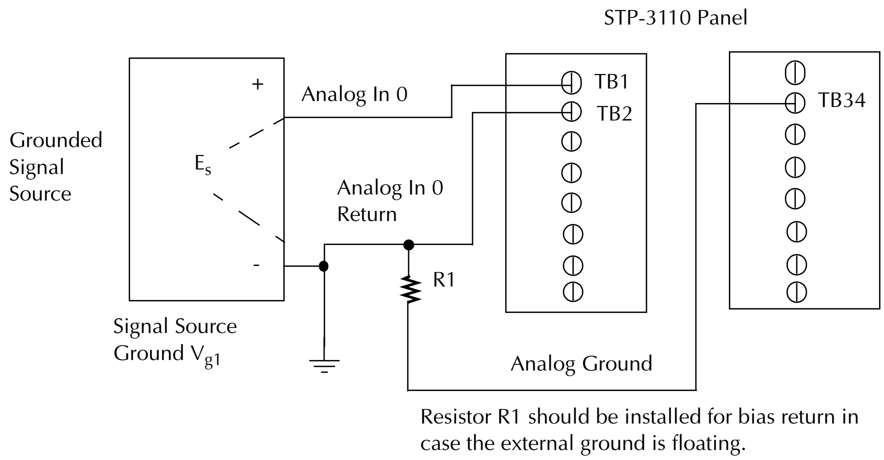


B)



Note that since they measure the difference between the signals at the high (+) and low (–) inputs, differential connections usually cancel any common-mode voltages, leaving only the signal. However, if you are using a grounded signal source and ground loop problems arise, connect the differential signals to the STP-3110 screw terminal panel as shown in Figure 3-8. In this case, make sure that the low side of the signal (–) is connected to ground at the signal source, not at the STP-3110 screw terminal panel, and do not tie the two grounds together.

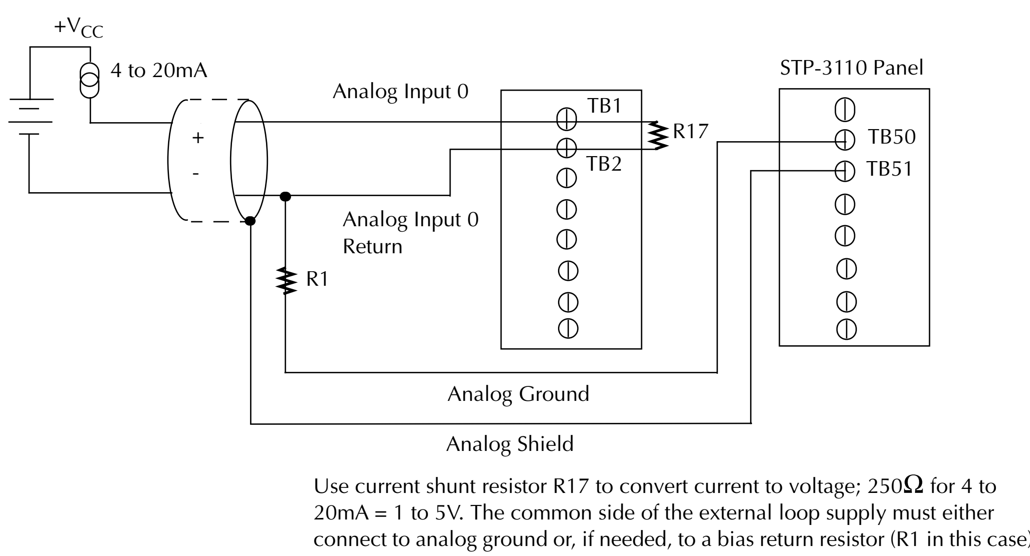
Figure 3-8
Connecting differential voltage inputs from a grounded signal source (shown for Channel 0)



Connecting current loop inputs

Figure 3-9 shows how to connect a current loop input (channel 0, in this case) to the STP-3110 screw terminal panel.

Figure 3-9
Connecting current inputs to the STP-3110 screw terminal panel (shown for Channel 0)



Connecting analog output signals

Figure 3-10 shows how to connect analog output voltage signals (channel 0, in this case) to the STP-3110 screw terminal panel.

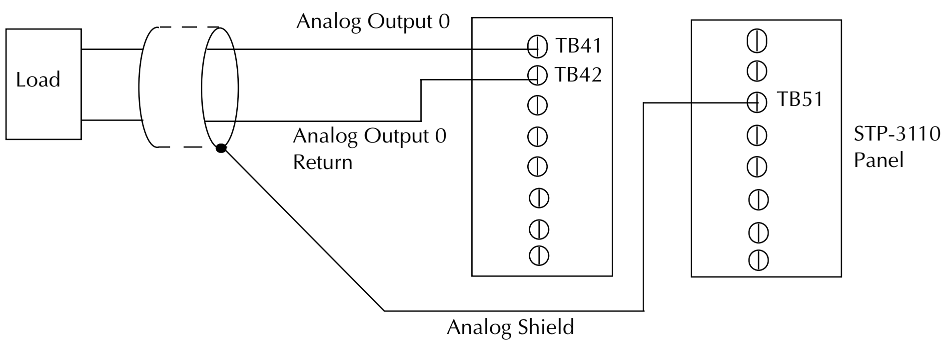


Figure 3-10
Connecting analog output voltages to the STP-3110 screw terminal panel (shown for Channel 0)

Connecting digital I/O signals

Figure 3-11 shows how to connect a digital input signal (lines 0 and 1 of digital Bank A, in this case) to the STP-3110 screw terminal panel.

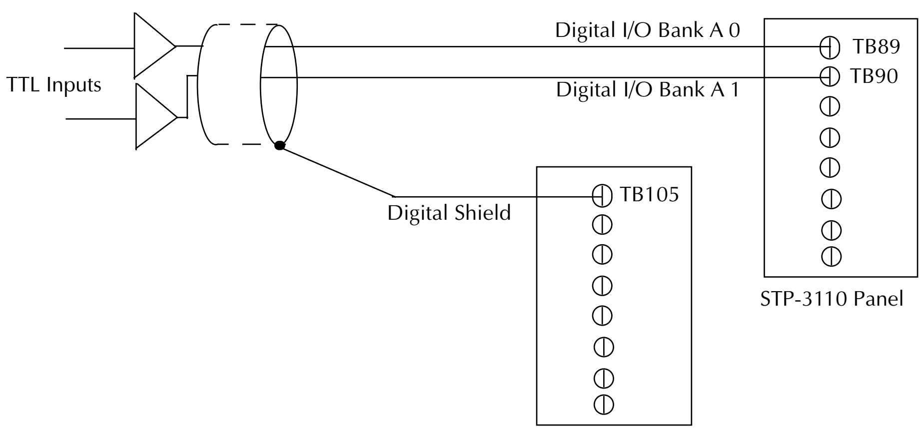
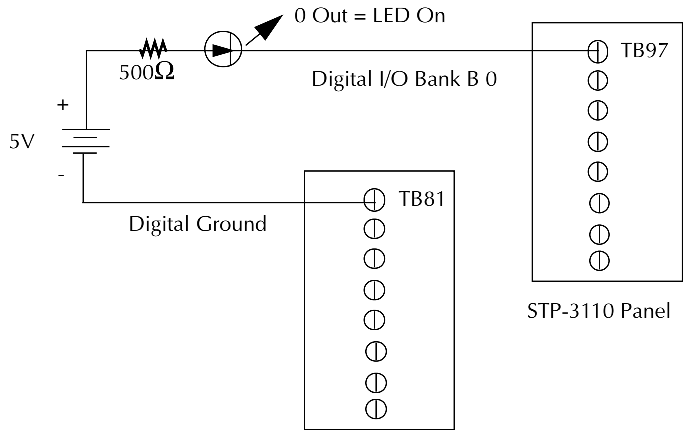


Figure 3-11
Connecting digital inputs to the STP-3110 screw terminal panel (Lines 0 and 1, Bank A shown)

Figure 3-12 shows how to connect a digital output signal (line 0 of digital Bank B, in this case) to the STP-3110 screw terminal panel.

Figure 3-12
Connecting digital outputs to the STP-3110 screw terminal panel (Line 0, Bank B shown)



Connecting counter/timer signals

The KPCI-3110 or KPCI-3116 boards with the STP-3110 screw terminal panel provide user counter/timers that you can use to perform the following operations:

- Event counting
- Frequency measurement
- Pulse output (rate generation, one-shot, and repetitive one-shot)

This section describes how to connect counter/timer signals to perform these operations. Refer to Section 2, "Functional Description," for more information on using the counter/timers.

Connecting event counting signals

Figure 3-13 shows one example of connecting event counting signals to the STP-3110 screw terminal panel using user counter 0. In this example, rising clock edges are counted while the gate is active.

Figure 3-13
Connecting event counting applications to the STP-3110 screw terminal panel (shown for Clock Input 0 and External Gate 0)

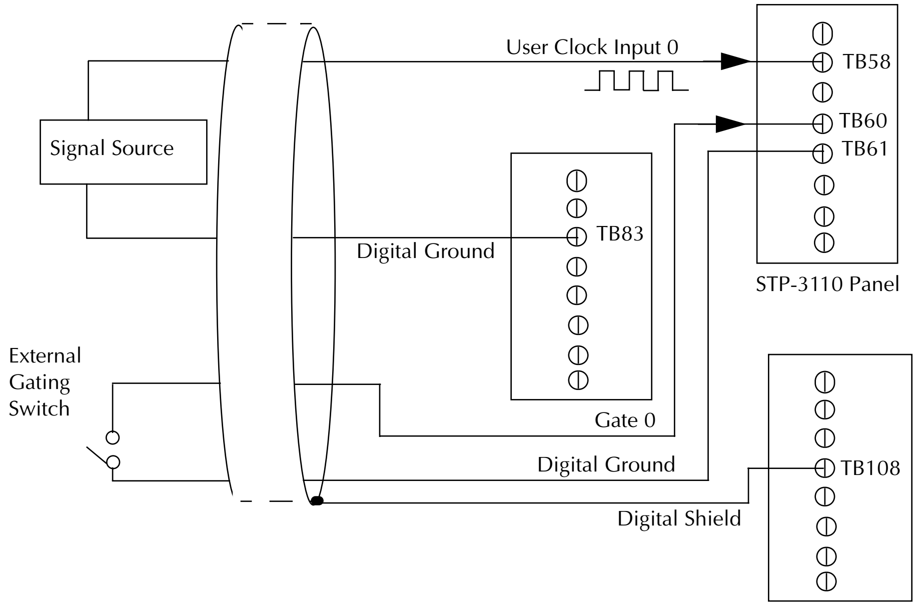


Figure 3-14 shows another example of connecting an event counting application to the STP-3110 screw terminal panel using user counter 0. In this example, a software gate is used to start the event counting operation.

