KUSB-3116

Getting Started Manual

KUSB3116-903-01 Rev. A / January 2005

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

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

12/04

KUSB-3116
Getting Started Manual

First Printing, January 2005
Cleveland, Ohio, U.S.A.
Document Number: KUSB3116-903-01A 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 KUSB3116-903-01A)..... 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

This manual describes how to install and set up your KUSB-3116 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-3116 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 operating system.

How this Manual is Organized

This manual is organized as follows:

- Chapter 1, "Overview," describes the key features of the KUSB-3116 hardware and software, and provides an overview of the getting started procedure.
- Chapter 2, "Preparing to Use a Module," describes how to unpack the KUSB-3116 package, check the system requirements, and install the software under Windows 2000 or Windows XP.
- Chapter 3, "Setting Up and Installing a Module," describes how to install a KUSB-3116 module, how to apply power to the module, and how to configure the device driver.
- Chapter 4, "Wiring Signals," describes how to wire signals to a KUSB-3116 module.
- Chapter 5, "Verifying the Operation of a Module," describes how to verify the operation of the KUSB-3116 module with the Quick Data Acq application.

- Appendix A, "Ground, Power, and Isolation Connections," describes the internal ground, power, and isolation connections on the KUSB-3116 module.

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-3116 module:

- *KUSB-3116 User's Manual*, included on the CD provided with the KUSB-3116 module. This manual describes the features of the KUSB-3116 module and the device driver in detail.
- *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-3116 module, please call the Keithley Technical Support Department.

Overview

Hardware Features

The KUSB-3116 is a high-performance, multifunction data acquisition modules for the USB (Ver. 2.0 or Ver. 1.1) bus. The key hardware features of the module is as follows:

- Installed in a metal BNC box to provide easy connections.
- Simultaneous operation of analog input, analog output, digital I/O, and counter/timer subsystems.
- Analog input subsystem:
  - 16-bit A/D converter.
  - Throughput rate up to 500 kSamples/s.
  - 16 single-ended or 8 differential analog input channels.
  - Programmable gain of 1, 2, 4, or 8 provides input ranges of ±10, ±5, ±2.5, and ±1.25 V.
  - 1024-location channel-gain list. You can cycle through the channel-gain list using continuous scan mode or triggered scan mode. The maximum sampling rate when using the channel-gain list is 500 kSamples/s.
- Analog output subsystem:
  - Four 16-bit D/A converters.
  - Output rate up to 500 kSamples/s.
  - Output range of ±10 V.
  - The DACs are deglitched to prevent noise from interfering with the output signal.
  - Output channel list. You can cycle through the output channel list using continuous output mode or waveform mode. For waveform generation mode, you can simultaneously update all four DACs at 500 kS/s per channel; for continuous output mode, you can simultaneously update all four DACs at 250 kS/s per channel.

- Digital I/O subsystem:
  - One digital input port, consisting of 16 digital input lines. You can program any of the first eight digital input lines to perform interrupt-on-change operations. You can read the value of the digital input port using the analog input channel-gain list.
  - One digital output port, consisting of 16 digital output lines. You can output the value of the digital output port using the output channel list.
  - An additional dynamic digital output line that changes state whenever an analog input channel is read.
- Five 32-bit counter/timer (C/T) channels that perform event counting, up/down counting, frequency measurement, edge-to-edge measurement, continuous pulse output, one-shot, and repetitive one-shot operations. You can read the value of one or more of the C/T channels using the analog input channel-gain list.
- External or internal clock source.
- Trigger operations using a software command, an analog threshold value, or an external digital input value as the trigger event.
- 500 V galvanic isolation barrier that prevents ground loops to maximize analog signal integrity and protect your computer.

Supported Software

The KUSB-3116 software, which is shipped on the CD provided with the module, includes the following software components:

- **Device Driver** –This software must be installed and loaded before you can use a KUSB-3116 module with any of the supported software packages or utilities.
- **Quick Data Acq application** –This application provides a quick way to get a KUSB-3116 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.
- **DataAcq SDK** –This DT-Open Layers Software Develop Kit (SDK) allows programmers to develop application programs for the KUSB-3116 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-3116 module.
- **DT-LV Link** –This software package allows LabVIEW® programmers to access the capabilities of the KUSB-3116 module.

