

KUSB-3102 and KUSB-3108

Getting Started Manual

KUSB3102/8-903-01 Rev. A / January 2005

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 3 years from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139
440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY (534-8453) • www.keithley.com

KUSB-3102 and KUSB-3108 Getting Started Manual

©2005, Keithley Instruments, Inc.
All rights reserved.

First Printing, January 2005
Cleveland, Ohio, U.S.A.

Document Number: KUSB3102/8-903-01A Rev. A

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 KUSB3102/8-903-01A)..... January 2005

KEITHLEY 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 Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement 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 a  screw 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  symbol indicates a connection terminal to the equipment frame.

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.

Table of Contents

| | |
|---|-----------|
| About this Manual | ix |
| Intended Audience..... | ix |
| How this Manual is Organized | ix |
| Conventions Used in this Manual | x |
| Related Information..... | x |
| Where To Get Help..... | xi |
| | |
| Chapter 1: Overview | 1 |
| Key Hardware Features..... | 2 |
| Software | 3 |
| Getting Started Procedure..... | 4 |
| | |
| Chapter 2: Preparing to Use a Module | 5 |
| Unpacking | 7 |
| Checking the System Requirements | 8 |
| Installing the Software..... | 9 |
| | |
| Chapter 3: Installing a Module and Configuring the Device Driver | 11 |
| Overview | 13 |
| Connecting Directly to the Host Computer | 14 |
| Connecting to a Self-Powered USB Hub..... | 16 |
| Configuring the Device Driver..... | 19 |
| | |
| Chapter 4: Wiring Signals | 21 |
| Wiring Overview | 23 |
| Connecting Analog Input Signals | 26 |
| Connecting Single-Ended Voltage Inputs | 27 |
| Connecting Pseudo-Differential Voltage Inputs..... | 28 |

| | |
|---|-----------|
| Connecting Differential Voltage Inputs | 29 |
| Connecting Current Loop Inputs | 32 |
| Connecting Thermocouple Inputs | 33 |
| Connecting Analog Output Signals. | 35 |
| Connecting Digital I/O Signals | 36 |
| Connecting Counter/Timer Signals | 38 |
| Connecting Event Counting Signals. | 38 |
| Connecting Frequency Measurement Signals. | 40 |
| Connecting Pulse Output Signals. | 42 |
| Chapter 5: Verifying the Operation of a Module | 45 |
| Overview | 47 |
| Running the Quick Data Acq Application | 48 |
| Performing a Single-Value Analog Input Operation | 49 |
| Performing a Single-Value Analog Output Operation | 50 |
| Performing a Continuous Analog Input Operation. | 51 |
| Performing a Single-Value Digital Input Operation | 53 |
| Performing a Single-Value Digital Output Operation. | 54 |
| Performing a Frequency Measurement Operation. | 55 |
| Performing a Pulse Output Operation. | 56 |
| Index | 59 |

About this Manual

This manual describes how to install and set up your KUSB-3102 or KUSB-3108 module and device driver, and verify that your module is working properly.

Intended Audience

This document is intended for engineers, scientists, technicians, or others responsible for installing and setting up a KUSB-3102 or KUSB-3108 module to perform data acquisition operations. It is assumed that you are familiar with the requirements of your application. It is also assumed that you are familiar with the Microsoft® Windows® 2000 or Windows XP.

How this Manual is Organized

This manual is organized as follows:

- [Chapter 1, “Overview,”](#) describes the key features of the KUSB-3102 and KUSB-3108 hardware and software, and provides an overview of the getting started procedure.
- [Chapter 2, “Preparing to Use a Module,”](#) describes how to unpack the module, check the system requirements, and install the software using Windows 2000 or Windows XP.
- [Chapter 3, “Installing a Module and Configuring the Device Driver,”](#) describes how to install the KUSB-3102 or KUSB-3108 module and configure the device driver.
- [Chapter 4, “Wiring Signals,”](#) describes how to wire signals to the module.
- [Chapter 5, “Verifying the Operation of a Module,”](#) describes how to verify the operation of the module with the Quick Data Acq application.

An index completes this manual.

Conventions Used in this Manual

The following conventions are used in this manual:

- Notes provide useful 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**.
- Courier font is used to represent source code.

Related Information

Refer to the following documents for more information on using the KUSB-3102 or KUSB-3108 module:

- *KUSB-3102 and KUSB-3108 User's Manual* provided with the module. This manual describes the features of the KUSB-3102 and KUSB-3108 modules and device driver.
- *DataAcq SDK User's Manual*. For programmers who are developing their own application programs using the Microsoft C compiler, this manual describes how to use the DT-Open Layers™ DataAcq SDK™ in Windows 2000 or Windows XP to access the capabilities of your module.
- *DTx-EZ Getting Started Manual*. This manual describes how to use the ActiveX controls provided in DTx-EZ™ to access the capabilities of your module in Microsoft Visual Basic® or Visual C++®.
- *DT-LV Link Getting Started Manual*. This manual describes how to use DT-LV Link™ with the LabVIEW® graphical programming language to access the capabilities of your module.

- Microsoft Windows 2000 or Windows XP documentation.
- USB web site (<http://www.usb.org>).

Where To Get Help

Should you run into problems installing or using your KUSB-3102 or KUSB-3108 module, please call the Keithley Technical Support Department.



Overview

| | |
|--------------------------------|---|
| Key Hardware Features..... | 2 |
| Software..... | 3 |
| Getting Started Procedure..... | 4 |

Key Hardware Features

Table 1 lists the key features of the KUSB-3102 and KUSB-3108 modules.

Table 1: Key Features

| Module | # of Analog Inputs | Sample Rate | # of Analog Outputs | # of DIO Lines | # of Counter/ Timers |
|---------------|---|--------------------|----------------------------|-----------------------|-----------------------------|
| KUSB-3102 | 16 single-ended/ or 8 differential | 100 kS/s | 2 | 8 in, 8 out | 2 |
| KUSB-3108 | 16 single-ended/ 8 differential/ or 7 thermocouples and 1 CJC | 50 kS/s | 2 | 8 in, 8 out | 2 |

Software

The software for the KUSB-3102 and KUSB-3108 modules, which is shipped on the Keithley CD that is provided with the modules, includes the following software components:

- **Device Driver** –This software must be installed and loaded before you can use a KUSB-3102 and KUSB-3108 module with any of the supported software packages or utilities.
- **The Quick Data Acq application** –This application provides a quick way to get your module up and running. Using the Quick Data Acq application, you can verify the features of the module, display data on the screen, and save data to disk.
- **Calibration Utility** –This software allows you to calibrate the analog I/O circuitry of the module. Refer to the *KUSB-3102 and KUSB-3108 User's Manual* for information on using this utility.
- **DataAcq SDK** –This DT-Open Layers Software Develop Kit (SDK) allows programmers to develop application programs for the KUSB-3102 and KUSB-3108 using the Microsoft C compiler in Windows 2000 or Windows XP.
- **DTx-EZ** –This software package contains ActiveX controls that allow Microsoft Visual Basic® or Visual C++® programmers to access the capabilities of the KUSB-3102 and KUSB-3108 modules.
- **DT-LV Link** –This software package allows LabVIEW® programmers to access the capabilities of the KUSB-3102 and KUSB-3108 modules.

Getting Started Procedure

The flow diagram shown in [Figure 1](#) illustrates the steps needed to get started using the KUSB-3102 or KUSB-3108 module. This diagram is repeated in each chapter; the shaded area in the diagram shows you where you are in the getting started procedure.