Figure 3-14
Connecting event counting applications to the STP-3110 screw terminal panel without an external gate input (shown for Clock Input 0)

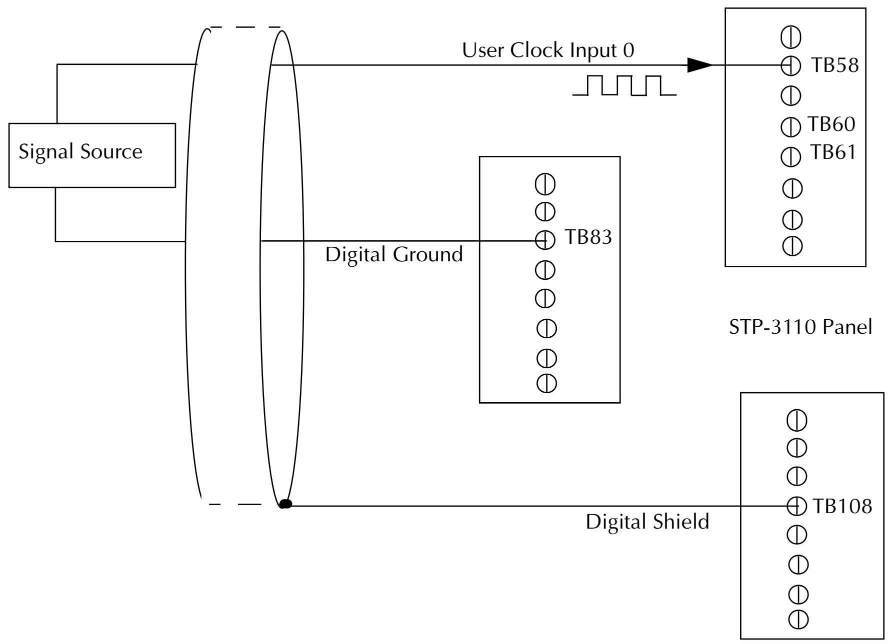
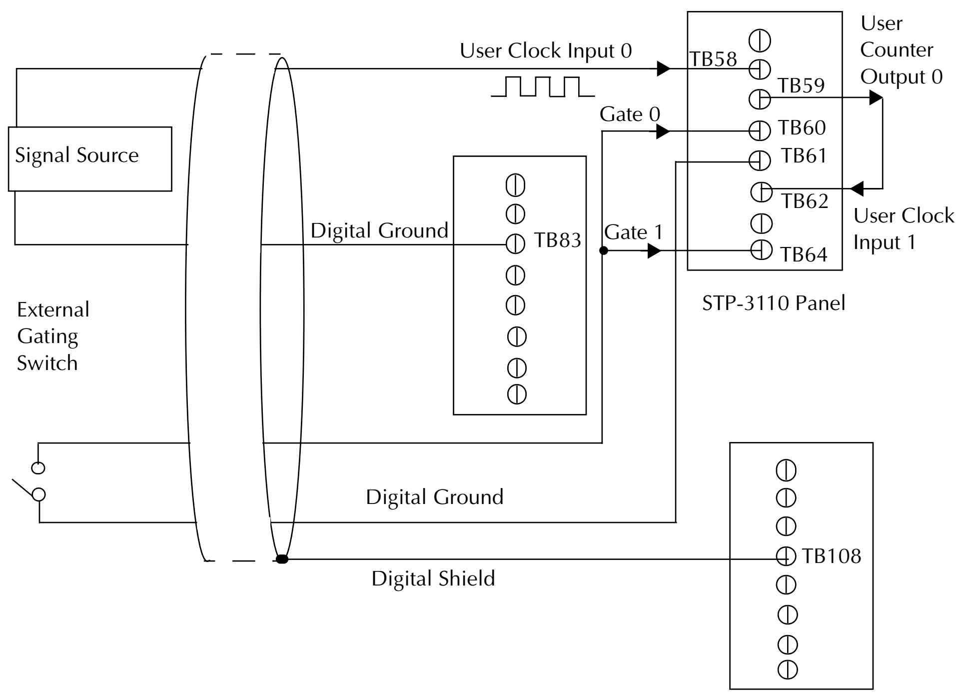


Figure 3-15 shows an example of how to externally cascade two counters to perform an event counting operation using user counters 0 and 1. Note that you can also internally cascade counters using software; if you internally cascade the counters, you do not have to make the external cascading connections. Note also that this example shows the use of an external gate; however, this connection is not required.

Figure 3-15
Cascading counters (shown for event counting using Counters 0 and 1 and External Gate 0)



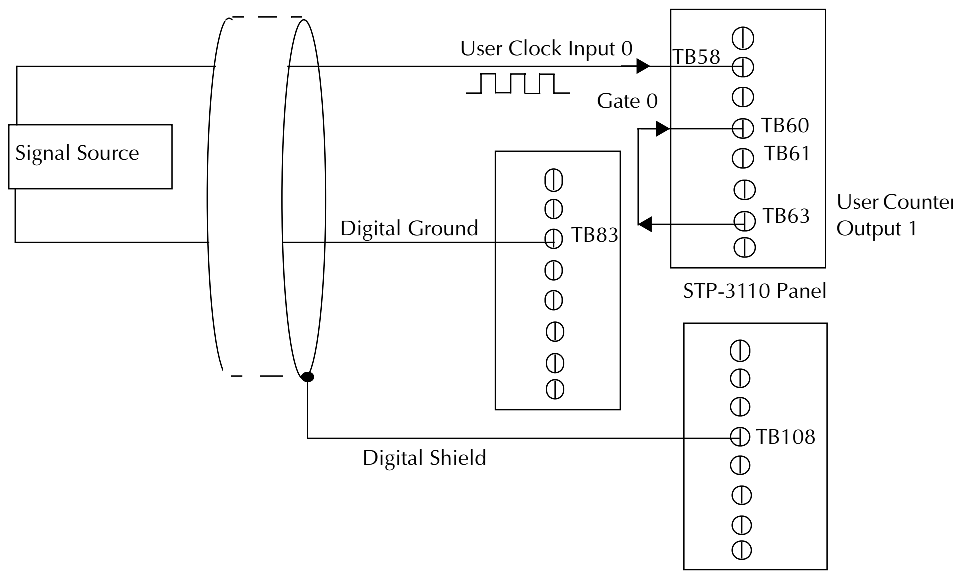
Connecting frequency measurement signals

You can connect a frequency measurement application to the STP-3110 screw terminal panel in two ways.

The first configuration uses the same wiring as an event counting application that does not use an external gate signal (see Figure 3-14) the software uses the Windows timer to specify the duration of the frequency measurement. In this configuration, the frequency of the clock input is the number of counts divided by the duration of the Windows timer.

If you need more accuracy than the Windows timer provides, you can connect a pulse of a known duration (such as a one-shot output of another user counter) to the external gate input, as shown in Figure 3-16. In this configuration, the frequency of the clock input is the number of counts divided by the period of the external gate input.

Figure 3-16
Connecting frequency measurement applications to the STP-3110 screw terminal panel (shown for Clock Input 0 and External Gate 0)



Connecting pulse output signals

Figure 3-17 shows one example of connecting a pulse output application to the STP-3110 screw terminal panel using user counter 0. Other combinations of signals can be used.

Figure 3-17
Connecting pulse output applications to the STP-3110 screw terminal panel (shown for Counter Output 0 and Gate 0)

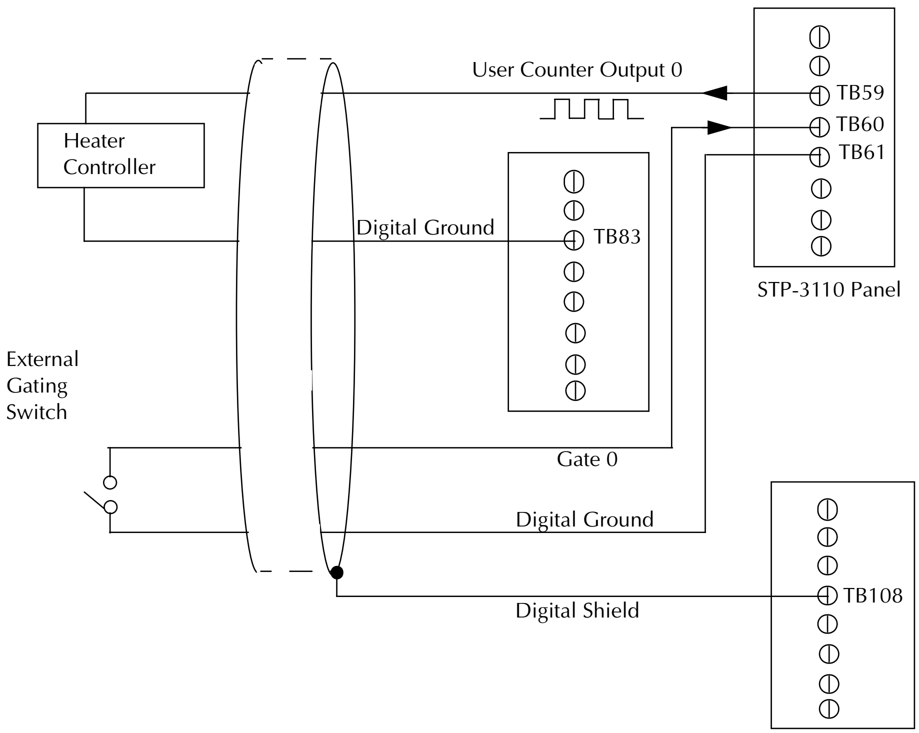


Figure 3-18 shows an example of how to externally cascade two counters to perform a rate generation operation using user counters 0 and 1. Note that you can also internally cascade counters using software; if you internally cascade the counters, you do not have to make the external cascading connections. In this example, counter 1 gate is logic high.

Figure 3-18
Cascading counters (shown for rate generation using Counters 0 and 1 and External Gate 0)

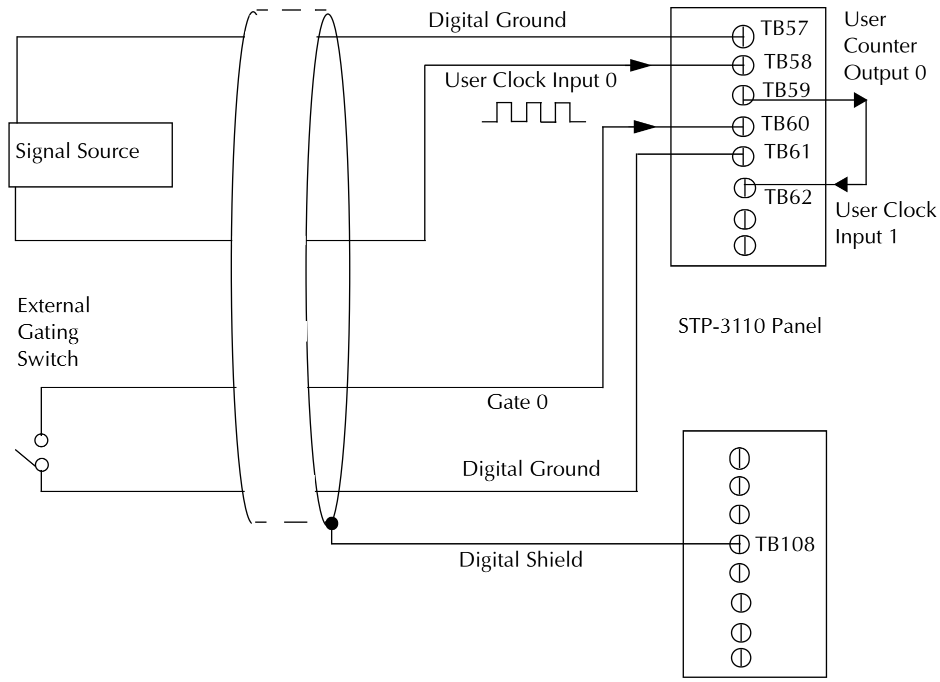
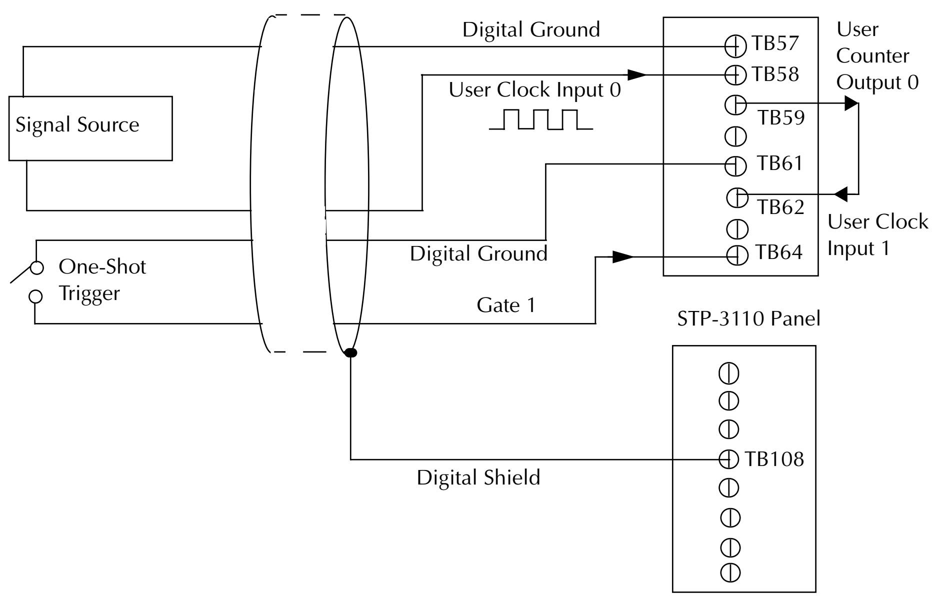


Figure 3-19 shows an example of how to externally cascade two counters to perform a one-shot operation using user counters 0 and 1. Note that you can also internally cascade counters using software; if you internally cascade the counters, you do not have to make the external cascading connections. In this example, counter 0 gate is logic high.