Getting Started Procedure

The flow diagram shown in Figure 1 illustrates the steps needed to get started using the KUSB-3116 module. This diagram is repeated in each chapter; the shaded area in the diagram shows you where you are in the getting started procedure.

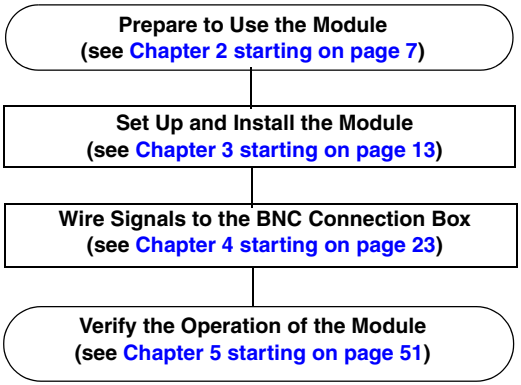
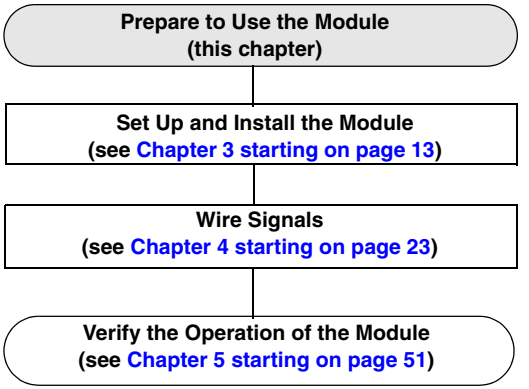


Figure 1: Getting Started Flow Diagram

Preparing to Use a Module


Prepare to Use the Module
(this chapter)
Set Up and Install the Module
(see Chapter 3 starting on page 13)
Wire Signals
(see Chapter 4 starting on page 23)
Verify the Operation of the Module
(see Chapter 5 starting on page 51)

Unpacking

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

- KUSB-3116 BNC module,
- USB cable,
- Power supply,
- 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-3116 module requires the following:

- PC with Pentium 233 MHz (or higher) processor.
- Windows 2000 or Windows XP (Professional Edition) operating system.

  For USB Ver. 2.0 support, make sure that you install Service Pack 1 (for Windows XP) or Service Pack 4 (for Windows 2000). In addition, for some systems, you may have to disable standby mode. If you are not sure whether you are using USB Ver. 1.1 or Ver. 2.0, run the Open Layers Control Panel applet, described on page 16.
- One or more USB ports (Ver. 2.0 or Ver. 1.1). USB Ver. 2.0 is recommended for optimal performance.
- 64 MB (or more) of RAM; 128 MB (or more) recommended.
- One or more CD-ROM drives.
- Super VGA (800 x 600 or higher resolution) display monitor.

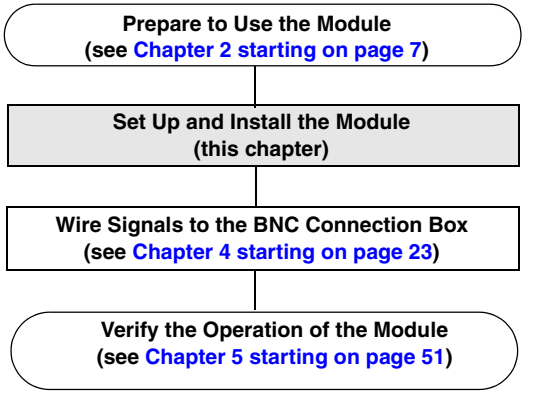
Once you have verified that your system meets the system requirements, install the software, as described in the next section.

Installing the Software

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**.

Setting Up and Installing a Module



Note: The KUSB-3116 module is factory-calibrated and requires no further adjustment prior to installation.