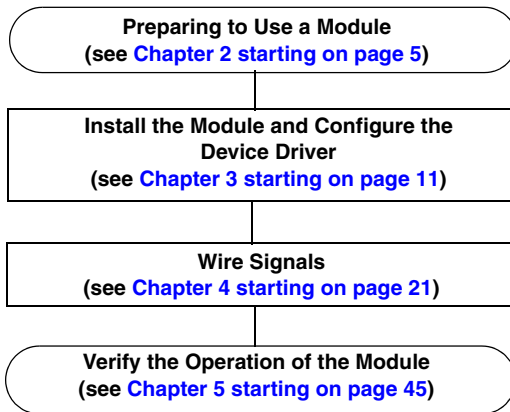
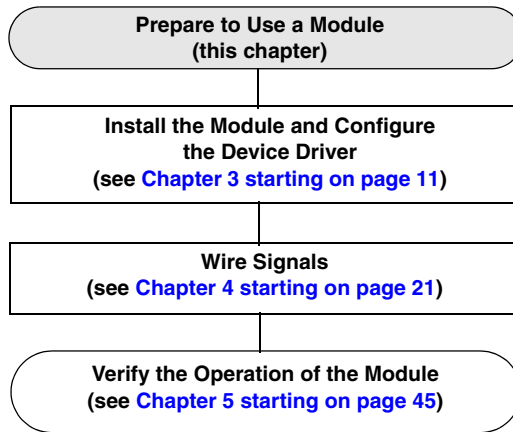


Figure 1: Getting Started Flow Diagram



Preparing to Use a Module

| | |
|--|---|
| Unpacking | 7 |
| Checking the System Requirements | 8 |
| Installing the Software..... | 9 |



Unpacking

Open the shipping box and verify that the following items are present:

- KUSB-3102 or KUSB-3108 module,
- USB cable, and
- Keithley CD.

If an item is missing or damaged, contact Keithley Technical Support. Once you have unpacked your module, check the system requirements, as described in the next section.

Checking the System Requirements

For reliable operation, your KUSB-3102 or KUSB-3108 module requires the items listed in [Table 2](#).

Table 2: Minimum System Requirements

| Feature | Minimum Requirements |
|------------------|---|
| Operating System | Windows 2000 or Windows XP |
| Processor | 80486, Pentium, or compatible |
| USB Ports | One or more |
| RAM | 16 MB or more |
| CD-ROM Drives | One or more |
| Monitor | VGA, or compatible, display (640 x 480 or higher, 256 colors recommended) |

Once you have verified that your system meets the system requirements, install the software as described in the next section.

Installing the Software

2

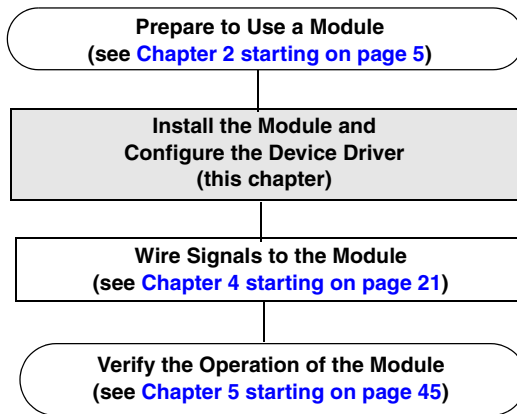
To install the driver software, Data Acq SDK, DTx-EZ, and the Quick Data Acq software, perform the following steps:

1. Insert the Keithley CD into your CD-ROM drive.
2. Click **Start** from the Task Bar, then click **Run**.
The Run dialog box appears.
3. In the Command Line edit box, enter **D:\Setup.Exe**.
If your CD-ROM is not in drive D:, enter the letter of the drive where your CD-ROM is located. The welcome screen appears.
4. Click **Install Drivers and SDK**.
5. Click **Install now!**
The installation wizard appears.
6. Click **Next**.
You are prompted for the destination location.
7. Either change the directory path and/or name using **Browse** or accept the default directory, then click **Next**.
8. Click **Next** to copy the files.
9. Click **Finish**.
10. Click **Quit Installer**.



Installing a Module and Configuring the Device Driver

| | |
|--|----|
| Overview | 13 |
| Connecting Directly to the Host Computer | 14 |
| Connecting to a Self-Powered USB Hub..... | 16 |
| Configuring the Device Driver..... | 19 |



Note: The KUSB-3102 and KUSB-3108 modules are factory-calibrated and require no further adjustment prior to installation. If you decide later to recalibrate them, refer to the *KUSB-3102 and KUSB-3108 User's Manual* for instructions.

Overview

You can attach a KUSB-3102 and KUSB-3108 module to the host computer in one of two ways:

- Connect directly to a USB port of the host computer, described on [page 13](#). Use this method if one or two modules are sufficient for your application.
- Connect to one or more self-powered USB hubs, described on [page 16](#). Use this method if your application requires more than two modules connected to the host computer.

Note: KUSB-3102 and KUSB-3108 modules are low-power devices (using less than 500 mA); therefore, they do not require external power supplies.

Connecting Directly to the Host Computer

Generally, host computers have two USB ports. These ports are completely independent. To connect a KUSB-3102 or KUSB-3108 module directly to a USB port of the computer, perform the following steps:

1. Attach one end of the USB cable, which is shipped with the module, to the USB port on the module.
2. Attach the other end of the cable to one of the USB ports on the host computer, as shown in [Figure 2](#).

The operating system automatically detects the USB device.

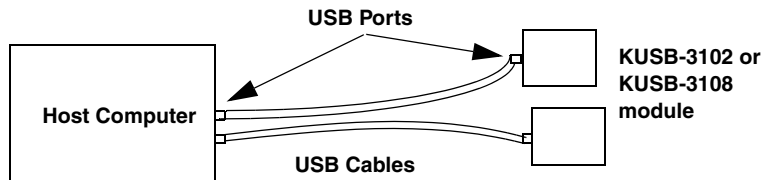


Figure 2: Attaching a KUSB-3102 or KUSB-3108 Module Directly to the Host Computer

3. If you previously installed the device driver, ignore the remaining steps, and repeat steps 1 and 2 to attach another module to the host computer, if desired.

If you have not yet installed the device driver, the New Hardware Found wizard appears. Click **Next** to have the wizard search for the device driver, then proceed to step 4.

4. Click the option to search for the driver, then click **Next**.
5. Click the option to specify the location, browse to the location on the CD that contains the driver files, then click **Next**.

6. Click **Next**.
7. Click **Finish**.
A New Hardware Found dialog box appears indicating that Windows is installing the driver for the USB device.
8. Repeat the steps 1 and 2 to attach another KUSB-3102 or KUSB-3108 module to the host computer, if desired.

Note: You can unplug a module, then plug it in again, if you wish, without causing damage. This process is called hot-swapping.

Your application may take a few seconds to recognize a module once it is plugged back in.

Connecting to a Self-Powered USB Hub

Self-powered USB hubs are USB hubs that are powered by their own external power supply. Theoretically, you can connect up to five self-powered USB hubs to a USB port on the host computer. However, the practical number of KUSB-3102 and KUSB-3108 modules that you can connect to a single USB port depends on the throughput you want to achieve. Each of the hubs supports up to four KUSB-3102 and KUSB-3108 modules.

Note: The bandwidth of the USB 1.1 bus is 12 Mbits/second. Each KUSB-3102 or KUSB-3108 module running at full speed (100 kHz) requires 200 kB of this bandwidth. Therefore, if you want to achieve full throughput on each module, you should connect no more than four KUSB-3102 or KUSB-3108 modules to a single USB port.

To connect a KUSB-3102 or KUSB-3108 module to a self-powered USB hub, perform the following steps:

1. Attach one end of the USB cable to the KUSB-3102 or KUSB-3108 module and the other end of the USB cable to a self-powered USB hub.
2. Connect the power supply for the self-powered USB hub to an external power supply.
3. Connect the hub to the USB port on the host computer using another USB cable.
The operating system automatically detects the USB device.
4. If you previously installed the device driver, ignore the remaining steps, and repeat steps 1 to 3 until you have attached the number of hubs (up to five) and modules (up to four per hub) that you desire.

If you have not installed the device driver, the New Hardware Found wizard appears. Click **Next** to have the wizard search for the device driver. Proceed to step 5.

5. Click the option to search for the driver, then click **Next**.
6. Click the option to specify the location, browse to the location on the CD that contains the driver files, then click **Next**.
7. Click **Next**.
8. Click **Finish**.

A New Hardware Found dialog box appears indicating that Windows is installing the driver for the USB device.

9. Repeat steps 1 to 3 until you have attached the number of hubs (up to five) and modules (up to four per hub) that you desire.

Refer to [Figure 3](#).

The operating system automatically detects the USB devices as they are installed.