Figure 3-19
Cascading counters (shown for one-shot using Counters 0 and 1 and External Gate 1)



4
Testing the Board

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.

This section describes how to use the DriverLINX Analog I/O Panel and DriverLINX Test Panel utilities to verify the operation of your KPCI-3110 or KPCI-3116 board.

DriverLINX analog I/O panel

The DriverLINX Analog I/O Panel is an application that demonstrates analog input/output using DriverLINX. With the Analog I/O Panel you can:

- Analyze analog signals using the two-channel Oscilloscope.
- Measure analog voltages using the Digital Volt Meter.
- Generate Sine, Square and Triangle waves using the SST Signal Generator.
- Output DC Level voltages using the Level Control.
- Set and read all digital input and output bits on your board.

The Analog I/O Panel is useful for:

- Testing the KPCI-3110 or KPCI-3116 board DriverLINX installation and configuration.
- Verifying signal inputs to your KPCI-3110 or KPCI-3116 board.
- Sending test signals to external devices.
- Controlling the DC output voltages of two analog output channels.
- Setting and reading all digital input and output bits on your board.

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-3110 or KPCI-3116 board is the only board in your computer installed under DriverLINX, only one item appears under Driver Selection.
    - If more than one type of board is installed in your computer under DriverLINX, the Analog I/O Panel will list multiple drivers under **Driver Selection** and multiple devices listed under **Device Selection** (for example, **Device0, Device1**, etc.).Your board type and device number may not be displayed initially. If so, click the scroll buttons next to the Driver Selection and Device Selection text boxes until your KPCI-3110 board type and device number are displayed.
4. Select the Logical Device you want to operate by dragging the pointer in the Device Selection section. The Analog I/O Panel displays the Scope, Meter, SST, Level control tabs, and Digital I/O, depending on the capabilities of your KPCI-3110 board.
5. The Scope uses two analog input channels, referred to as ChA and ChB. Drag the channel selectors in the AI Channel Mapping section to map them to different channel numbers.

6. The SST Signal Generator uses two analog output channels, referred to as ChA and ChB. Drag the channel selectors in the AO Channel Mapping section to map them to different channel numbers.
7. The Analog I/O Level Control determines the DC output voltages of two analog output channels.
8. The Digital I/O Control allows you to set and read all digital input and output bits on your board.

You can now select the Scope, Meter, SST, Level Control, and Digital I/O tabs to operate your KPCI-3110 or KPCI-3116 board.

5
Calibration

Introduction

The KPCI-3110 and KPCI-3116 boards are calibrated at the factory and should not require calibration for initial use. It is recommended that you check and, if necessary, readjust the calibration of the analog I/O circuitry on the KPCI-3110 and KPCI-3116 boards every six months.

NOTE *Ensure that you installed the DriverLINX software prior to using the DriverLINX KPCI-3110 and KPCI-3116 Calibration Utility. Refer to the DriverLINX Online Documentation for more information.*

This section describes how to run the KPCI-3110 and KPCI-3116 DriverLINX Calibration Utility and calibrate the analog I/O circuitry of the KPCI-3110 and KPCI-3116 boards.

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 digital-to-analog converters (DACs) on your KPCI-3110 or KPCI-3116 board.

Calibration summary

Analog inputs and outputs are calibrated using 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 calibration potentiometers must be adjusted. No test points on the board are used. Only connections to the I/O connector pins, via a screw terminal accessory, are needed.

Equipment

The following equipment is needed to calibrate your KPCI-3110 or KPCI-3116 board:

- A digital voltmeter (DVM) or digital multimeter (DMM) accurate to 6½ digits, such as a Keithley Model 2000.
- An STP-3110 screw terminal accessory to make analog connections to the board.
- A Keithley CAB-307 cable to connect the screw terminal accessory to the connector of the KPCI-3110 board.
- A DC calibrator or precisely adjustable and metered power supply having up to a 10VDC range and accurate to 6½ digits.

Calibration procedure

This section describes the steps required to calibrate the analog inputs and outputs of your KPCI-3110 or KPCI-3116 board.

Preparing for the calibrations

Prepare your system for calibration as follows:

1. Warm up the calibrator and the DVM/DMM.
2. Turn off the host computer.
3. Connect the STP-3110 screw terminal accessory to your KPCI-3110 or KPCI-3116 board, using the CAB-307 cable. Refer to Section 3, "Installation and Configuration," for more information about connecting these accessories.
4. Turn on the host computer.
5. Start the calibration utility 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-3110 and KPCI-3116 Calibration Utility** entry. The Select DriverLINX Device dialog box appears.
   d. In the Select DriverLINX Device dialog box, select your board and click **OK**. The KPCI-3110 and KPCI-3116 Calibration Utility dialog box appears.

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. Do the following:

1. In the KPCI-3110 and KPCI-3116 Calibration Utility dialog box, click the **A/D Calibration** tab. The A/D Calibration dialog box appears.
2. To calibrate the analog inputs, follow the on-screen instructions in the The A/D Calibration dialog box.
3. When finished with the analog input calibration, continue with the next subsection.

Calibrating the analog outputs

The KPCI-3110 and KPCI-3116 boards each have two independent analog outputs, provided by two digital-to-analog converters (DACs or D/A converters). In this part of the procedure, offset and gain adjustments for the DACs are made. Do the following:

1. In the KPCI-3110 and KPCI-3116 Calibration Utility dialog box, click the **D/A Calibration** tab. The D/A Calibration dialog box appears.
2. To calibrate each DAC, follow the on-screen instructions in the D/A Calibration dialog box.

6
Troubleshooting

General checklist

Should you experience problems using the KPCI-3110 or KPCI-3116 board, please follow these steps:

1. Read all the appropriate sections of this manual. Make sure that you have added any "Read This First" information to your manual and that you have used this information.
2. Check your distribution disk for a README file and ensure that you have used the latest installation and configuration information available.
3. Check that your system meets the requirements stated in this manual.
4. Check that you have installed your hardware properly using the instructions in this manual.
5. Check that you have installed and configured DriverLINX properly using the instructions in the *DriverLINX manuals* that come with the DriverLINX software.

If your KPCI-3110 or KPCI-3116 board is not operating properly, use the information in this section to help you isolate the problem. If the problem appears serious enough to require technical support, refer to page 6-6 for information on how to contact an applications engineer.

If you encounter a problem with a KPCI-3110 or KPCI-3116 board, use the instructions in this section to isolate the cause of the problem before calling Keithley for technical support.

Using the DriverLINX event viewer

The DriverLINX Event Viewer displays the Windows system event log. Applications and hardware drivers make entries in the system event log to assist in predicting and troubleshooting hardware and software problems.

DriverLINX uses the event log to report problems during driver loading or unexpected system errors. The event log can assist in troubleshooting resource conflicts and DriverLINX configuration errors. If you are having trouble configuring or initializing a Logical Device, check the event log for information from the DriverLINX driver.

Using the DriverLINX Event Viewer, you can view, save and e-mail DriverLINX event log entries under Windows 95/98 or Windows NT. DriverLINX event log entries can help you or technical support troubleshoot data-acquisition hardware and software problems.

Device initialization error messages

During device initialization, DriverLINX performs a thorough test of all possible subsystems on the KPCI-3110 or KPCI-3116 board as well as the computer interface. If DriverLINX detects any problems or unexpected responses, it reports an error message to help isolate the problem. The device initialization error messages fall into three basic categories:

- **"Device not found"** — Board address does not match hardware setting or conflicts with another board. Verify the board's address settings. Also, don't confuse hexadecimal with decimal addresses in the DriverLINX Device Configure dialog box.
- **"Invalid IRQ level"** or **"Invalid DMA level"** — Selected level does not match hardware setting, conflicts with another board's IRQ/DMA levels, or is dedicated to the computer's internal functions (COM port, disk drive controller, network adapter, etc.)
- **"Hardware does not match configuration"** — Operating mode/range switch or jumper setting does not match selection(s) made in the DriverLINX Device Configuration dialog box.

Problem isolation

If you encounter a problem with a KPCI-3110 or KPCI-3116 board, perform the following steps to determine whether the problem is in the computer, in the KPCI-3110 or KPCI-3116 board, or in the I/O circuitry:

1. Remove power connections to the host computer.
2. Unplug the accessory connector(s) or cable(s) from the KPCI-3110 or KPCI-3116 board(s), keeping the connections intact on the accessory or expansion board(s).
3. Remove the KPCI-3110 or KPCI-3116 board(s) from the computer and visually check for damage. If a board is obviously damaged, refer to page 6-7 for information on returning the board.
4. With the KPCI-3110 or KPCI-3116 board(s) out of the computer, check the computer for proper operation. Power up the computer and perform any necessary diagnostics.
5. When you are sure that the computer is operating properly, remove computer power again, and install a KPCI-3110 or KPCI-3116 board that you know is functional. Do not make any I/O connections.
6. Apply computer power and check operation with the functional KPCI-3110 or KPCI-3116 board in place. This test checks the computer accessory slot. If you are using more than one KPCI-3110 or KPCI-3116 board, check the other slots you are using.
7. If the accessory slots are functional, check the I/O hookups. Connect the accessory and expansion boards, one at a time, and check operation.
8. If operation is normal, the problem is in the KPCI-3110 or KPCI-3116 board(s) originally in the computer. Try the KPCI-3110 or KPCI-3116 board(s) one at a time in the computer to determine which is faulty. Use the troubleshooting information in the next section to try to isolate the problem.
9. If you cannot isolate the problem using the general instructions here, refer to Appendix C, "Systematic Problem Isolation" for a more detailed problem isolation scheme.
10. If you cannot isolate the problem after further investigation, refer to page 6-6 for instructions on getting technical support.

Troubleshooting table

If you still experience problems, try using the information in Table 6-1 to isolate and solve the problem. If you cannot identify the problem, refer to "Technical support," starting on page 6-6.

Table 6-1
Troubleshooting problems

Symptom	Possible Cause	Possible Solution
Board does not respond.	The board configuration is incorrect.	Check the configuration of your device driver to ensure that the board name and type are correct.
	The board is incorrectly aligned in a PCI expansion slot.	Check that the slot in which your KPCI-3110 or KPCI-3116 board is located is a PCI slot and that the board is correctly seated in the slot.
	The board is damaged.	Contact Keithley Instruments.
Intermittent operation.	Loose connections or vibrations exist.	Check your wiring and tighten any loose connections or cushion vibration sources.
	The board is overheating.	Check environmental and ambient temperature; consult the board's specifications in the Appendix of this manual and the documentation provided by your computer manufacturer for more information.
	Electrical noise exists.	Check your wiring and either provide better shielding or reroute unshielded wiring.
Data appears to be invalid.	An open connection exists.	Check your wiring and fix any open connections.
	A transducer is not connected to the channel being read.	Check the transducer connections.
	The board is set up for differential inputs while the transducers are wired as single-ended inputs or vice versa.	Check your wiring and ensure that what you specify in software matches your hardware configuration.
Computer does not boot.	Board is not seated properly.	Check that the slot in which your KPCI-3110 or KPCI-3116 board is located is a PCI slot, that the board is correctly seated in the slot, and that the board is secured in the slot with a screw.
	The power supply of the computer is too small to handle all the system resources.	Check the power requirements of your system resources and, if needed, get a larger power supply; consult the board's specifications in the Appendix of this manual.
System lockup.	Board is not seated properly.	Check that the slot in which your KPCI-3110 or KPCI-3116 board is located is a PCI slot, that the board is correctly seated in the slot, and that the board is secured in the slot with a screw. Try another slot, if available.

Testing the board and host computer

To isolate the problem to the KPCI-3110 board or to the host computer, use the following steps.

CAUTION **Removing a board with the power ON can cause damage to your board and/or computer.**

1. Turn the power to the host computer OFF, and remove power connections to the computer.
2. While keeping connections to accessories intact, unplug the cable to the main I/O connector of the KPCI-3110 board.
3. Remove the board from the computer and visually check for damage. If a board is obviously damaged, refer to "Technical support" for information on returning the board.
4. With the KPCI-3110 board out of the computer, check the computer for proper operation. Power up the computer and perform any necessary diagnostics.