Applying Power to the Module

The KUSB-3116 module is shipped with a +5V power supply and cable. To apply power to the KUSB-3116 module, perform the following steps:

1. Connect the +5 V power supply to the power connector on the KUSB-3116 module. Refer to Figure 2.

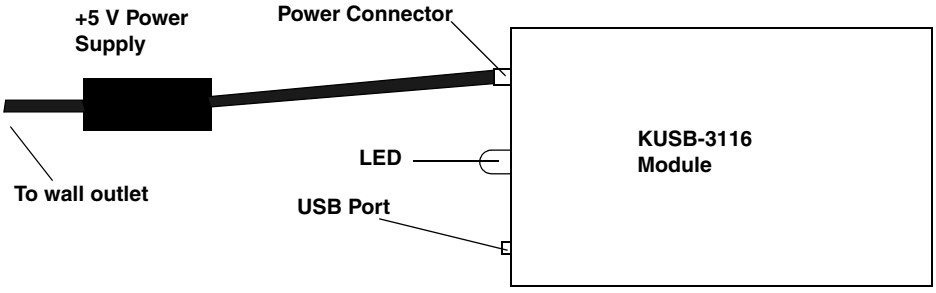


Figure 2: Attaching a +5 V Power Supply to the Module

2. Plug the power supply to a wall outlet.

Continue by configuring the device driver, as described in the next section.

Configuring the Device Driver

To configure the device driver for the KUSB-3116 module, perform the following steps:

1. If you have not already done so, power up the host computer and all peripherals.
2. From the Windows Start menu, select **Settings | Control Panel**.
3. From the Control Panel, double-click **Open Layers Control Panel**.
   The Data Acquisition Control Panel dialog box appears.
4. Click the KUSB-3116 module that you want to configure, then click **Advanced**.
   The Control Panel dialog box appears.
5. 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 kΩ 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.
6. If required, select the digital input line(s) that you want to use for interrupt-on-change operations. When any of the selected lines changes state, the module reads the entire 16-bit digital input value and generates an interrupt.
7. Click **OK**.
8. If you want to rename the module, click **Edit Name**, enter a new name for the module, then click **OK**. The name is used to identify the module in all subsequent applications.
9. When you are finished configuring the module, click **Close**.

10. Repeat steps 4 to 8 for the other modules that you want to configure.

11. Close the Data Acquisition Control Panel dialog box.

Continue by connecting the KUSB-3116 module to the computer, as described in the next section.

Attaching Modules to the Computer

This section describes how to attach KUSB-3116 modules to the host computer.

Notes: Most computers have two USB ports that allow direct connection to USB devices. If your application requires more than two KUSB-3116 modules, you can expand the number of USB devices attached to a single USB port by using expansion hubs. For more information, refer to page 20.

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 One or Two Modules

To connect one or two KUSB-3116 modules to a USB port of the computer, perform the following steps:

1. Make sure that you have attached a power supply to the module.
2. Attach one end of the USB cable to the USB port on the module.
3. Attach the other end of the USB cable to one of the USB ports on the host computer, as shown in Figure 3.
   The operating system automatically detects the USB module. If the power supply and module are attached correctly, the LED turns green.

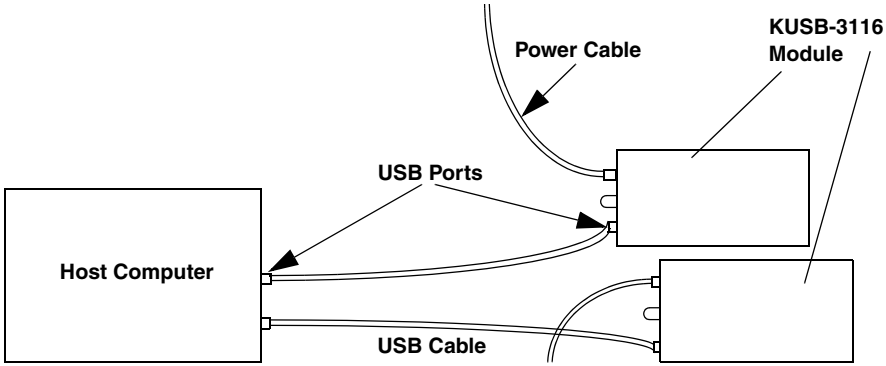


Figure 3: Attaching the Module to the Host Computer

4. If you previously installed the device driver, ignore the remaining steps, and repeat steps 1 and 2 to attach another KUSB-3116 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 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 module.