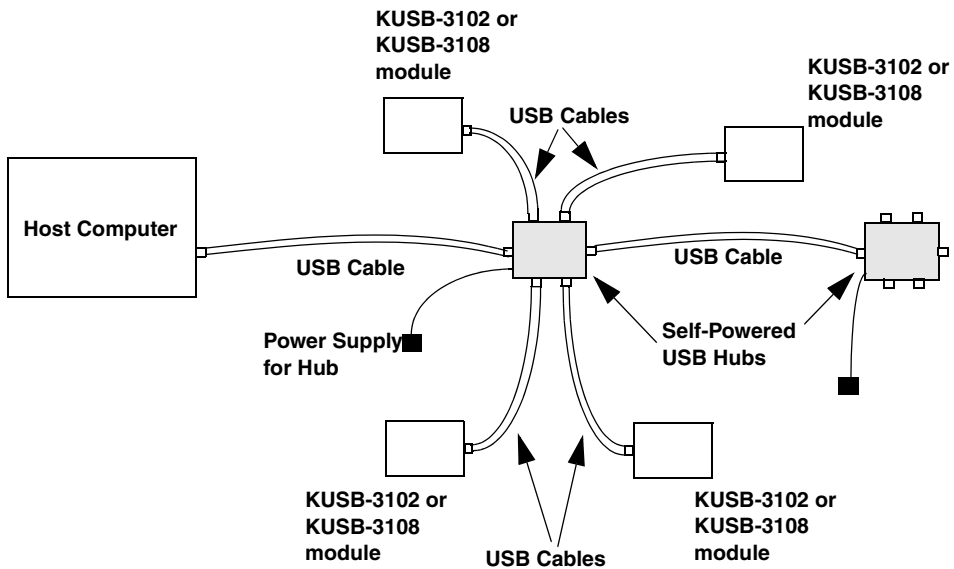


Figure 3: Attaching a KUSB-3102 or KUSB-3108 Module to the Host Computer Using Self-Powered USB Hubs

Note: You can unplug a module, then plug it in again, if you wish, without causing damage. This process is called hot-swapping.

Your application may take a few seconds to recognize a module once it is plugged back in.

You are now ready to wire signal to your module, as described in [Chapter 4 starting on page 21](#).

Configuring the Device Driver

To configure the device driver for the KUSB-3102 and KUSB-3108 modules, perform the following steps:

1. If you have not already done so, power up the host computer and all peripherals.
2. From the Control Panel, double-click the **Open Layers Data Acquisition Control Panel** icon.
The Open Layers dialog box appears.
3. Click the module that you want to configure, then click **Advanced**.
The Configuration dialog box appears.
4. If you are using differential analog input channels, it is recommended that you select the **10k Ohm Resistor Terminations** checkbox for each analog input channel on the module. This ensures that 10 k Ω of bias return termination resistance is used for the analog input channels. (This is the default configuration.) Bias return termination resistance is particularly useful when your differential source is floating.

If you are using single-ended analog input channels, clear the checkbox for each analog input channel so that bias return resistance is not used.

5. To continuously power the analog and/or digital outputs, select the **Power Always On** checkbox. When this setting is checked, the module will remain on even when you exit from the applications that use the module.

If you want to shut down power to the module, you must uncheck this checkbox and close the control panel. Once all applications that use this module are exited, the module will power down. The module will remain off until you either run an application that uses the module or click the Advanced button from the Open Layers Data Acquisition Control Panel.

6. Click **OK**.
7. If you want to rename the module, click **Edit Name**; otherwise, go to step 9.
8. Enter a new name for the module, then click **OK**.

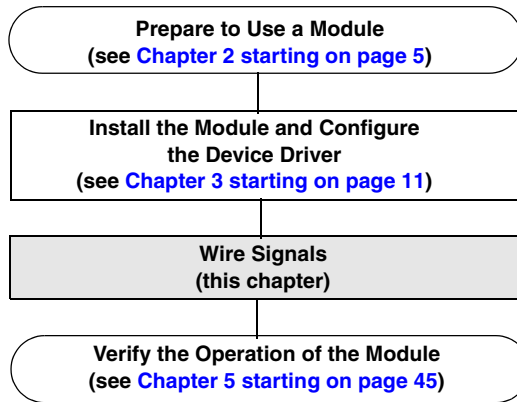
Note: This name is used to identify the module in all subsequent applications.

9. When you are finished configuring the module, click **Close**.
10. Repeat steps 3 to 9 for the other modules that you want to configure.
11. Close the Control Panel.



Wiring Signals

| | |
|--|----|
| Wiring Overview | 23 |
| Connecting Analog Input Signals | 26 |
| Connecting Analog Output Signals..... | 35 |
| Connecting Digital I/O Signals | 36 |
| Connecting Counter/Timer Signals | 38 |



Wiring Overview

Before wiring signals to a KUSB-3102 or KUSB-3108 module, peel off the color labels provided in the shipping box and attach one to the outside of each screw terminal block. Ensure that you match the color of the peel-off label to the color on the label on top of the unit. This way, if you later remove the screw terminal blocks, you will know where to reattach them.

CAUTION:

To avoid electrostatic sensitivity, it is recommended that you unplug your module from the computer before wiring signals.

In addition, to ensure that your module performs as expected, insert each screw terminal block into the location on the module with the matching color.

4

Keep the following recommendations in mind when wiring signals to the KUSB-3102 or KUSB-3108 module:

- Use individually shielded twisted-pair wire (size 14 to 26 AWG) when using the modules in highly noisy electrical environments.
- Separate power and signal lines by using physically different wiring paths or conduits.
- To avoid noise, do not locate the modules 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 mumetal shield.
- Prevent electrostatic discharge to the I/O while the modules are operational.
- Connect all unused analog input channels to analog ground.

- When first installing the module, try wiring the signals as follows:
 - Wire a function generator or a known voltage source to analog input channel 0 using the differential configuration.
 - Wire an oscilloscope or voltage meter to analog output channel 0.
 - Wire a digital input to digital input line 0 of port A.
 - Wire a digital output to digital output line 0 of port B.
 - Wire an external clock or scope to counter/timer channel 0.
 - Then, run the Quick Data Acq application (described in [Chapter 5 starting on page 45](#)) to verify that the module is operating properly.

Once you have determined that the module is operating properly, wire the signals according to your application's requirements.

[Figure 4](#) shows the assignments of the screw terminals on the KUSB-3102 and KUSB-3108 modules. The screw terminal blocks are removable for your convenience.

| | | | | |
|--|----|------------------|----|--------------------|
| User Clk Input 0 | 54 | | 1 | Channel 00 |
| User Cntr Out 0 | 53 | | 2 | Channel 08/00 Ret |
| External Gate 0 | 52 | | 3 | Channel 01 |
| Isolated Dig Gnd | 51 | | 4 | Channel 09/01 Ret |
| User Clk Input 1 | 50 | | 5 | Channel 02 |
| User Cntr Out 1 | 49 | | 6 | Channel 10/02 Ret |
| External Gate 1 | 48 | | 7 | Channel 03 |
| Isolated Dig Gnd | 47 | | 8 | Channel 11/03 Ret |
| Dynamic Dig Out | 46 | | 9 | Channel 04 |
| KUSB-3102 and KUSB-3108 Modules | | | | |
| Digital Output 0 | 45 | | 10 | Channel 12/04 Ret |
| Digital Output 1 | 44 | | 11 | Channel 05 |
| Digital Output 2 | 43 | | 12 | Channel 13/05 Ret |
| Digital Output 3 | 42 | | 13 | Channel 06 |
| Digital Output 4 | 41 | | 14 | Channel 14/06 Ret |
| Digital Output 5 | 40 | | 15 | Channel 07 |
| Digital Output 6 | 39 | | 16 | Channel 15/07 Ret |
| Digital Output 7 | 38 | | 17 | Isolated An Gnd |
| Isolated Dig Gnd | 37 | | 18 | Amp Low |
| | 36 | | 19 | Analog Out 0+ |
| | 35 | | 20 | Analog Out 0 Ret |
| | 34 | | 21 | Analog Out 1+ |
| | 33 | | 22 | Analog Out 1 Ret |
| | 32 | | 23 | Isolated Dig Gnd |
| | 31 | | 24 | Ext A/D Trigger |
| | 30 | | 25 | Ext A/D Sample Clk |
| | 29 | | 26 | Isolated Dig Gnd |
| | 28 | | 27 | Isolated +5 V Out |
| | 28 | Digital Input 0 | | |
| | 29 | Digital Input 1 | | |
| | 30 | Digital Input 2 | | |
| | 31 | Digital Input 3 | | |
| | 32 | Digital Input 4 | | |
| | 33 | Digital Input 5 | | |
| | 34 | Digital Input 6 | | |
| | 35 | Digital Input 7 | | |
| | 36 | Isolated Dig Gnd | | |

Figure 4: Screw Terminal Assignments

Connecting Analog Input Signals

The KUSB-3102 and KUSB-3108 modules support both voltage and current loop inputs.