At this point, if you have another KPCI-3110 board that you know is functional, you can test the slot and I/O connections using the instructions in the next section. If you do not have another board, call technical support.

Testing the accessory slot and I/O connections

When you are sure that the computer is operating properly, test the computer accessory slot and I/O connections using another KPCI-3110 board that you know is functional. To test the computer accessory slot and the I/O connections, follow these steps:

1. Remove computer power again, and install a KPCI-3110 board that you know is functional. Do not make any I/O connections.
2. Turn computer power ON and check operation with the functional board in place. This test checks the computer accessory slot. If you were using more than one board when the problem occurred, use the functional board to also test the other slot.
3. If the accessory slots are functional, use the functional board to check the I/O connections. Reconnect and check the operation of the I/O connections, one at a time.
4. If operation fails for an I/O connection, check the individual inputs one at a time for shorts and opens.
5. If operation remains normal to this point, the problem is in the KPCI-3110 board(s) originally in the computer. If you were using more than one board, try each board one at a time in the computer to determine which is faulty.
6. If you cannot isolate the problem using the general instructions here, refer to Appendix C, "Systematic Problem Isolation" for a more detailed problem isolation scheme.
7. If you cannot isolate the problem, refer to the following paragraph for information on obtaining technical support.

Technical support

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

1-888-KEITHLEY
Monday - Friday, 8:00 a.m. - 5:00 p.m., Eastern Time

An applications engineer will help you diagnose and resolve your problem over the telephone.

Please make sure you have the following information available before calling the factory for technical support:

KPCI-3110 Board Configuration	Model	____________________
	Serial #	____________________
	Revision code	____________________
	Base address setting	____________________
	Interrupt level setting	____________________
	Number of channels	____________________
Computer	Manufacturer	____________________
	CPU type	____________________
	Clock speed (MHz)	____________________
	KB of RAM	____________________
	Video system	____________________
	BIOS type	____________________
Operating System	DOS version	____________________
	Windows version	____________________
	Windows mode	____________________
Software Package	Name	____________________
	Serial #	____________________
	Version	____________________
	Invoice/Order #	____________________
Compiler (if applicable)	Language	____________________
	Manufacturer	____________________
	Version	____________________
Accessories	Type	____________________
	Type	____________________
	Type	____________________
	Type	____________________
	Type	____________________
	Type	____________________
	Type	____________________
	Type	____________________

Returning equipment to Keithley

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.

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 1-888-KEITHLEY
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.

A
Specifications

Table A-1 lists the specifications for the A/D subsystem on the KPCI-3110 and KPCI-3116 boards.

Table A-1
A/D subsystem specifications

Feature	KPCI-3110 Specifications	KPCI-3116 Specifications
Number of analog input channels Single-ended/ pseudo-differential: Differential:	 32 16	
Number of gains	4 (1, 2, 4, 8)	
Resolution	12 bits	16 bits
Data encoding Bipolar: Unipolar:	 Offset binary Binary	
System accuracy (full-scale) Gain = 1: Gain = 2: Gain = 4: Gain = 8:	 0.03% 0.04% 0.05% 0.05%	 0.01% 0.02% 0.02% 0.03%
Nonlinearity (integral)	±1.0 LSB	±2.0 LSB
Differential linearity	±0.75 LSB (no missing codes)	
Range Bipolar: Unipolar:	 ±10V 0 to 10V	
Drift Zero: Gain:	 ±30μV + (+15μV * Gain)/°C ±30 ppm/°C	 ±20μV + (+10μV * Gain)/°C ±25 ppm/°C
Input impedance Off: On:	 100MΩ, 10pF 100MΩ, 200pF	 100MΩ, 10pF 100MΩ, 200pF
Input bias current	±20nA	
Common mode voltage	±11V maximum (operational)	
Maximum input voltage	±20V maximum (protection)	
A/D converter noise	0.3 LSB rms	0.5 LSB rms
Amplifier input noise	15.0μV rms + (20μV rms * gain) 20.0pA rms (current)	
Channel-to-channel offset	±40.0μV	±30.0μV
Channel acquisition time	1μs to 0.05%	4μs to 0.01%
A/D conversion time	0.8μs	4.0μs
Effective number of bits @ 1kHz sine wave, 2 channels: 10kHz sine wave, 2 channels: sine wave, 2 channels:	 11.7 bits typical (1 MS/s aggregate rate) 11.6 bits typical (1 MS/s aggregate rate) 11.5 bits typical (1 MS/s aggregate rate with sine wave of 40kHz)	 14.4 bits typical (at 150 kS/s aggregate rate) 14.2 bits typical (at 150 kS/s aggregate rate) 13.5 bits typical (at 150 kS/s aggregate rate with sine wave of 20kHz)
Total Harmonic Distortion @ 1kHz input	–71dB typical (at 1.25 MS/s rate)	–82dB typical (at 250 kS/s rate)

Table A-1
A/D subsystem specifications (cont.)

Feature	KPCI-3110 Specifications	KPCI-3116 Specifications
Channel crosstalk	−80 dB @ 1kHz	
Data throughput Single channel: Multiple channel (scan):	 1.25 MSamples/s, 0.03% accuracy 1.0 MSamples/s, 0.05% accuracy 750 kSamples/s, 0.03% accuracy	 250 kSamples/s, 0.01% accuracy 200 kSamples/s, 0.03% accuracy 150 kSamples/s, 0.01% accuracy
External A/D sample clock Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Maximum frequency: Termination:	 Schmitt trigger, falling-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA −1.0µA 100ns (high); 150ns (low) 1.25MHz 22kΩ resistor pullup to 5V	 Schmitt trigger, falling-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA −1.0µA 100ns (high); 150ns (low) 250kHz 22kΩ resistor pullup to 5V
External A/D digital (TTL) trigger Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Termination:	 Schmitt trigger, falling-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA −1.0µA 100ns (high); 100ns (low) 22kΩ resistor pullup to +5V	
External analog trigger Input type: Threshold voltage: Threshold range: Threshold resolution: Hysteresis: Input impedance: Maximum input voltage: Minimum pulse width:	 Threshold sensitive Programmable −10V to +10V (includes TTL) 8 bits/78 mV per LSB 50mV typical 12kΩ/20pF typical ±20V 100ns (high); 100ns (low)	

Table A-1
A/D subsystem specifications (cont.)

Feature	KPCI-3110 Specifications	KPCI-3116 Specifications
A/D sample clock output signal		
Output driver:	ALS244 (TTL)	
Output driver high voltage:	2.0V minimum (I_{OH} = −15mA); 2.4V minimum (I_{OH} = −3mA)	
Output driver low voltage:	0.5V maximum (I_{OL} = 24mA); 0.4V maximum (I_{OL} = 12mA)	
Termination:	22Ω series resistor	
A/D trigger output signal		
Output driver:	ALS244 (TTL)	
Output driver high voltage:	2.0V minimum (I_{OH} = −15mA); 2.4V minimum (I_{OH} = −3mA)	
Output driver low voltage:	0.5V maximum (I_{OL} = 24mA); 0.4V maximum (I_{OL} = 12mA)	
Termination:	22Ω series resistor	
Dynamic Digital Output Channels		
Number of channels:	2	
Output driver:	ALS244 (TTL)	
Output driver high voltage:	2.0V minimum (I_{OH} = −15mA); 2.4V minimum (I_{OH} = −3mA)	
Output driver low voltage:	0.5V maximum (I_{OL} = 24mA); 0.4V maximum (I_{OL} = 12mA)	
Termination:	22Ω series resistor	

Table A-2 lists the specifications for the D/A subsystem on the KPCI-3110 and KPCI-3116 boards.

Table A-2
D/A subsystem specifications

Feature	KPCI-3110 Specifications	KPCI-3116 Specifications
Number of analog output channels	2 (voltage output)	
Resolution	12 bits	16 bits
Data encoding (input)	Offset binary	
Nonlinearity (integral)	±1.0 LSB	±4.0 LSB
Differential linearity	±0.75 LSB (monotonic)	
Output range	±10V (bipolar)	
Error Zero: Gain:	 Adjustable to 0 Adjustable to 0	
Throughput Full scale: 100mV Step, continuously paced: 100mV Step, waveform mode:	 200 kSamples/s maximum per channel 500 kSamples/s maximum per channel (system dependent) 500 kSamples/s maximum per channel	 100 kSamples/s maximum per channel 200 kSamples/s maximum per channel (system dependent) 200 kSamples/s maximum per channel
Current output	±5mA maximum load	
Output impedance	0.1Ω maximum	
Capacitive drive capability	0.004µF (no oscillators)	
Protection	Short circuit to Analog Common	
Power-on voltage	0V ±10mV maximum	
Settling time to 0.01% of FSR	5µs, 20V step; 2.0µs, 100mV step	10µs, 20V step; 5.0µs, 100V step
Slew rate	10V/µs	5V/µs
Filters	-	20kHz (software-selectable)
External D/A sample clock Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Maximum frequency: Termination:	 Schmitt trigger, falling-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA –1.0µA 200ns (high); 150 ns (low) 500kHz 22kΩ resistor pullup to 5V	 Schmitt trigger, falling-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA –1.0µA 200ns (high); 150ns (low) 200kHz 22kΩ resistor pullup to 5V
External D/A digital (TTL) trigger Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Termination:	 Schmitt trigger, edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA –1.0µA 100ns (high); 100ns (low) 22kΩ resistor pullup to +5V	

Table A-3 lists the specifications for the DIN/DOUT subsystems on the KPCI-3110 and KPCI-3116 boards.

Table A-3
DIN/DOUT subsystem specifications

Feature	Specifications
Number of lines	16 (bidirectional)
Number of ports	2 (8 bits each)
Termination	22kΩ resistor pullup to +5V; 22Ω series resistor
Inputs Input type: Input load: High-level input voltage: Low-level input voltage: High-level input current: Low-level input current:	 Level sensitive 1 ALS652 (TTL), 1 ALS374 (TTL) 2.0V minimum 0.8V maximum 20µA –0.2mA
Outputs Output driver: Output driver high voltage: Output driver low voltage:	 ALS652 (TTL) 2.0V minimum (I_{OH} = –15mA); 2.4V minimum (I_{OH} = –3mA) 0.5V maximum (I_{OL} = 24mA); 0.4V maximum (I_{OL} = 12mA)

Table A-4 lists the specifications for the C/T subsystems on the KPCI-3110 and KPCI-3116 boards.

Table A-4
C/T subsystem specifications

Feature	Specifications
Number of counter/timers	4
Clock Inputs Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Maximum frequency: Termination:	 Schmitt trigger, rising-edge sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA –1.0µA 100ns (high); 100ns (low) 5.0MHz 22kΩ resistor pullup to +5V
Gate Inputs Input type: Input load: High-level input voltage: Low-level input voltage: Hysteresis: High-level input current: Low-level input current: Minimum pulse width: Maximum frequency: Termination:	 Schmitt trigger, level sensitive 1 HCT14 (TTL) 2.0V minimum 0.8V maximum 0.4V (minimum); 1.5V (maximum) 1.0µA –1.0µA 100ns (high); 100ns (low) 5.0MHz 22kΩ resistor pullup to +5V
Counter Outputs Output driver: Output driver high voltage: Output driver low voltage: Termination:	 ALS244 (TTL) 2.0V minimum (I_{OH} = –15mA); 2.4V minimum (I_{OH} = –3mA) 0.5V maximum (I_{OL} = 24mA); 0.4V maximum (I_{OL} = 12mA) 22Ω series resistor

Table A-5 lists the power, physical, and environmental specifications for the KPCI-3110 and KPCI-3116 boards.

Table A-5
Power, physical, and environmental specifications

Feature	Specifications
Power	
+5V (±0.25V)	1.5A nominal
– 5V	not used
+12V	0.12A nominal
–12V	0.1A nominal
Physical	
Dimensions:	8.5 inches (length) by 4.2 inches (width)
Weight:	5.95 ounces (170 grams)
Environmental	
Operating temperature range:	0°C to 70°C
Storage temperature range:	–25°C to 85°C
Relative humidity:	To 95%, noncondensing

Table A-6 lists the connector specifications for the KPCI-3110 and KPCI-3116 boards and corresponding cables.