9. Repeat the steps 1 to 3 to attach another KUSB-3116 module to the host computer, if desired.

Connecting Multiple Modules Using an Expansion Hub

Expansion hubs are powered by their own external power supply. Theoretically, you can connect up to five expansion hubs to a USB port on the host computer. However, the practical number of KUSB-3116 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-3116 modules.

Note: The bandwidth of the USB Ver. 1.1 bus is 12 Mbits/second; the bandwidth of the USB Ver. 2.0 bus is 480 Mbits/second. Particularly if you are using the USB Ver. 2.0 bus, you may be limited in the number of KUSB-3116 modules that you can connect to a single USB port.

To connect multiple KUSB-3116 modules to an expansion hub, perform the following steps:

1. Make sure that you have attached a power supply to the module.
2. Attach one end of the USB cable to the KUSB-3116 module and the other end of the USB cable to an expansion hub.
3. Connect the power supply for the expansion hub to an external power supply.
4. Connect the expansion hub to the USB port on the host computer using another USB cable.
   The operating system automatically detects the USB device. If the power supply and module are attached correctly, the LED turns green.
5. If you have previously installed the device driver, ignore the remaining steps, and repeat steps 1 to 3 until you have attached the number of expansion hubs (up to five) and modules (up to four per hub) that you require. Refer to Figure 4.

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 6.

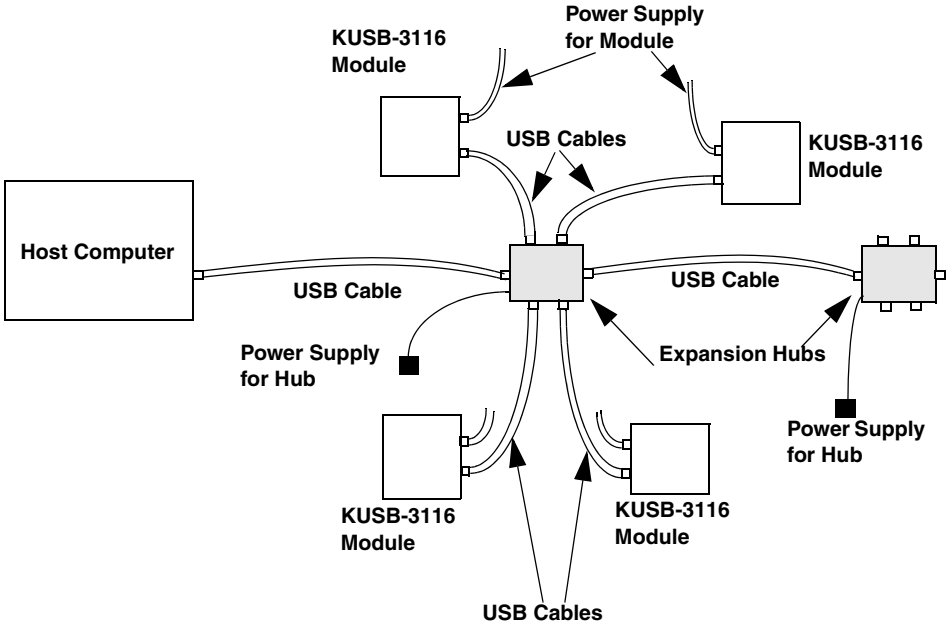


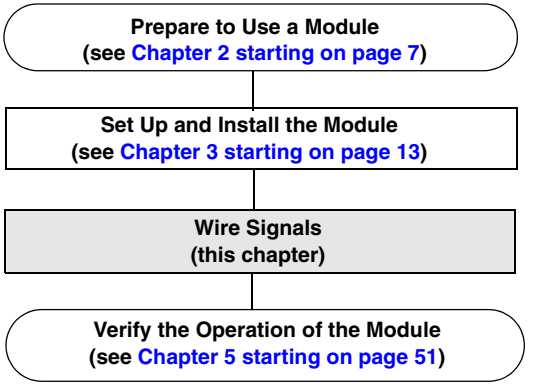
Figure 4: Attaching Multiple KUSB-3116 Modules Using Expansion Hubs

6. Click the option to search for the driver, then click **Next**.
7. Click the option to specify the location, browse to the location on the CD that contains the driver files, then click **Next**.
8. Click **Next**.
9. Click **Finish**.
   A New Hardware Found dialog box appears indicating that Windows is installing the driver for the USB device.