You can connect analog input signals to the module in the following configurations:

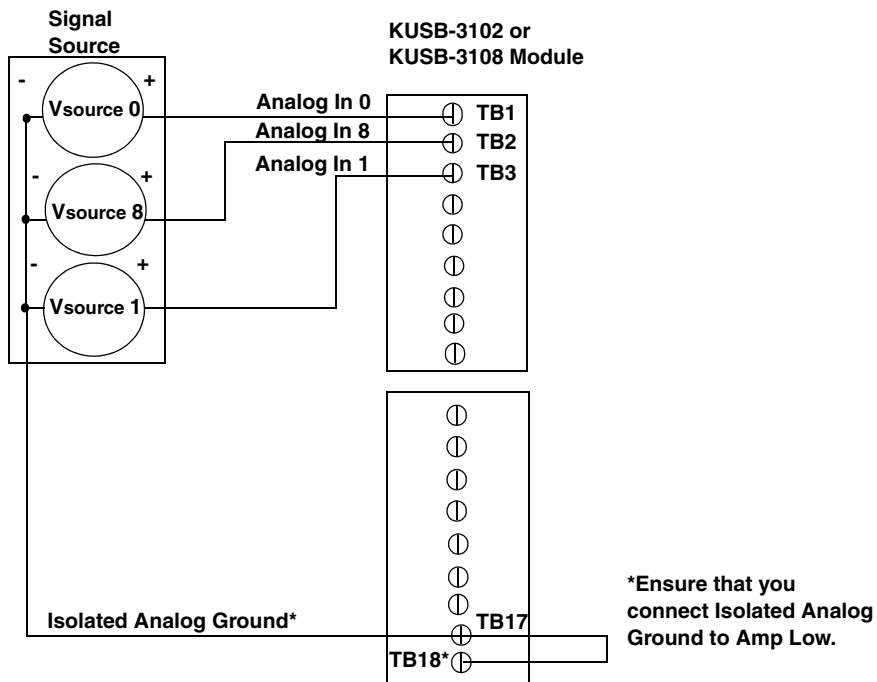
- **Single-ended** –Choose this configuration when you want to measure high-level signals, noise is not significant, the source of the input is close to the module, and all the input signals are referred to the same common ground. When you choose the single-ended configuration, all 16 analog input channels 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 module 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 16 analog input channels are available.
- **Differential** –Choose this configuration when you want to measure thermocouple or low-level signals (less than 1 V), you are using an A/D converter with high resolution (greater than 12 bits), noise is a significant part of the signal, or common-mode voltage exists. When you choose the differential configuration, eight analog input channels are available.

This section describes how to connect single-ended, pseudo-differential, and differential voltage inputs, as well as current loop and thermocouple inputs to the module.

Connecting Single-Ended Voltage Inputs

Figure 5 shows how to connect single-ended voltage inputs (channels 0, 1, and 8, in this case) to a KUSB-3102 or KUSB-3108 module.

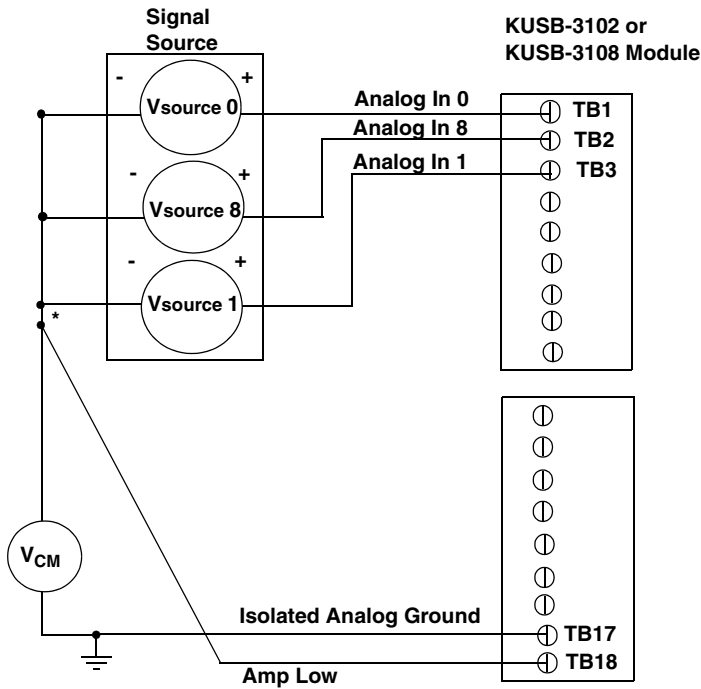
Note: If you are using single-ended inputs, set up the software so that bias return resistance is not used.



**Figure 5: Connecting Single-Ended Voltage Inputs
(Shown for Channels 0, 1, and 8)**

Connecting Pseudo-Differential Voltage Inputs

Figure 6 shows how to connect pseudo-differential voltage inputs (channels 0, 1, and 8, in this case) to a KUSB-3102 or KUSB-3108 module.



*Make this connection as close to V_{IN} sources as possible to reduce ground loop errors. V_{CM} is the common mode voltage for all 16 analog inputs.

Figure 6: Connecting Pseudo-Differential Voltage Inputs (Shown for Channels 0, 1, and 8)

Note: If you are using pseudo-differential inputs, set up the software so that bias return resistance is not used.

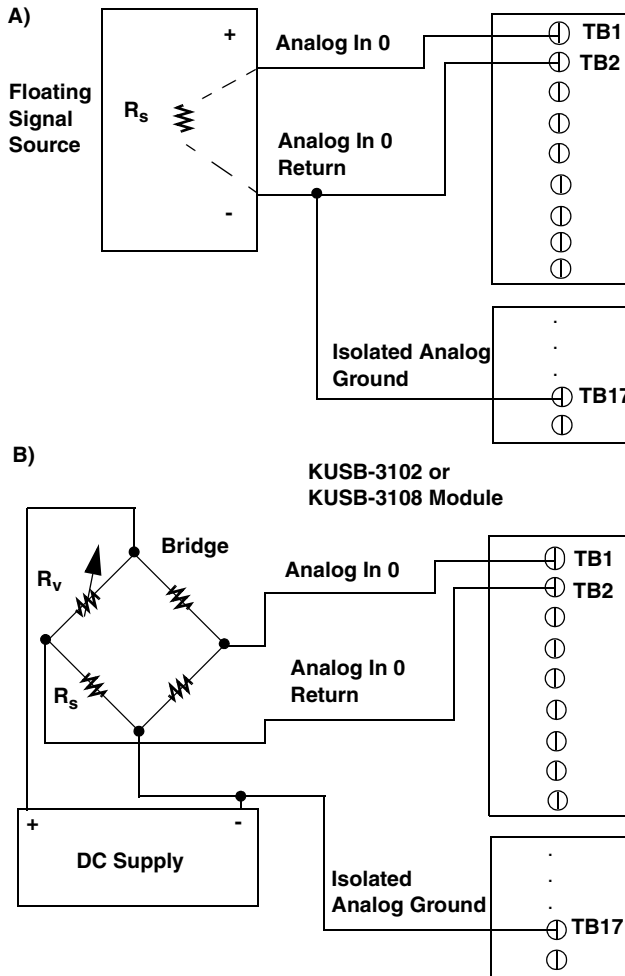
Connecting Differential Voltage Inputs

[Figure 7A](#) illustrates how to connect a floating signal source to a KUSB-3102 or KUSB-3108 module using differential inputs. (A floating signal source is a voltage source that has no connection with earth ground.)