Table A-6
Connector specifications

Feature	Specifications
50-Pin Connector	
Plug for cable:	AMP#787131-1
Cable shell kit:	AMP#787133-2
Termination covers:	AMP#787056-1 (included with kit)
Cable wire:	AMP#57506-1
Receptacle for board:	AMP#787096-1
Latching posts:	AMP#787003-3 (bag of 200)
68-Pin Connector	
Plug for cable:	AMP#787131-3
Cable shell kit:	AMP#787229-2
Termination covers:	AMP#787131-3 (included with kit)
Cable wire:	AMP#57508-1
Receptacle for board:	AMP#787254-1
Latching posts:	AMP#787003-3 (bag of 200)

Supported capabilities

The KPCI-3110 and KPCI-3116 DriverLINX software provides support for analog input (A/D), analog output (D/A), digital input (DIN), digital output (DOUT), and counter/timer (C/T) sub-systems. For information on how to install the device driver, refer to Section 3, "Installation and Configuration."

Table A-7 summarizes the KPCI-3110 and KPCI-3116 capabilities available for use with Driver-LINX. DriverLINX provides functions that return support information for specified subsystem capabilities at runtime.

The first row in the table lists the subsystem types. The first column in the table lists all possible subsystem capabilities. A description of each capability is followed by the parameter used to describe that capability in DriverLINX.

NOTE *Blank fields represent unsupported options.*

For more information, refer to the description of these functions in the DriverLINX online help. See the DriverLINX manuals for information on launching this help file.

Table A-7
KPCI-3110 and KPCI-3116 supported options

	KPCI-3110 and KPCI-3116	A/D	D/A	DIN	DOUT	C/T
	Total Subsystems on Board	**1**	**2[a]**	**2[b]**	**2[b]**	**4**
Data Flow Mode	Single Value Operation Support	Yes	Yes	Yes	Yes	
	Continuous Operation Support	Yes	Yes	No[c]		Yes
	Continuous Operation until Trigger Event Support	Yes				
	Continuous Operation before and after Trigger Event	Yes				
Sim. Oper.	Simultaneous Start List Support	Yes	Yes			
Wind. Mess.	Asynchronous Operation Support	Yes	Yes			Yes
Buffering	Buffer Support	Yes	Yes			
	Single Buffer Wrap Mode Support	Yes	Yes			
	Multiple Buffer Wrap Mode Support	Yes	Yes			
	Inprocess Buffer Flush Support	Yes				
DMA	Number of DMA Channels	0	0	0	0	0
	Supports Gap Free Data with No DMA	Yes	Yes			
Triggered Scan Mode	Triggered Scan Support	Yes				
	Maximum Number of CGL Scans per Trigger	256[d]	0	0	0	0
	Supports Scan per Trigger Event Triggered Scan	Yes				
	Supports Internal Retriggered Triggered Scan	Yes				
	Extra Retrigger Support	Yes				
	Maximum Retrigger Frequency	357.14kHz or 166.67kHz[e]	0	0	0	0
	Minimum Retrigger Frequency	1.2Hz[f]	0	0	0	0

Table A-7
KPCI-3110 and KPCI-3116 supported options (cont.)

	KPCI-3110 and KPCI-3116	A/D	D/A	DIN	DOUT	C/T
	Total Subsystems on Board	**1**	**2[a]**	**2[b]**	**2[b]**	**4**
Channel-Gain List	Maximum Channel Gain List Depth	1024	2	1[c]	1[c]	0
	Sequential Channel Gain List Support	Yes	Yes			
	Zero Start Sequential Channel Gain List Support	Yes	Yes			
	Random Channel-Gain List Support	Yes	Yes			
Gain	Programmable Gain Support	Yes				
	Number of Gains	4	1	1	1	0
Synchronous Digital I/O	Synchronous Digital I/O Support	Yes				
	Maximum Synchronous Digital I/O Value	3	0	0	0	0
I/O Channels	Number of Channels	33[g]	2	1	1	0
Channel Type	SE Support	Yes				
	SE Channels	32	0	0	0	0
	DI Support	Yes	Yes	Yes	Yes	
	DI Channels	16	2	1	1	0
Filters	Filter/Channel Support		Yes[h]			
	Number of Filters	1	2[h]	1	1	0
Ranges	Number of Voltage Ranges	2	1	1	1	0
	Range per Channel Support					
Resolution	Software Programmable Resolution			Yes	Yes	
	Number of Resolutions	1[i]	1[i]	2[j]	2[j]	1
Triggers	Software Trigger Support	Yes	Yes			Yes
	External Trigger Support	Yes[k]	Yes[k]			Yes
	Threshold Trigger Support	Yes	Yes[k]			
	Threshold Trigger Support	Yes[k]	Yes[k]			
	Analog Event Trigger Support					
	Digital Event Trigger Support					
	Timer Event Trigger Support					
	Number of Extra Triggers	3	3	0	0	0

Table A-7
KPCI-3110 and KPCI-3116 supported options (cont.)

	KPCI-3110 and KPCI-3116	A/D	D/A	DIN	DOUT	C/T
	Total Subsystems on Board	**1**	**2[a]**	**2[b]**	**2[b]**	**4**
Clocks	Internal Clock Support	Yes	Yes			Yes
	External Clock Support	Yes	Yes			Yes
	Number of Extra Clocks	0	0	0	0	0
	Base Clock Frequency	20MHz	20MHz	0	0	20MHz
	Maximum External Clock Divider	1.0	1.0	1.0	1.0	65536
	Minimum External Clock Divider	1.0	1.0	1.0	1.0	2.0
	Maximum Throughput	1.25MHz or 250kHz[l]	500kHz or 200kHz[m]	0	0	10MHz[n]
	Minimum Throughput	1.2Hz	1.2Hz	0	0	0.005Hz[o]
Counter/Timers	Cascading Support					Yes
	Event Count Mode Support					Yes
	Generate Rate Mode Support					Yes
	One-Shot Mode Support					Yes
	Repetitive One-Shot Mode Support					Yes
	High to Low Output Pulse Support					Yes
	Low to High Output Pulse Support					Yes
	None (internal) Gate Type Support					Yes
	High Level Gate Type Support					Yes[p]
	Low Level Gate Type Support					Yes[p]
	High Edge Gate Type Support					Yes[p]
	Low Edge Gate Type Support					Yes[p]
Interrupt	Interrupt Support					

a. The second D/A subsystem has limited capabilities and is used for threshold triggering only. It has an output range of -10V to +10V.
b. DIN and DOUT subsystems use the same DIO lines.
c. All 16 bits of the DIO lines are assigned to A/D input channel 32. While the DIN subsystem itself is incapable of continuous operation, continuous DIN operation can be performed by specifying channel 32 in the channel-gain list of the A/D subsystem and starting the A/D subsystem.
d. The channel-gain list depth of 1024 entries in conjunction with a multiscan of 256 provides an effective channel-gain list depth of up to 256K entries.
e. For KPCI-3116 boards, the maximum retrigger frequency is 166.666kHz. For KPCI-3110 boards, the maximum retrigger frequency is 357.14kHz. The maximum retrigger frequency is based on the number of samples per trigger, as follows:

$$\text{Min. Retrigger Period} = \frac{\text{\# of CGL entries x \# of CGLs per trigger}}{\text{A/D sample clock frequency}} + 2\mu s$$

$$\text{Max. Retrigger Frequency} = \frac{1}{\text{Min. Retrigger Period}}$$

f. The value of 1.2Hz assumes the minimum number of samples is 1.
g. Channels 0 to 31 are provided for analog input; channel 32 reads all 16 bits from the DIN subsystem.
h. For the KPCI-3116 board only, a filter of 0kHz or 20kHz is software-selectable for each DAC.
i. For the KPCI-3110 boards, the resolution is 12 bits; for the KPCI-3116 board, the resolution is 16 bits.
j. When configured for 16 bits of resolution, element 0 uses DIO bits 15 to 0 (Banks A and B). When configured for 8 bits of resolution, element 0 uses bits 7 to 0 (Bank A), and element 1 uses bits 15 to 8 (Bank B).
k. If you are using an analog threshold trigger for both A/D and D/A subsystems, both triggers must by of the same type (that is, either both must be from an analog input channel or external analog threshold). However, the polarities of the two triggers can be different.
l. For KPCI-3110 boards, the maximum A/D throughput is 1.25 MSamples/s. For KPCI-3116 boards, the maximum throughput is 250 kSamples/s.

m. Three conditions are possible:
   - 200kHz per DAC (for the KPCI-3110) or 100kHz per DAC (for the KPCI-3116) with full-scale steps in continuously-paced or waveform generation mode.
   - 500kHz per DAC (for the KPCI-3110) or 200kHz per DAC (for the KPCI-3116) with 100mV steps in waveform generation mode.
   - 500kHz per DAC (for the KPCI-3110) or 200kHz per DAC (for the KPCI-3116) with 100mV steps in continuously-paced mode (system-dependent).

n. If using cascaded timers, this value is 5MHz.

o. Any two adjacent counter/timers, such as (1,2) or (2,3) or (3,4), can be cascaded in software.
   If not using cascaded timers, this value is approximately 305.18Hz.

p. High-edge and low-edge are supported for one-shot and repetitive one-shot modes. High-level and low-level are supported for event counting and rate generation modes.

B
Connector Pin Assignments

Table B-1 lists the pin assignments of connector J1 on the KPCI-3110 and KPCI-3116 boards.

Table B-1
Connector J1 pin assignments on the KPCI-3110 and KPCI-3116 boards

Pin Number	Signal Description	Pin Number	Signal Description
1	+5V Ref_Out	2	Reserved
3	Reserved	4	Analog Output 1+
5	Analog Output 0+	6	−15V output
7	+15V output	8	Shield Ground
9	Amp Low	10	Analog Input 23/15
11	Analog Input 22/14	12	Analog Input 21/13
13	Analog Input 20/12	14	Analog Input 19/11
15	Analog Input 18/10	16	Analog Input 17/9
17	Analog Input 16/8	18	Analog Input 7
19	Analog Input 6	20	Analog Input 5
21	Analog Input 4	22	Analog Input 3
23	Analog Input 2	24	Analog Input 1
25	Analog Input 0	26	Analog Ground
27	Reserved	28	Reserved
29	Analog Output 1 Return	30	Analog Output 0 Return
31	Reserved	32	Power Ground
33	Shield Ground	34	Analog Ground
35	Analog Input 31/15 Return	36	Analog Input 30/14 Return
37	Analog Input 29/13 Return	38	Analog Input 28/12 Return
39	Analog Input 27/11 Return	40	Analog Input 26/10 Return
41	Analog Input 25/9 Return	42	Analog Input 24/8 Return
43	Analog Input 15/7 Return	44	Analog Input 14/6 Return
45	Analog Input 13/5 Return	46	Analog Input 12/4 Return
47	Analog Input 11/3 Return	48	Analog Input 10/2 Return
49	Analog Input 9/1 Return	50	Analog Input 8/0 Return

Table B-2 lists the pin assignments of connector J2 on the KPCI-3110 and KPCI-3116 boards.

Table B-2
Connector J2 pin assignments on the KPCI-3110 and KPCI-3116 boards

Pin Number	Signal Description	Pin Number	Signal Description
1	+5V Output	2	+5V Output
3	Reserved	4	A/D Sample Clock Output
5	A/D Trigger Output	6	External A/D TTL Trigger
7	External A/D Sample Clock Input	8	External D/A TTL Trigger
9	External D/A Clock Input	10	User Counter Output 3
11	User Clock Input 3	12	User Counter Output 2
13	User Clock Input 2	14	User Counter Output 1
15	User Clock Input 1	16	User Counter Output 0
17	User Clock Input 0	18	Digital Ground
19	Digital I/O Bank B 3	20	Digital I/O Bank B 2
21	Digital I/O Bank B 1	22	Digital I/O Bank B 0
23	Digital Ground	24	Digital I/O Bank A 3
25	Digital I/O Bank A 2	26	Digital I/O Bank A 1
27	Digital I/O Bank A 0	28	Digital Ground
29	Dynamic Digital Output 1	30	Dynamic Digital Output 0
31	Reserved	32	Reserved
33	Shield Ground	34	Analog Trigger
35	Digital Ground	36	Digital Ground
37	Reserved	38	Digital Ground
39	Digital Ground	40	Digital Ground
41	Digital Ground	42	Digital Ground
43	Digital Ground	44	External Gate 3
45	Digital Ground	46	External Gate 2
47	Digital Ground	48	External Gate 1
49	Digital Ground	50	External Gate 0
51	Digital Ground	52	Digital Ground
53	Digital I/O Bank B 7	54	Digital I/O Bank B 6
55	Digital I/O Bank B 5	56	Digital I/O Bank B 4
57	Digital Ground	58	Digital I/O Bank A 7
59	Digital I/O Bank A 6	60	Digital I/O Bank A 5
61	Digital I/O Bank A 4	62	Digital Ground
63	Digital Ground	64	Digital Ground
65	Reserved	66	Reserved
67	Shield Ground	68	Analog Trigger Return

Table B-3 lists the screw terminal assignments for connector J1 on the STP-3110 screw terminal panel.