10. Repeat steps 1 to 3 until you have attached the number of expansion hubs (up to five) and modules (up to four per hub) that you require.
The operating system automatically detects the USB devices as they are installed.

Continue with the instructions on wiring in Chapter 4 starting on page 23.

Wiring Signals


Prepare to Use a Module
(see Chapter 2 starting on page 7)
Set Up and Install the Module
(see Chapter 3 starting on page 13)
Wire Signals
(this chapter)
Verify the Operation of the Module
(see Chapter 5 starting on page 51)

Preparing to Wire Signals

CAUTION:

To avoid electrostatic sensitivity, it is recommended that you unplug your KUSB-3116 module from the computer before wiring signals.

This section provides recommendations and information about wiring signals to the KUSB-3116 module.

Wiring Recommendations

Keep the following recommendations in mind when wiring signals to a BNC connection box:

- Use individually shielded twisted-pair wire (size 14 to 26 AWG) 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 box 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 box is operational.
- Connect all unused analog input channels to analog ground.

Wiring Methods

The KUSB-3116 module contains both BNC connectors and 37-pin, D-sub connectors, as shown in Figure 5.

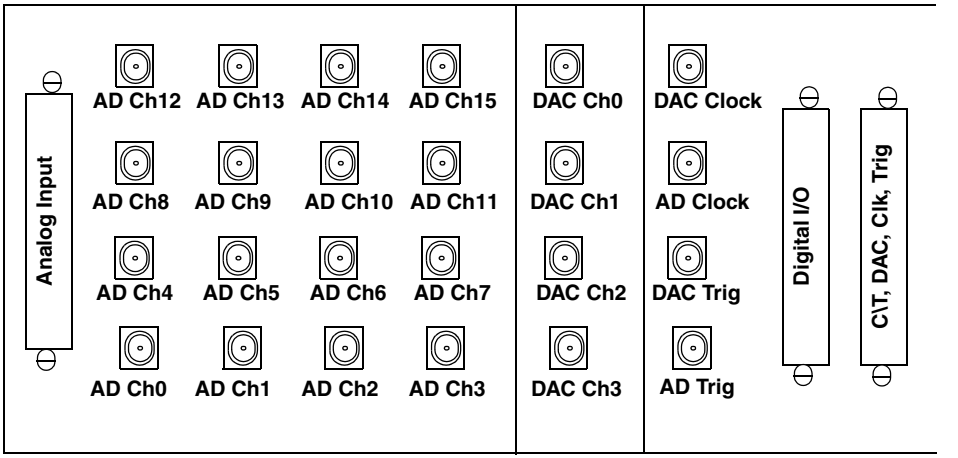


Figure 5: KUSB-3116 Module

You can wire signals to the KUSB-3116 module in one of the following ways:

- **Analog input signals** – You can wire analog input signals in one of the following ways:
  - Using the BNC connectors labelled AD Ch0 to AD Ch15.
  - Using the appropriate pins on the Analog Input connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.

- **Analog output signals** – You can wire analog output signals in one of the following ways:
  - Using the BNC connectors labelled DAC Ch0 to DAC Ch3.
  - Using the appropriate pins on the C\T, DAC, Clk, Trig connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.
- **Digital I/O signals** – To wire digital I/O signals, you must use the appropriate pins on the Digital I/O connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.
- **Counter/timer signals** – To wire counter/timer signals, you must use the appropriate pins on the C\T, DAC, Clk, Trig connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.
- **External A/D clock or trigger signal** – You can wire external clock/trigger signals in one of the following ways:
  - Using the BNC connectors labelled AD Clock and AD Trig.
  - Using the appropriate pins on the C\T, DAC, Clk, Trig connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.
- **External DAC clock or trigger signal** – You can wire external clock/trigger signals in one of the following ways:
  - Using the BNC connectors labelled DAC Clock and DAC Trig.
  - Using the appropriate pins on the C\T, DAC, Clk, Trig connector. Refer to Appendix A in the *KUSB-3116 User's Manual* for information about the required mating connectors.