Note: For floating signal sources, it is recommended that you provide a bias return path for the differential channels by adding 10 k Ω of termination resistance from the low side of the channel to isolated analog ground.

[Figure 7B](#) illustrates how to connect a nonfloating signal source to a KUSB-3102 or KUSB-3108 module using differential inputs. In this case, the signal source itself provides the bias return path; therefore, you do not need to provide bias return resistance through software.

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.



It is recommended that you software-select $10\text{ k}\Omega$ of resistance to connect the low side of channel 0 to analog ground (a physical resistor is not required). Refer to [page 19](#) for more information.

Figure 7: Connecting Differential Voltage Inputs (Shown for Channel 0)

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 KUSB-3102 or KUSB-3108 module as shown in [Figure 8](#). In this case, make sure that the low side of the signal (-) is connected to ground at the signal source, not at the module, and do not tie the two grounds together.

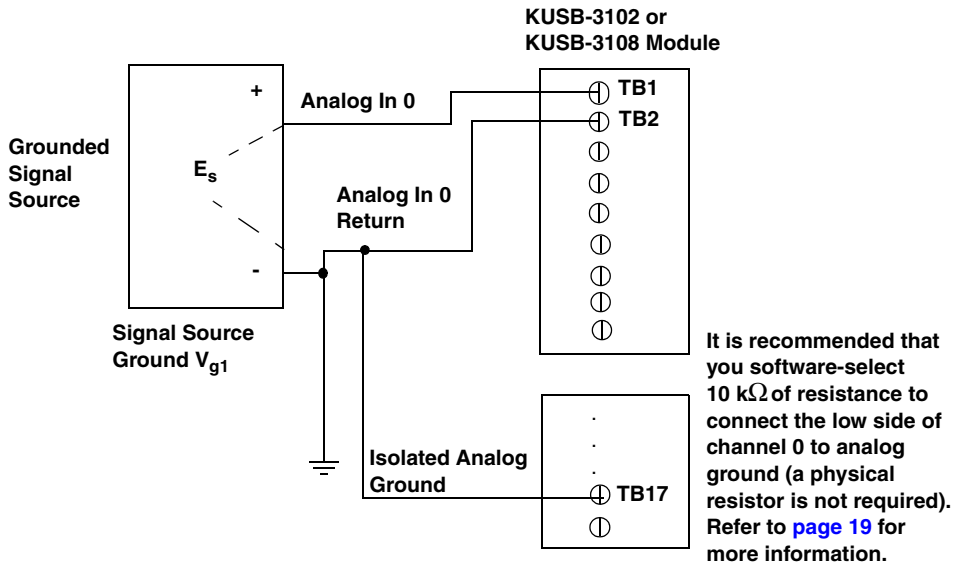
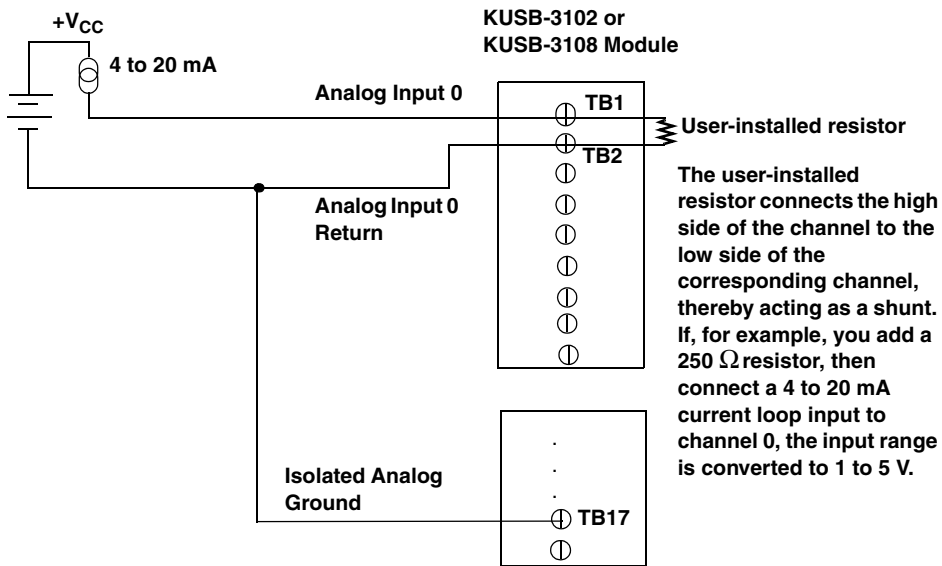


Figure 8: Connecting Differential Voltage Inputs from a Grounded Signal Source (Shown for Channel 0)

Connecting Current Loop Inputs

Figure 9 shows how to connect a current loop input (channel 0, in this case) to a KUSB-3102 or KUSB-3108 module.



It is recommended that you software-select 10 k Ω of termination resistance to connect the low side of channel 0 to analog ground (a physical resistor is not required). Refer to [page 19](#) for more information.

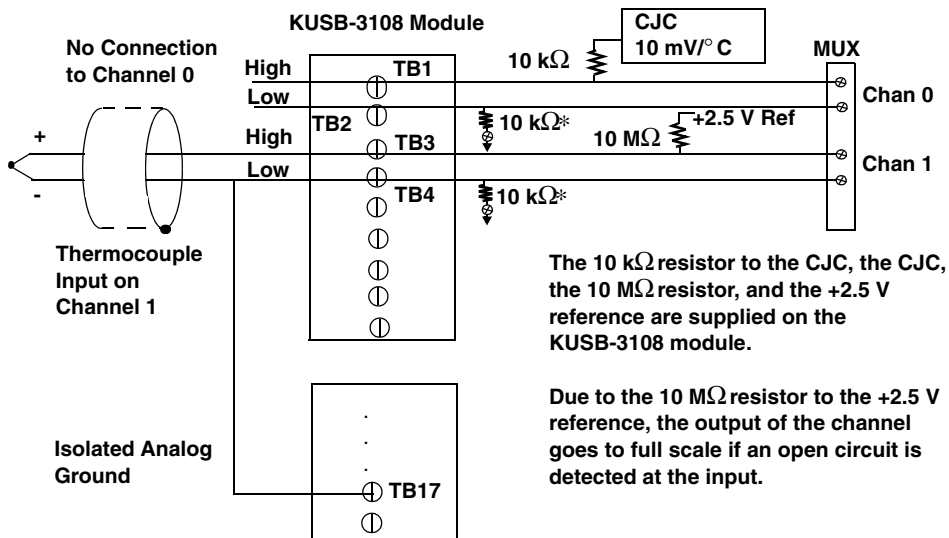
Figure 9: Connecting Current Inputs (Shown for Channel 0)

Note: If you are using current loop inputs, set up the software so that bias return resistance is used.

Connecting Thermocouple Inputs

The KUSB-3108 module provides cold junction compensation (CJC) on channel 0 at $10 \text{ mV}/^\circ\text{C}$. You can attach up to seven thermocouples to the KUSB-3108 module using channel 0 as a CJC. The accuracy of the CJC is $\pm 1^\circ$ from 5° to 45° C .

Figure 10 shows how to connect a thermocouple input to channel 1 of a KUSB-3108 module.



*It is recommended that you software-select 10 kΩ of termination resistance to connect the low side of channels 0 and 1 to analog ground (a physical resistor is not required). Refer to [page 19](#) for more information.

Figure 10: Connecting Thermocouple Inputs (Shown for Channel 1)

Note: You can connect voltages instead of thermocouples to the KUSB-3108 module. In this case, ensure that the signal you attach to channel 0 is capable of driving $10\text{ k}\Omega$ and that the signals you attach to channels 1, 2, 3, 4, 5, 6, and 7 are capable of driving $10\text{ M}\Omega$

Connecting Analog Output Signals

Figure 11 shows how to connect an analog output voltage signal (channel 0, in this case) to a KUSB-3102 or KUSB-3108 module.