Table B-3
Pin assignments for connector J1 on the STP-3110

TB #	J1 Pin #	Description	TB #	J1 Pin #	Description
1	25	Analog In 0/0	2	50	Analog In 8/0 Return
3	24	Analog In 1/1	4	49	Analog In 9/1 Return
5	23	Analog In 2/2	6	48	Analog In 10/2 Return
7	22	Analog In 3/3	8	47	Analog In 11/3 Return
9	21	Analog In 4/4	10	46	Analog In 12/4 Return
11	20	Analog In 5/5	12	45	Analog In 13/5 Return
13	19	Analog In 6/6	14	44	Analog In 14/6 Return
15	18	Analog In 7/7	16	43	Analog In 15/7 Return
17	17	Analog In 16/8	18	42	Analog In 24/8 Return
19	16	Analog In 17/9	20	41	Analog In 25/9 Return
21	15	Analog In 18/10	22	40	Analog In 26/10 Return
23	14	Analog In 19/11	24	39	Analog In 27/11 Return
25	13	Analog In 20/12	26	38	Analog In 28/12 Return
27	12	Analog In 21/13	28	37	Analog In 29/13 Return
29	11	Analog In 22/14	30	36	Analog In 30/14 Return
31	10	Analog In 23/15	32	35	Analog In 31/15 Return
33	9	Amp Low	34	34	Analog Ground
35	8	Analog Shield Ground	36	33	Analog Shield Ground
37	7	+15V Output	38	32	Power Ground
39	6	−15V Output	40	31	Reserved
41	5	Analog Output 0+	42	30	Analog Output 0 Return
43	4	Analog Output 1+	44	29	Analog Output 1 Return
45	3	Reserved	46	28	Reserved
47	2	Reserved	48	27	Reserved
49	1	+5V Reference Out	50	26	Analog Ground
51	-	Analog Shield Ground	52	-	Analog Shield Ground
53	-	Analog Shield Ground	54	-	Analog Shield Ground
55	-	Analog Shield Ground	56	-	Analog Shield Ground

NOTE *For analog input channels (TB1-32), two values are shown. The value before the slash is the assignment in single-ended and pseudo-differential configurations when 32 channels are available. The value after the slash applies to differential configurations, when 16 channels are available and each channel has a separate return.*

In particular, be aware that when changing to/from differential configuration, the high side of channels 8-15 must be moved to a different terminal.

Table B-4 lists the screw terminal assignments for connector J2 on the STP-3110 screw terminal panel.

Table B-4
Screw terminal assignments for connector J2 on the STP-3110 screw terminal panel

TB #	J2 Pin #	Description	TB #	J2 Pin #	Description
57	51, 52	Digital Ground	58	17	User Clock Input 0
59	16	User Counter Output 0	60	50	External Gate 0
61	49	Digital Ground	62	15	User Clock Input 1
63	14	User Counter Output 1	64	48	External Gate 1
65	47	Digital Ground	66	13	User Clock Input 2
67	12	User Counter Output 2	68	46	External Gate 2
69	45	Digital Ground	70	11	User Clock Input 3
71	10	User Counter Output 3	72	44	External Gate 3
73	43	Digital Ground	74	9	External D/A Sample Clock In
75	8	External D/A TTL Trigger	76	7	External A/D Sample Clock In
77	6	External A/D TTL Trigger	78	5	A/D Trigger Out
79	4	A/D Sample Clock Out	80	3	Reserved
81	23, 28, 42	Digital Ground	82	39, 41, 57, 62	Digital Ground
83	18, 38, 40, 63, 64	Digital Ground	84	65	Reserved
85	31	Reserved	86	37	Reserved
87	30	Dynamic Digital Output 0	88	29	Dynamic Digital Output 1
89	27	Digital I/O Bank A 0	90	26	Digital I/O Bank A 1
91	25	Digital I/O Bank A 2	92	24	Digital I/O Bank A 3
93	61	Digital I/O Bank A 4	94	60	Digital I/O Bank A 5
95	59	Digital I/O Bank A 6	96	58	Digital I/O Bank A 7
97	22	Digital I/O Bank B 0	98	21	Digital I/O Bank B 1
99	20	Digital I/O Bank B 2	100	19	Digital I/O Bank B 3
101	56	Digital I/O Bank B 4	102	55	Digital I/O Bank B 5
103	54	Digital I/O Bank B 6	104	53	Digital I/O Bank B 7
105	33	Digital Shield Ground	106	68	Analog Ground
107	34	Analog Trigger	108	67	Digital Shield Ground
109	32	Reserved	110	66	Reserved
111	35, 36	Digital Ground	112	1, 2	+5V Out

C
Systematic Problem Isolation

Problem isolation schemes

If you were unable to isolate the problem by using Section 6, then try to isolate the problem systematically using the schemes detailed in this Appendix.

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 most 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. One particular scheme may not alone 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(s) 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 issues.
- 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," unless you have been directed otherwise in this manual.

CAUTION **Always turn OFF your computer and any external circuits connected to the KPCI-3110 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.

In the following procedure, the term "board" always refers to a KPCI-3110 or KPCI-3116 board. The procedure never directs you to install or remove any type of board other than a KPCI-3110 or KPCI-3116 board.

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. If you attempt to use schemes independently, you 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-3110 or KPCI-3116 board(s) and check 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-3110 or KPCI-3116 board(s).

Follow these instructions as you perform Scheme A:

1. Remove and inspect the KPCI-3110 or KPCI-3116 board(s) 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-3110 or KPCI-3116 board(s) that is installed.
   c. Disconnect STP-3110 screw terminal accessories from your KPCI-3110 or KPCI-3116 board(s).
   d. Remove the KPCI-3110 or KPCI-3116 boards from the computer, making note of the socket(s) in which the board(s) was installed. (If more than one KPCI-3110 or KPCI-3116 board is installed, remove all boards and note which board was in which socket.)
   e. Visually inspect all removed KPCI-3110 or KPCI-3116 board(s) for damage.
2. Based on the results of step 1, do the following:
   - If the board(s) you removed 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 "Problem isolation Scheme G: verification of problem solution."
   - If the board(s) you removed is not obviously damaged, then continue with step 3 and check for host computer malfunction.
3. Check if the computer functions satisfactorily by itself. Proceed as follows:
   a. Place the board(s) that you removed from the computer 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:
   - If you find no computer or operating system malfunctions in step 3, then the problem likely lies elsewhere; take action as follows:
     – If you do not have another KPCI-3110 or KPCI-3116 board that you know is working properly, read the instructions in Section 6, "Technical support." Then contact Keithley for help in isolating the cause of your problem.
     – If you have another KPCI-3110 or KPCI-3116 board that you know is working properly, then continue with step 5.
   - If you find computer or operating system malfunctions in step 3, do the following:
     a. Determine the cause of the computer hardware or operating system malfunctions.
     b. Fix the computer hardware or operating system malfunctions.
     c. Assume that fixing the malfunctions has solved your problem, and skip to "Problem isolation Scheme G: verification of problem solution."

5. Determine the PCI resources detected by your computer before any KPCI-3110 or KPCI-3116 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 saying at the bottom: **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.
6. Install a good board—a KPCI-3110 or KPCI-3116 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 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-3110 or KPCI-3116 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.
8. 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.
9. If you removed KPCI-3110 or KPCI-3116 boards from other PCI slots in step 1, then repeat steps 6 and 7 with the good board in each of these other slots.

10. 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 "Problem isolation Scheme B: installation."
    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 "Problem isolation Scheme D: expansion slot connectors."

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.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

Follow these 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 16; DriverLINX and your board are installed properly and are working together.
        - A KPCI-3110 or KPCI-3116 board is the only board in your computer installed under DriverLINX.
        - The DriverLINX Analog I/O Panel appears with the **KPCI3110 or KPCI-3116** board listed under **Driver Selection.**
    - Case B — If all three of the following statements are true, then skip to step 16; 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, but perhaps 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.
        - To change the tabs at the top of the screen use the tiny buttons next to the text boxes: 1) select the board driver under **Driver Selection** to be **KPCI3110 or KPCI-3116** and 2) select the correct device number under **Device Selection**, which is **0** if only one KPCI-3110 or KPCI-3116 board is installed.
    - 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 the 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 Section 6, "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-3110 or KPCI-3116 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-3110 or KPCI-3116 board. More than one KPCI-3110 or KPCI-3116 board may be listed here if you installed more than one KPCI-3110 or KPCI-3116 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. If you find a KPCI-3110 or KPCI-3116 board listed with an exclamation point over it, keep the Device Manager open and go directly to step 5. Skip substeps 4g through 4j.
      - 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. However, this is not by itself a sufficient indication in at least one situation. Therefore, if you find that *all* of your KPCI-3110 or KPCI-3116 boards are listed in the Device Manager 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.
      - If the list of devices in the Device Manager includes an **? Other Devices** item, also click the **+** sign to the left of this item. If a KPCI-3110 or KPCI-3116 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-3110 or KPCI-3116 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.

i. Inspect the DriverLINX Configuration Panel.
   - If you see the following on the screen for a KPCI-3110 or KPCI-3116 board, then the board is recognized as a device under DriverLINX but is **not** properly configured:
     – **Keithley KPCI-3110** or **KPCI-3116** is listed under DriverLINX.
     – The amplifier icon next to **Keithley KPCI-3110 or KPCI-3116** board listing is colored yellow.
     – The specific board part number(s) of the unconfigured Keithley KPCI-3110 or KPCI-3116 board(s) is listed under Keithley KPCI-3110 or KPCI-3116.
     – The lamp icon next to the specific board part number is uncolored.
   - If you see the following on the screen for a KPCI-3110 or KPCI-3116 board, then the board is recognized as a device under DriverLINX and *is* properly configured:
     – Your **Keithley KPCI-3110** or **KPCI-3116 Board** is listed under DriverLINX.
     – The amplifier icon next to **Keithley KPCI-3110 or KPCI-3116** listing is colored pale gray.
     – A device number — for example, **Device0** (or **Device1, Device2,** etc.)— is listed under your **Keithley KPCI-3110 or KPCI-3116** board, 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-3110 or KPCI-3116 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-3110 or KPCI-3116 boards is listed under **? Other Devices**, or is listed in the Device Manager at multiple places, then the installation is faulty. 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 "Problem isolation Scheme A: basic system," 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 Section 6, "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-3110 or KPCI-3116 board by clicking on its part number. An unconfigured KPCI-3110 or KPCI-3116 board may be identified as follows:
      - The specific board part number of the unconfigured Keithley KPCI-3110 or KPCI-3116 board is listed under **Keithley KPCI-3110 or KPCI-3116**.
      - The lamp icon next to the specific board part number is uncolored.
      - The amplifier icon next to **Keithley KPCI-3110 or KPCI-3116** is colored yellow.
   b. Click the **Configure** button. The Select Logical Device dialog box appears.
   c. Select your next action based on the criteria given in the following alternatives:
      - If only one KPCI-3110 or KPCI-3116 board is installed, a default device number of **0** in the text box is correct. Click **OK**.
      - If other KPCI-3110 or KPCI-3116 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**.
   d. The Configure DriverLINX Device dialog box appears, as well as the Device Manager.
   e. No changes in the Device dialog box changes are normally required. Click **OK**.
   f. If a Device Change message appears, then click **OK**.
   g. 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.
   h. Close out all programs and reboot your computer to complete the configuration process.
   i. Open and check the Device Manager as you did in step 4. Your KPCI-3110 or KPCI-3116 board(s) should now be listed under the DriverLINX with no exclamation mark over it.
   j. 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-3110 or KPCI-3116**. Refer back to step 4.
      - 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-3110 or KPCI-3116 boards physically.

NOTE *You should remove all KPCI-3110 or KPCI-3116 boards before reinstalling the KPCI-3110 and KPCI-3116 version of DriverLINX, because the installation order is DriverLINX first, board second. If a KPCI-3110 or KPCI-3116 board is present, physically or in the computer list of devices, driver installation difficulties may occur.*

10. Proceed as follows:
    a. Turn off the computer.
    b. Remove all KPCI-3110 or KPCI-3116 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.**

11. Remove all KPCI-3110 or KPCI-3116 boards from the list of devices in your system. If your operating system is Windows 95/98, remove the KPCI-3110 or KPCI-3116 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.
    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-3110 or KPCI-3116 board. More than one KPCI-3110 or KPCI-3116 board may be listed if you previously installed more than one KPCI-3110 or KPCI-3116 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-3110 or KPCI-3116 board listed under this item if it is not properly recognized by DriverLINX.
    d. Select any one of the KPCI-3110 or KPCI-3116 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-3110 or KPCI-3116 board was listed in the Device Manager, or if the same board was listed in more than one place, then repeat substeps d, e, and f of step 10 until no KPCI-3110 or KPCI-3116 boards are listed anywhere in the Device Manager.
12. Uninstall *only* the KPCI-3110 or KPCI-3116 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 3110 or KPCI-3116**.

NOTE *Uninstall only* **DriverLINX for Keithley 3110 or KPCI-3116**. *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.**

13. Reinstall DriverLINX, referring to the brief DriverLINX installation instructions on the Read This First sheet that was shipped with your KPCI-3110 or KPCI-3116 board and is also provided on the CD-ROM containing this manual. Make sure that DriverLINX installs smoothly and completely.
14. 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.*

15. 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 the manual.
    c. Turn ON and reboot the computer.
    d. Run the procedure for configuring the board to work with DriverLINX, in Section 3.
    e. Return to step 1 and run the installation check again.
16. 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-3110 or KPCI-3116 board are installed correctly. Return to Section 3 and finish installing your data acquisition system.
    - 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 go to "Problem isolation Scheme G: verification of problem solution."
    - 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 "Problem isolation Scheme C: application software" 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, you temporarily installed a KPCI-3110 or KPCI-3116 board that is known to be good in place of a KPCI-3110 or KPCI-3116 board that you removed from the computer. This substitution, still in place, eliminates possible board I/O problems during Scheme C. You now perform I/O tests using your application software. You debug custom code, if necessary, and recheck.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

Follow these instructions as you perform Scheme C:

1. Perform the procedure outlined in the "Analog input hardware test," found later in this appendix.
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 AND your board does *not* have analog outputs, skip to step 5.
   - If your software appears to be working properly AND your board has analog outputs, continue with step 3.
3. Perform the procedure outlined in the "Analog output hardware test" found later in this appendix.
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 "General-purpose digital I/O hardware test" found later in this appendix.
6. Based on the results of the "General-purpose digital I/O hardware 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—if you experienced no problems in the tests at any point—then the problem you originally experienced must lie elsewhere. Go to "Problem isolation Scheme E: user wiring" and check your external connections.
   - If you reached this point by having to modify the custom software or reinstall the commercial software—if you no longer experience problems in the tests—then assume that you have solved the original problem. Go to "Problem isolation Scheme G: verification of problem solution" 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 Section 6, "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 after 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 none or only one of the above statements are true, then continue with step 11, and selectively redo I/O software tests.
11. Select your next step in Scheme C based on the criteria given in the following alternatives:
    - If you have done the analog input software test at least once AND your software did not pass the analog input software test the last time, then return to step 1 and redo that test.
    - If you have done the analog input software test at least once AND your software passed the analog input software test the last time, then 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 all three of the following apply, then return to step 3 and redo the analog output software test:
      – Your board has analog outputs.
      – You have done the analog output software test at least once.
      – Your software did not pass the analog output software test the last time you tried.
    - If all three of the following apply, then assume that you do not need to repeat the analog output software test. However, by process of elimination, you failed the digital I/O software test the last time you tried. Go to step 5 and repeat the digital I/O software test.
      – Your board has analog outputs.
      – You have done the analog output software test at least once.
      – Your software passed the analog output software test the last time you tried.
    - If your board does not have analog outputs then by process of elimination, you failed the digital I/O software test the last time you tried. Go to step 5 and repeat 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-3110 or KPCI-3116 version of DriverLINX. For example, not all versions of TestPoint will work with KPCI-3110 or KPCI-3116 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 Section 6, "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.

Problem isolation Scheme D: expansion slot connectors

In Scheme D, you further check and try to remedy apparent expansion slot malfunctions.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

1. Remove computer power again, and install a KPCI-3110 or KPCI-3116 board that you know is functional. Do not make any I/O connections.
2. Turn computer power on and check operation with the functional board in place. This test checks the computer accessory slot. If you were using more than one board when the problem occurred, use the functional board to also test the other slot.
3. If the accessory slots are functional, use the functional board to check the I/O connections. Reconnect and check the operation of the I/O connections, one at a time.
4. If operation fails for an I/O connection, check the individual inputs one at a time for shorts and opens.
5. If operation remains normal to this point, the problem is in the KPCI-3110 or KPCI-3116 board(s) originally in the computer. If you were using more than one board, try each board one at a time in the computer to determine which is faulty.

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.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

Follow these 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-3110 or KPCI-3116 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 "Problem isolation Scheme G: verification of problem solution."
   - If all external I/O connections are found to be normal, then, by process of elimination, the KPCI-3110 or KPCI-3116 board(s) originally installed in the computer is likely the cause of the problem. Continue with "Problem isolation Scheme F: the board."

Problem isolation Scheme F: the board

In Scheme F, after having eliminated other problem causes, you assume that KPCI-3110 or KPCI-3116 hardware malfunctions are at fault. If only one KPCI-3110 or KPCI-3116 board was installed, you replace or repair it. If more than one KPCI-3110 or KPCI-3116 board was installed, you use PCI connection tests, and if necessary I/O tests, to find which board is bad.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

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.

NOTE *This is not a stand-alone procedure. Use it only when it is called for by another procedure.*

Follow these 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-3110 or KPCI-3116 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 and Configuration."
   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 2, 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 Section 6, "Technical support," and then contact Keithley for help in isolating the cause of your problem.

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 procedure. However, they may also be used at any time for general functional checks of your KPCI-3110 or KPCI-3116 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-3110 or KPCI-3116 channel 01 is measured using the on-screen digital voltmeter utility that is supplied with DriverLINX. In the same way, channel 00 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-3110 or KPCI-3116 board, 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 C-1 for more details.
- (Optional) A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) to accurately determine the voltage of the voltage source.
- An STP-3110 screw terminal accessory wired as shown in Table C-1. (These are the same connections as made for the analog input *software* 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 C-1
Wiring for analog input hardware test using an STP-3110 screw terminal accessory connected to the analog I/O connections

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	TB1 (Analog In 0 [pin 25])	TB34 (Analog Ground [Pin 34])
<+5V from one of the following: A battery An isolated power supply A voltage divider — e.g. 10kΩ or 20kΩ— between the +5V board power output (terminal TB49 [pin 1]) and analog ground (terminal TB34 [pin 34]) *	TB3 (Analog In 1 [pin 24])	TB34 (Analog Ground [pin 34])

*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-3110 or KPCI-3116.
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.

NOTE *If more than one type of board is installed in your computer under DriverLINX, the Analog I/O Panel, your board type and device number may not be displayed initially, and fewer tabs may be displayed at the top of the display. If so, click the scroll buttons next to the Driver Selection and Device Selection text boxes until your KPCI-3110 or KPCI-3116 board type and device number are displayed. All six tabs will then be displayed.*

8. Click the **Meter** tab. An on-screen digital voltmeter appears, displaying the voltage connected to Channel 00. Because Channel 00 is grounded, the displayed voltage should be nominally zero.
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.*

10. The on-screen digital voltmeter now displays the voltage connected to channel 01.
11. Based on the displayed voltages in step 8 and step 9, act as follows:
    - If the channel 00 voltage displayed in step 8 is not 0V and/or if the channel 01 voltage displayed in step 9 does not nominally agree with the applied voltage, then your board apparently has analog input problems. Stop here, and return to the problem isolation step in "Problem isolation Scheme F: the board," that asked you to perform the Analog input hardware test.
    - If the channel 00 voltage displayed in step 8 is 0V and the channel 01 voltage displayed in step 9 nominally agrees with the applied voltage, then the analog inputs are apparently satisfactorily. Stop here, and return to the problem isolation step in "Problem isolation Scheme F: the board," that asked you to perform the Analog input hardware test.

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."*

Analog output hardware test

This test applies only to a board having analog outputs.The analog output test checks whether the two digital-to-analog converters (DACs) of the board 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-3110 or KPCI-3116 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-3110 screw terminal accessory, to which you connect the DVM/DMM as indicated in Table C-2.These are the same connections as made for the analog output *software* 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 C-2
Terminals on STP-3110 screw terminal accessory to which DVM/DMM will be connected during analog output hardware test

To check this analog output…	…the DVM or DMM will be connected to these terminals	
	Analog output screw terminal	**Analog-ground screw terminal**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]
Analog output 1+ [pin 4]	TB43	TB50 [pin 26]

CAUTION **The following test procedure involves changing DVM/DMM connections while the computer and KPCI-3110 or KPCI-3116 board are powered. Take care not to short analog outputs to the adjacent +10V reference terminal or nearby ground terminal. 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, using 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.
3. Connect the STP-3110 screw terminal accessory to the KPCI-3110 or KPCI-3116 J1 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.

NOTE *If more than one type of board is installed in your computer under DriverLINX, the Analog I/O, your board type and device number may not be displayed initially, and fewer tabs may be displayed at the top of the screen. If so, click the scroll buttons next to the* **Driver Selection** *and* **Device Selection** *text boxes until your KPCI-3110 or KPCI-3116 board type and device number are displayed. All six tabs will then be displayed.*

7. Click the **Level Control** tab. The on-screen analog-output level control appears.
8. Using your mouse, slide the CH0 level control button until the tiny display at the bottom of the level control reads **0.0** (volts).
9. In the same way, set the CH1 level control so that its tiny display reads **0.0** (volts).

10. Measure and compare the analog output voltages as indicated in Table C-3:
    a. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM.
    b. Compare the voltages you measured in step 10a with the voltages you set via the analog-output level control.

Table C-3
Test connections and correct readings for zero-voltage analog output, using an STP-3110 screw terminal accessory connected to J1.

To test this analog output…	…connect the DVM or DMM to these terminals on an STP-3110 accessory:		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	**Analog-ground screw terminal**	**Level control setting**	**Voltage reading at DVM or DMM**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]	0.0V	0.0V
Analog output 1+ [pin 4]	TB43		0.0V	0.0V

11. 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.
12. Measure and compare the analog output voltages as indicated in Table C-4:
    a. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM.
    b. Compare the voltages you measured in step 12a with the voltages you set via the analog-output level control.

Table C-4
Test connections and correct readings for mid-range analog output, using an STP-3110 screw terminal accessory connected to the J1 connector

To test this analog output…	…connect the DVM or DMM to these terminals on an STP-3110 accessory:		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	**Analog-ground screw terminal**	**Level control setting**	**Voltage reading at DVM or DMM**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]	5.0V	5.0V
Analog output 1+ [pin 4]	TB43		5.0V	5.0V

13. Based on the measured voltages in step 10 and step 12, 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. Stop here, and return to the problem isolation step in "Problem isolation Scheme F: the board," that asked you to perform the Analog output hardware test.
    - If the voltages measured with the DVM/DMM agree with level control settings, then the analog outputs are working satisfactorily. Stop here, and return to the problem isolation step in "Problem isolation Scheme F: the board," that asked you to perform the Analog output hardware test.

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."*

General-purpose digital I/O hardware test

This test checks whether the general-purpose digital input and output circuits of the board are operating properly.

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-3110 screw terminal accessory in the loop-back configuration. 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.

The following summarizes the test procedure:

- Wire an STP-3110 screw terminal accessory in a loop-back configuration. Connect the channel 0 digital I/O terminals, bit-for-bit, to the channel 3 digital I/O terminals. Connect the channel 1 terminals, bit-for-bit, to the channel 2 terminals.
- Using a DriverLINX graphical interface, configure the channel 0 and 1 bits as outputs and the channel 2 and 3 bits as inputs.
- Using the same DriverLINX graphical interface, set the channel 0 and 1 outputs in a particular bit pattern and check channels 2 and 3 inputs for the same bit pattern. Repeat, using a second bit pattern.