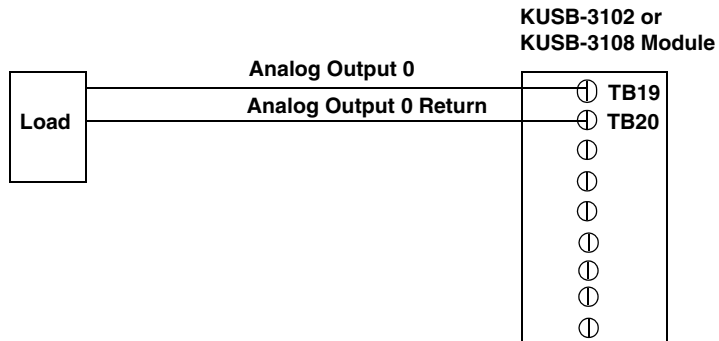


Figure 11: Connecting Analog Output Voltages (Shown for Channel 0)

Connecting Digital I/O Signals

Figure 12 shows how to connect digital input signals (lines 0 and 1, Port A, in this case) to a KUSB-3102 or KUSB-3108 module.

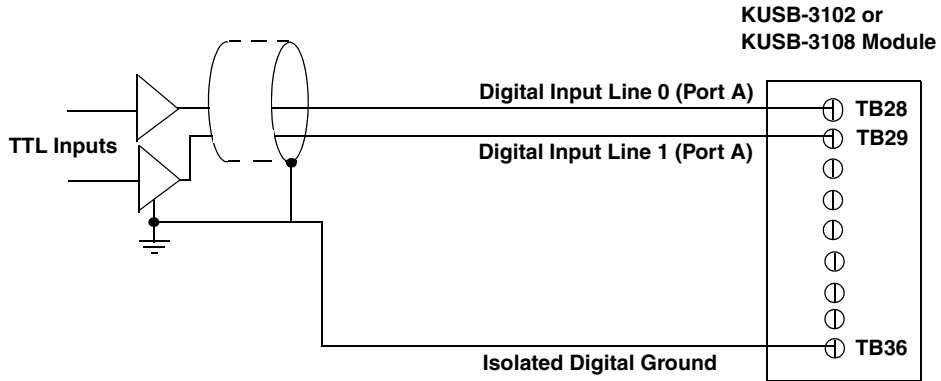


Figure 12: Connecting Digital Inputs (Shown for Lines 0 and 1, Port A)

Figure 13 shows how to connect a digital output (line 0, Port B, in this case) to a KUSB-3102 or KUSB-3108 module.

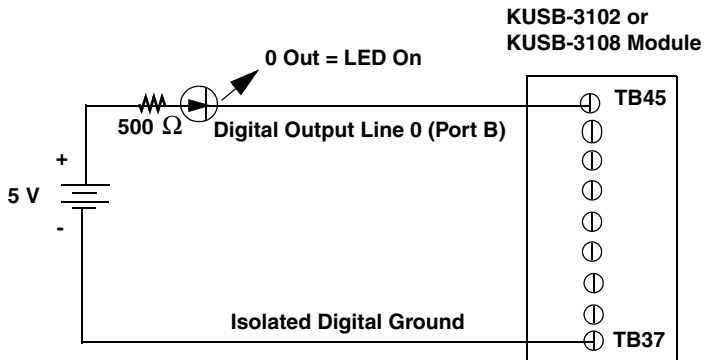


Figure 13: Connecting Digital Outputs (Shown for Line 0, Port B)

Connecting Counter/Timer Signals

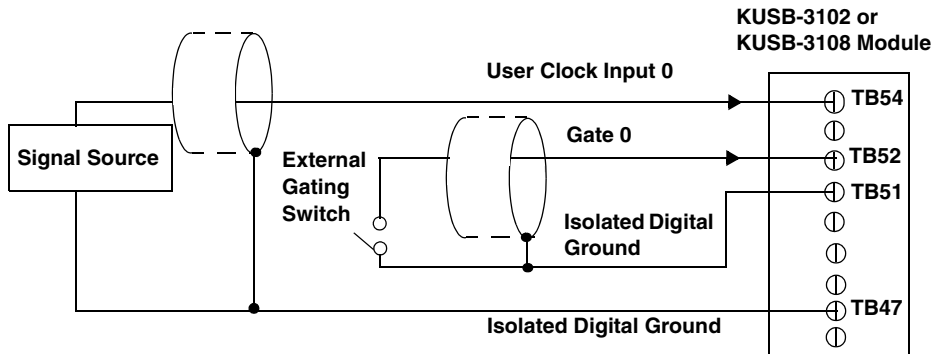
KUSB-3102 and KUSB-3108 modules provide two user counter/timer channels that you can use to perform the following operations:

- Event counting,
- Frequency measurement, and
- 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 the *KUSB-3102 and KUSB-3108 User's Manual* for more information on using the counter/timers.

Connecting Event Counting Signals

Figure 14 shows one example of connecting event counting signals to a KUSB-3102 or KUSB-3108 module using user counter 0. In this example, rising clock edges are counted while the gate is active.



**Figure 14: Connecting Event Counting Signals
(Shown for Clock Input 0 and External Gate 0)**

Figure 15 shows another example of connecting event counting signals to a KUSB-3102 or KUSB-3108 module using user counter 0. In this example, a software gate is used to start the event counting operation; however, this connection is not required.

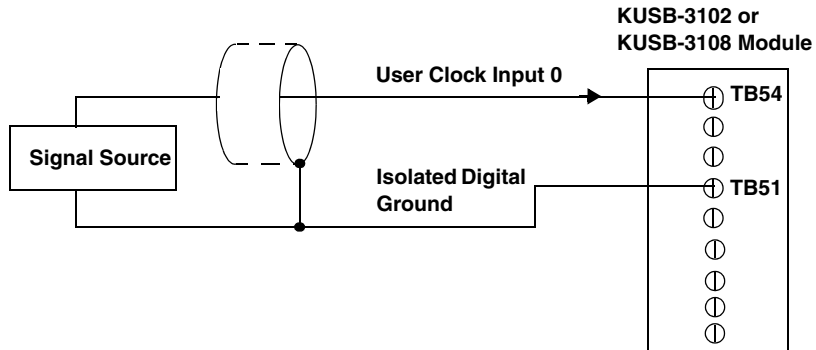


Figure 15: Connecting Event Counting Signals without an External Gate Input (Shown for Clock Input 0)

Figure 16 shows an example of how to cascade two counters externally 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 need to make the external cascading connections.

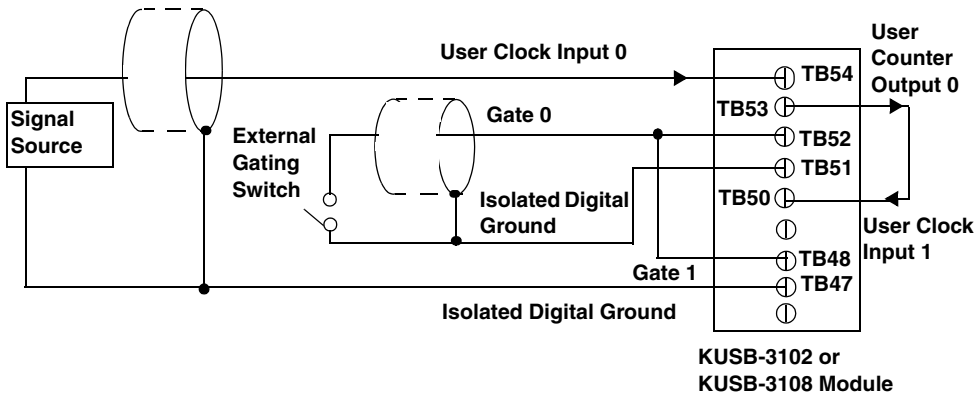


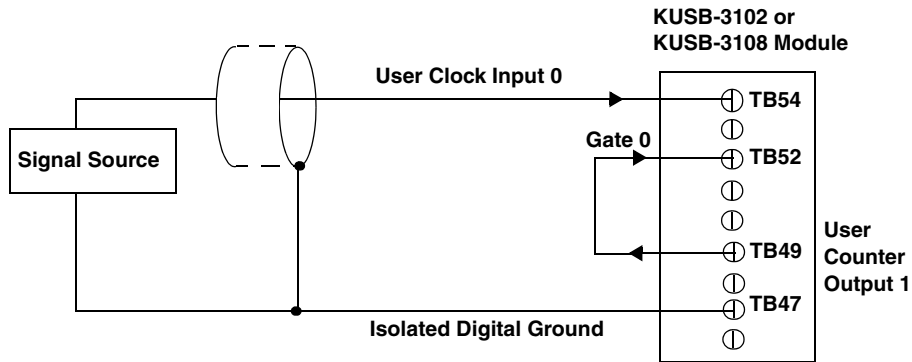
Figure 16: Cascading Counters (Shown for Event Counting Using Counters 0 and 1 and External Gate 0)

Connecting Frequency Measurement Signals

This section describes two examples of how to connect frequency measurement signals to a KUSB-3102 or KUSB-3108 module.