The digital I/O of the board is performing satisfactorily if all bits respond appropriately. Choose bit patterns that check both for direct ON/OFF response and for shorts between bits.

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-3110 or KPCI-3116 board known to work properly, thereby bypassing potential board problems. These tests are intended to be used when specified in the preceding systematic problem isolation 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 analog 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-3110 or KPCI-3116 board, via the required screw terminal accessory, except for analog input connections specified for the test.*

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 C-5 for more details.
- (Optional) A Digital Voltmeter (DVM) or a Digital Multimeter (DMM) to accurately determine the voltage of the voltage source.
- An STP-3110 screw terminal accessory wired as shown in Table C-5. 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 C-5
Wiring for analog input hardware test using an STP-3110 screw terminal accessory connected to the Analog I/O connections

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	TB1 (Analog In 0 [pin 25])	TB34 (Analog Ground [Pin 34])
<+5V from one of the following: A battery An isolated power supply A voltage divider — e.g. 10kΩ or 20kΩ— between the +5V board power output (terminal TB37 [pin 7]) and analog ground (terminal TB34 [pin 34]) *	TB3 (Analog In 1 [pin 24])	TB34 (Analog Ground [pin 34])

*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 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-3110 or KPCI-3116 board J1.
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 00 and 01 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. Stop here, and return to the systematic problem isolation Scheme C, step 1, where you were directed to do analog input software tests.
   - 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. Stop here, and return to the systematic problem isolation Scheme C, step 1, where you were directed to do analog input software tests.

Analog output software test

This test applies only to a board having analog outputs.This basic analog input test checks whether your application software correctly sets direct current (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-3110 or KPCI-3116 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.

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-3110 screw terminal accessory, to which you connect the DVM/DMM as indicated in Table C-6. These are the same connections as made for the analog output *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 C-6
Terminals on STP-3110 screw terminal accessory to which DVM/DMM will be connected during analog output hardware test

To check this analog output…	…the DVM or DMM will be connected to these terminals	
	Analog output screw terminal	**Analog-ground screw terminal**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]
Analog output 1+ [pin 4]	TB43	TB50 [pin 26]

CAUTION **The following test procedure involves changing DVM/DMM connections while the computer and KPCI-3110 or KPCI-3116 board are powered. Be careful not to short analog outputs to the adjacent +10V reference terminal or nearby ground 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 C-7.
3. Connect the STP-3110 screw terminal accessory to the KPCI-3110 or KPCI-3116 board.
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 output 0V at analog outputs 0 and 1.

7. Measure and compare the analog output voltages as indicated in Table C-7:
   a. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM.
   b. Compare the voltages you measured in step 7a with the voltages you set via the analog-output level control.

Table C-7
Test connections and correct readings for zero-voltage analog output, using an STP-3110 screw terminal accessory connected to J1.

To test this analog output…	…connect the DVM or DMM to these terminals on an STP-3110 accessory:		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	**Analog-ground screw terminal**	**Level control setting**	**Voltage reading at DVM or DMM**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]	0.0V	0.0V
Analog output 1+ [pin 4]	TB43		0.0V	0.0V

8. Set your application software to output +5V at analog outputs 0 and 1.
9. Measure and compare the analog output voltages as indicated in Table C-8:
   a. Measure the voltages at analog outputs 0 and 1 with your DVM/DMM.
   b. Compare the voltages you measured in step 9a with the voltages you set via the analog-output level control.

Table C-8
Test connections and correct readings for mid-range analog output, using an STP-3110 screw terminal accessory connected to the KPCI-3110 or KPCI-3116 board.

To test this analog output…	…connect the DVM or DMM to these terminals on an STP-3110 accessory:		If board works correctly, the following voltages should agree:	
	Analog output screw terminal	**Analog-ground screw terminal**	**Level control setting**	**Voltage reading at DVM or DMM**
Analog output 0+ [pin 5]	TB41	TB50 [pin 26]	5.0V	5.0V
Analog output 1+ [pin 4]	TB43		5.0V	5.0V

10. Based on the measured voltages in step 7 and step 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. Stop here, and return to step 3 of "Problem isolation Scheme C: application software," where you were directed to do analog output software tests.
    - 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 step 3 of "Problem isolation Scheme C: application software," where you were directed to do analog output software tests.

General-purpose digital I/O software test

This test checks whether your application software is performing general-purpose digital I/O functions properly.

Test summary

The following summarizes the test procedure:

- Wire an STP-3110 screw terminal accessory in a loop-back configuration. Connect the channel 0 general-purpose digital I/O terminals, bit-for-bit, to the channel 3 general-purpose digital I/O terminals. Connect the channel 1 terminals, bit-for-bit, to the channel 2 terminals. (These are the same loop-back connections as made for the general-purpose digital I/O *hardware* test.)
- Using your application software, set the channel 0 and 1 outputs in a particular alternating OFF-ON bit pattern and check channels 2 and 3 inputs for the same bit pattern. Repeat, using a second ON-OFF bit pattern.

Your application software is performing general-purpose digital I/O satisfactorily if all bits respond appropriately.

Equipment for general-purpose digital I/O software test

All I/O is set and read using your application software; no instruments are required. However, you must wire an STP-3110 screw terminal accessory to J2 in the loop-back configuration. 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.

Procedure for general-purpose digital I/O software test

NOTE *The bit patterns prescribed in this procedure are shown graphically as follows:*

- *OFF bits appear as white squares*
- *ON bits appear as green squares when the manual is viewed in color or as light gray squares when the manual is viewed in black and white.*

Perform the I/O hardware test as follows:

1. Turn off the host computer
2. If a screw terminal accessory is attached to the J2 connector of the KPCI-3110 or KPCI-3116 I/O board, remove it. No circuits should be connected to Analog I/O connections during these tests.
3. Attach the wired screw terminal accessory.
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 configure and monitor general-purpose digital I/O bits.

7. Using your application software, do the following:
   a. Configure general-purpose bits 0 to 7 (channel 1) as outputs.
   b. Configure general-purpose bits 8 to 15 (channel 2) as Inputs.
8. Using your application software, configure bits 0 to 7 (channel 1) for an alternating OFF-ON bit pattern
9. Using your application software, observe the channel 2 input bits.
   - If the observed channel 2 output bit pattern is not the same as the pattern you input, your application software is not performing general-purpose digital I/O functions properly. Stop here, and return to step 5 of "Problem isolation Scheme C: application software," procedure.
   - If the observed channel 2 input bit pattern is the same OFF-ON pattern, continue with step 10.
10. Using your application software, configure bits 0 to 7 (channel 1) for an alternating ON-OFF bit pattern.
11. Using your application software, observe the channel 2 input bits.
12. If the observed channel 2 input bit pattern is not the same ON-OFF pattern, your application software is not performing general-purpose digital I/O functions properly. Stop here, and return to step 5 of "Problem isolation Scheme C: application software," procedure.
    - If the observed channel 2 input bit pattern is the same ON-OFF pattern, continue with step 13.
13. Using your application software, repeat the procedure for channels 1 and 3 with OFF-ON and ON-OFF bit patterns.
14. If the observed channel 3 input bit pattern is not the same ON-OFF pattern, your application software is not performing general-purpose digital I/O functions properly. Stop here, and return to step 5 of "Problem isolation Scheme C: application software," procedure.
    - If the observed channel 3 input bit pattern is the same pattern, your application software is performing general-purpose digital I/O functions properly. Stop here, and return to step 5 of "Problem isolation Scheme C: application software," procedure.

D

Using Your Own Screw Terminal Panel

Data acquisition boards can perform only as well as the input connections and signal integrity you provide. If you choose not to use the STP-3110 screw terminal panel, considerations must be given as to how the signals interact in the real world as well as how they interact with each other.

This appendix describes additional considerations to keep in mind when designing your own screw terminal panel for use with a KPCI-3110 or KPCI-3116 board.

Analog inputs

Typical data acquisition boards have three different types of analog input configurations that you can use:

- Single-ended
- Pseudo-differential
- Differential

Single-ended inputs

With single-ended inputs, you have the maximum number of inputs but have the worst-case noise immunity without external signal conditioning.

The major problem with this configuration it that you need a common ground between the external inputs and the data acquisition board. Even with conditioning, consideration must be given to the cable length and how the cable is routed. If the cable is over three feet, you must consider the ringing and cross-talk in the cable. A typical cable has 30pF per foot of capacitance. If the source impedance is 1,000Ω and the cable is three feet, then the cross talk based on the source impedance is 1,000Ω x (30pF x 3 ft) = 90 ns.

This seems negligible, but when you consider that it requires nine time constants to settle within 0.01%, the cross-talk becomes almost 10% of the time required to settle when switching channels at 100kHz.

Coupling must also be considered when adjacent channels have high-speed signals, especially if these signals are TTL-type with high-speed edges.

Pseudo-differential inputs

Pseudo-differential inputs allow one common-mode voltage for all single-ended inputs. With this type of connection, the low side of the instrumentation amplifier is used to sense an external common-mode voltage. For example, if you have a signal-conditioning rack, the AMP LOW signal connects to the analog common of the external rack.

The pseudo-differential configuration allows you to use the maximum number of input channels, while placing an impedance between the external ground and the data acquisition ground or analog common. Even if it is 100Ω, this impedance provides the bias return currents for the inputs and causes only 10mA of current to flow with a ground potential difference of 1V. (The input bias current is typically in milliamperes.) This is usually manageable by the common-mode range of the instrumentation amplifier and analog ground system. Consider the problems with 1Ω of impedance between 1V of potential difference. The resulting 1A of current causes many problems in the analog signal integrity.

If it is provided and not used, ensure that you connect AMP LOW to the analog common of the data acquisition board or to ground when running in single-ended mode.

Differential inputs

Differential inputs offer the maximum noise rejection at the expense of half your total channel count. For the best results, shielded twisted pairs are a must. The shield must connect at one end so that ground currents do not travel over the shield. In low-level voltage applications, differential inputs reduce problems not only due to electrostatic and magnetic noise, but due to cross-talk and thermal errors.

One problem to consider with differential inputs is the bias current error. The differential impedance is usually hundreds of megaohms. With a very small bias current multiplied by this high input impedance, the voltage produced is out of the common-mode input range of the instrumentation amplifier.

An external resistor must be provided to return this bias current to the analog common of the data acquisition board. This resistor is typically in the order of 1kΩ to 100kΩ from the input low side to analog common. Alternatively, the external common can be returned through a 10Ω to 100kΩ resistor to analog common (it cannot be Ω due to ground currents).

Analog outputs

Most data acquisition boards have a minimum of two analog output channels, with a resolution of 12 to 16 bits (even though the accuracy may be less).

On all Keithley boards, we ensure that the analog outputs do not break into a high frequency oscillation with high capacitance loads that may be experienced with long cables. Typically, the analog outputs drive 1,000pF without degradation and bandwidth-limit with higher capacitive loads.

The grounds of most boards are optimized for analog inputs at the expense of some logic or high-frequency noise on the analog outputs. This is because the analog and digital grounds of the board are connected at the ADC's input.

The analog outputs are brought out as a high and a low signal, but the low side is the analog ground at the DAC's output buffer. To remove the high-frequency noise and smooth the glitch energy on the analog outputs, you can install a 15kHz RC filter on the output, a 100Ω resistor in series with the output, and a 0.1µF capacitor between the output side of the 100Ω resistor and output low.

Digital inputs and counter/timer inputs

TTL-type inputs must have current limiting so that circuitry is not damaged when power is removed. On all Keithley PCI boards, current limiting is used to prevent damage in this fault condition.

On high-speed clock inputs, a ground that is located in the connector next to the clock must be connected as a twisted pair with the high-speed clock input.

Digital outputs

If you are using the high drive capability of any of the PCI boards, ensure that the load is returned to the digital ground provided in the connector next to the outputs.

If just eight of the digital outputs are switching 16 mA per output, then 128 mA of current flows. To minimize problems with ringing, loading, and EMI, a 22Ω resistor is used in series with all digital outputs. You must consider this 22Ω resistor if you are matching cable impedance to the far end.

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Printed in the U.S.A.
4/02