The first configuration uses the same wiring as an event counting application that does not use an external gate signal (see [Figure 15](#) on [page 39](#)); a system timer specifies 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.

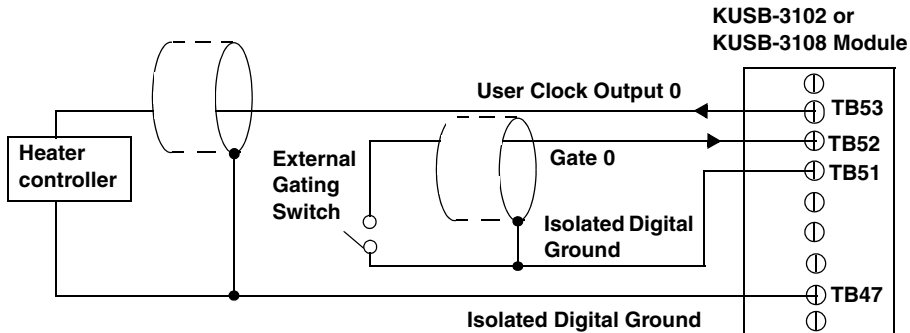
If you need more accuracy than the system timer provides, you can connect a pulse of a known duration (such as a one-shot output of another user counter) to the external gate input, as shown in [Figure 17](#). In this configuration, the frequency of the clock input is the number of counts divided by the period of the external gate input.



**Figure 17: Connecting Frequency Measurement Signals
(Shown for Clock Input 0 and External Gate 0)**

Connecting Pulse Output Signals

Figure 18 shows one example of connecting pulse output signals to a KUSB-3102 or KUSB-3108 module using user counter 0.



**Figure 18: Connecting Pulse Output Signals
(Shown for Counter Output 0 and Gate 0)**

Figure 19 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 cascade counters internally using software; if you internally cascade the counters, you do not need to make the external cascading connections. In this example, counter 1 gate is logic high.

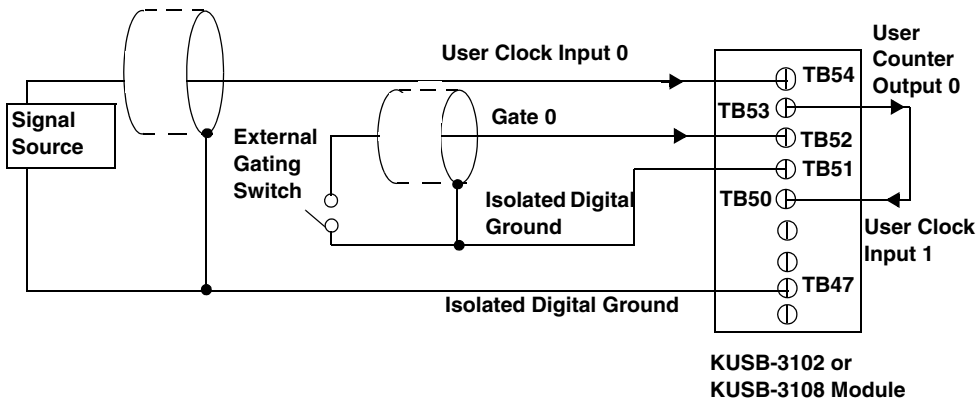


Figure 19: Cascading Counters (Shown for Rate Generation Using Counters 0 and 1 and External Gate 0)

4

Figure 20 shows an example of how to cascade two counters externally 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 need to make the external cascading connections. In this example, counter 0 gate is logic high.

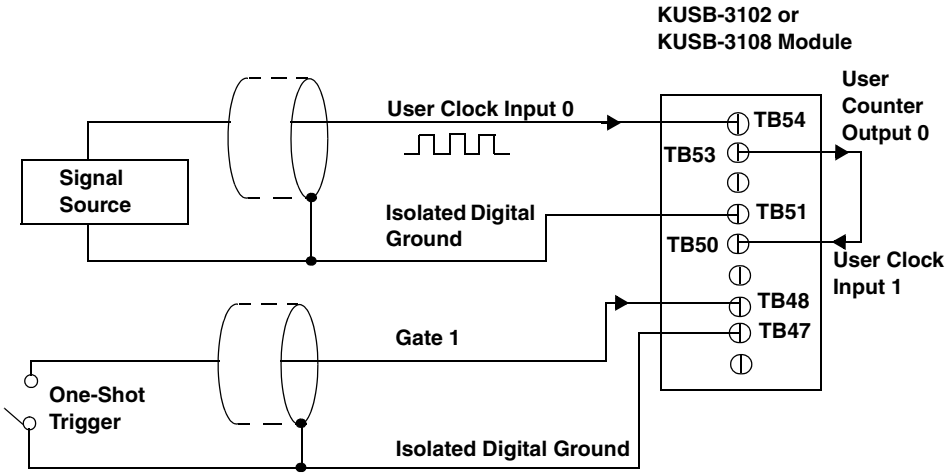
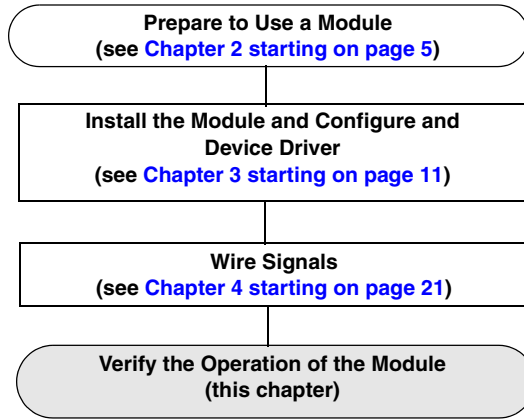


Figure 20: Cascading Counters (Shown for One-Shot Using Counters 0 and 1 and External Gate 1)



Verifying the Operation of a Module

| | |
|--|----|
| Overview | 47 |
| Running the Quick Data Acq Application | 48 |



Overview

Quick Data Acq allows you to perform the following operations:

- Acquire data from a single analog input channel or digital input port;
- Acquire data continuously from one or more analog input channels using an oscilloscope, strip chart, or Fast Fourier Transform (FFT) view;
- Measure the frequency of events;
- Output data from a single analog output channel or digital output port;
- Output pulses either continuously or as a one-shot; and
- Save the input data to disk.

Quick Data Acq is installed automatically when you install the driver software, described on [page 11](#).

Running the Quick Data Acq Application

To run the Quick Data Acq application, perform the following steps:

1. If you have not already done so, power up your computer and any attached peripherals.
2. Select **Quick Data Acq** from the Keithley Instruments\Quick Data Acq program group.

Note: The Quick Data Acq application allows you to verify basic operations on the module; however, it may not support all of the module's features.

For information on each of the features provided, use the online help for the Quick Data Acq application by pressing F1 from any view or selecting the **Help** menu.

For detailed information on the supported features of the module, refer to the *KUSB-3102 and KUSB-3108 User's Manual*.

Performing a Single-Value Analog Input Operation

To verify that the module can read a single analog input value, perform the following steps:

1. Connect a voltage source, such as a function generator, to analog input channel 0 (differential mode) on the module. Refer to [page 29](#) for an example of how to connect a differential analog input.
2. Click the **Acquisition** menu.
3. Click **Single Analog Input**.
4. Select the appropriate module from the Board list box.
5. Once you select the module, the LED on the module turns red.
6. In the Channel list box, select analog input channel 0.
7. In the Range list box, select the range for the channel. The default is ± 10 V.
8. Select **Differential**.
9. Click **Get** to acquire a single value from analog input channel 0. *The value is displayed on the screen in both text and graphical form.*

Performing a Single-Value Analog Output Operation

To verify that the module can output a single analog output value, perform the following steps:

1. Connect an oscilloscope or voltmeter to DAC 0 on the module. Refer to [page 35](#) for an example of how to connect analog output signals.
2. Click the **Control** menu.
3. Click **Single Analog Output**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. In the Channel list box, select analog output channel 0.
6. In the Range list box, select the output range of DAC 0. The default is ± 10 V.
7. Enter an output value, or use the slider to select a value to output from DAC0.
8. Click **Send** to output a single value from DAC 0.
The value that is output is displayed on the screen in both text and graphical form.

Performing a Continuous Analog Input Operation

To verify that the module can perform a continuous analog input operation, perform the following steps:

1. Connect known voltage sources, such as the outputs of a function generator, to analog input channels 0 and 1 on the module (using the differential configuration). Refer to [page 29](#) for an example of how to connect a differential analog input.
2. Click the **Acquisition** menu.
3. For this example, click **Scope**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. In the Sec/Div list box, select the number of seconds per division (.1 to .00001) for the display.
6. In the Channels list box, select analog input channel 1, then click **Add** to add the channel to the channel list.
Note that, by default, channel 0 is included in the channel list.
7. Click **Config** from the Toolbar.
8. From the Config menu, select **ChannelType**, then select **Differential**.
9. From the Config menu, select **Range**, then select **Bipolar** or **Unipolar** depending on the configuration of your module.
The default is Bipolar.

10. From the Scope view, double-click the input range of the channel to change the input range of the module (± 10 V, ± 5 V, ± 2.5 V, ± 1.25 V for bipolar ranges or 0 to 10 V, 0 to 5 V, 0 to 2.5 V or 0 to 1.25 V for unipolar ranges). The default is ± 10 V.
The display changes to reflect the selected range for all the analog input channels on the module.
11. In the Trigger box, select **Auto** to acquire data continuously from the specified channels or **Manual** to acquire a burst of data from the specified channels.
12. Click **Start** from the Toolbar to start the continuous analog input operation.
The values acquired from each channel are displayed in a unique color on the oscilloscope view.

Note: When the module is performing a continuous Scope or FFT operation, the LED on the module turns green (the resulting color may appear yellow).

13. Click **Stop** from the Toolbar to stop the operation.

Performing a Single-Value Digital Input Operation

To verify that the module can read a single digital input value, perform the following steps:

1. Connect a digital input to digital input line 0 of port A on the module. Refer to [page 36](#) for an example of how to connect a digital input.
2. Click the **Acquisition** menu.
3. Click **Digital Input**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. Select digital input port A by clicking **Port A**.
6. Click **Get**.

The value of each digital input line in port A is displayed on the screen in both text and graphical form.

Performing a Single-Value Digital Output Operation

To verify that the module can output a single digital output value, perform the following steps:

1. Connect a digital output to digital output line 0 of port B on the module. Refer to [page 36](#) for an example of how to connect a digital output.
2. Click the **Control** menu.
3. Click **Digital Output**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. Select digital output port B by clicking **Port B**.
6. Click the appropriate bits to select the type of signal to write from the digital output lines. If the bit is selected, a high-level signal is output from the digital output line; if the bit is not selected, a low-level signal is output from the digital output line. Optionally, you can enter an output value in the Hex text box.
7. Click **Send**.
The value of each digital output line of digital port B is output and displayed on the screen in both text and graphical form.

Performing a Frequency Measurement Operation

To verify that the module can perform a frequency measurement operation, perform the following steps:

1. Wire an external clock source to counter/timer 0 on the module. Refer to [page 40](#) for an example of how to connect an external clock.

Note: The Quick Data Acq application works only with counter/timer 0.

2. Click the **Acquisition** menu.
3. Click **Frequency Counter**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. In the Count Duration text box, enter the number of seconds during which events will be counted.
6. Click **Start** to start the frequency measurement operation.
The operation automatically stops after the number of seconds you specified has elapsed, and the frequency is displayed on the screen.

If you want to stop the frequency measurement operation when it is in progress, click **Stop**.

Performing a Pulse Output Operation

To verify that the module can perform a pulse output operation, perform the following steps:

1. Connect a scope to counter/timer 0 on the module. Refer to [page 42](#) for an example of how to connect a scope (a pulse output) to counter/timer 0.

Note: The Quick Data Acq application works only with counter/timer 0.

2. Click the **Control** menu.
3. Click **Pulse Generator**.
4. Select the appropriate module from the Board list box.

Note: Once you select the module, the LED on the module turns red.

5. Select either **Continuous** to output a continuous pulse stream or **One Shot** to output one pulse.
6. Select either **Low-to-high** to output a rising-edge pulse (the high portion of the total pulse output period is the active portion of the signal) or **High-to-low** to output a falling-edge pulse (the low portion of the total pulse output period is the active portion of the signal).
7. Enter a percentage or use the slider to select a percentage for the pulse width. The percentage determines the duty cycle of the pulse.

8. Click **Start** to generate the pulse(s).
The results are displayed both in text and graphical form.
9. Click **Stop** to stop a continuous pulse output operation. One-shot pulse output operations stop automatically.

Index

A

- analog inputs 49, 51
 - current loops 32
 - differential configuration 26, 29
 - pseudo-differential configuration 26, 28
 - single-ended configuration 26, 27
 - thermocouple 33
- analog outputs 35, 50
- application wiring
 - analog outputs 35
 - current loop analog inputs 32
 - differential analog inputs 29
 - digital inputs and outputs 36
 - event counting applications 38, 39
 - externally cascaded counter/timers 39, 42, 43
 - frequency measurement applications 40
 - pseudo-differential analog inputs 28
 - pulse output applications 42
 - single-ended analog inputs 27
 - thermocouple analog inputs 33
- attaching the module to the computer 13

B

- bias return resistance 19, 29

C

- calibration utility 3

- cascading counters, externally 39, 42, 43
- CJC 33
- configuring the device driver 19
- connecting signals
 - analog outputs 35
 - current loop analog inputs 32
 - differential analog inputs 29
 - digital inputs and outputs 36
 - event counting applications 38, 39
 - externally cascaded counter/timers 39, 42, 43
 - frequency measurement applications 40
 - pseudo-differential analog inputs 28
 - pulse output applications 42
 - single-ended analog inputs 27
 - thermocouple analog inputs 33
- connecting to the host computer
 - directly 14
 - using a self-powered USB hub 16
- conventions used x
- counter/timers
 - cascading externally 39, 42, 43
 - connecting event counting signals 38, 39
 - connecting frequency measurement signals 40
 - connecting pulse output signals 42
- current loop inputs 32

D

DataAcq SDK 3
device driver 3, 19
differential inputs 26
digital I/O 36
digital inputs 53
digital outputs 54
DT-LV Link 3
DTx-EZ 3

E

event counting 38

F

frequency measurement 40, 55

H

hot-swapping 15, 18

I

input configuration
differential analog 26
pseudo-differential analog 26
single-ended analog 26

O

output pulses 42, 56

P

pseudo-differential inputs 26
pulse outputs 42, 56

Q

Quick Data Acq 3
running 48

R

related documents x
requirements 8
running the Quick Data Acq
application 48

S

single-ended inputs 26
software supported 3
system requirements 8

T

thermocouple inputs 33

U

unpacking 7

W

wiring signals
analog outputs 35
current loop analog inputs 32
differential analog inputs 29
digital inputs and outputs 36
event counting applications 38, 39
externally cascading counter/timers
39, 42, 43
frequency measurement applications
40

pseudo-differential analog inputs [28](#)
pulse output applications [42](#)
single-ended analog inputs [27](#)
thermocouple analog inputs [33](#)

Specifications are subject to change without notice.
All Keithley trademarks and trade names are the property of Keithley Instruments, Inc.
All other trademarks and trade names are the property of their respective companies.

KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY (534-8453) • www.keithley.com