The following sections describe how to wire signals using the BNC connectors and how to wire signals using the appropriate D-sub connector.

Wiring Signals to the BNC Connectors

To wire signals using the BNC connectors, connect the appropriate BNC connector to the appropriate input/output using a BNC cable.

The KUSB-3116 module, shown in Figure 5 on page 26, contains 24 BNC connectors (16 BNC connectors for single-ended analog inputs, four BNC connectors for analog outputs, and four BNC connectors for external clocks and triggers).

Wiring Signals to the D-Sub Connectors on the BNC Connection Box

If you do not want to use the BNC connectors or if you want to connect digital I/O or counter/timer signals to the KUSB-3116 module, you can use the 37-pin, D-sub connectors. These connectors are described in the following sections.

Analog Input Connector

The Analog Input connector allows you to access the analog input signals. Table 1 lists the pin assignments for the analog input connector.

Table 1: Analog Input Connector Pin Assignments

Pin Assignment	Signal Description	Pin Assignment	Signal Description
1	Analog Input 0	2	Analog Input 1
3	Analog Input 2	4	Analog Input 3
5	Analog Input 4	6	Analog Input 5
7	Analog Input 6	8	Analog Input 7
9	Analog Input 8	10	Analog Input 9

Table 1: Analog Input Connector Pin Assignments (cont.)

Pin Assignment	Signal Description	Pin Assignment	Signal Description
11	Analog Input 10	12	Analog Input 11
13	Analog Input 12	14	Analog Input 13
15	Analog Input 14	16	Analog Input 15
17	Amplifier Low	18	+5 V Analog
19	Chassis Ground	20	Analog Input 0 Return/ Analog In 8[a]
21	Analog Input 1 Return/ Analog In 9[a]	22	Analog Input 2 Return/ Analog In 10[a]
23	Analog Input 3 Return/ Analog In 11[a]	24	Analog Input 4 Return/ Analog In 12[a]
25	Analog Input 5 Return/ Analog In 13[a]	26	Analog Input 6 Return/ Analog In 14[a]
27	Analog Input 7 Return/ Analog In 15[a]	28	Analog Input 8 Return[a]
29	Analog Input 9 Return[a]	30	Analog Input 10 Return[a]
31	Analog Input 11 Return[a]	32	Analog Input 12 Return[a]
33	Analog Input 13 Return[a]	34	Analog Input 14 Return [a]
35	Analog Input 15 Return[a]	36	Analog Ground
37	Digital Ground		

a. The first signal description (Return) applies to the differential configuration for all modules. The second signal description applies to the single-ended configuration for the module.

Digital In/Out Connector

The Digital In/Out connector allows you to access the digital I/O signals. Table 2 lists the pin assignments for the Digital In/Out connector.

Table 2: Digital In/Out Connector Pin Assignments

Pin Assignment	Signal Description	Pin Assignment	Signal Description
1	Digital Input 0	2	Digital Input 1
3	Digital Input 2	4	Digital Input 3
5	Digital Input 4	6	Digital Input 5
7	Digital Input 6	8	Digital Input 7
9	Digital Input 8	10	Digital Input 9
11	Digital Input 10	12	Digital Input 11
13	Digital Input 12	14	Digital Input 13
15	Digital Input 14	16	Digital Input 15
17	Digital Ground	18	Digital Ground
19	Not Used	20	Digital Output 0
21	Digital Output 1	22	Digital Output 2
23	Digital Output 3	24	Digital Output 4
25	Digital Output 5	26	Digital Output 6
27	Digital Output 7	28	Digital Output 8
29	Digital Output 9	30	Digital Output 10
31	Digital Output 11	32	Digital Output 12

Table 2: Digital In/Out Connector Pin Assignments (cont.)

Pin Assignment	Signal Description	Pin Assignment	Signal Description
33	Digital Output 13	34	Digital Output 14
35	Digital Output 15	36	Dynamic Digital Output
37	Digital Ground		

C/T, DAC, Clk, Trig Connector

The C/T, DAC, Clk, Trig connector allows you to access the counter/timer, analog output, external clock, and external trigger signals. Table 3 lists the pin assignments for the C/T, DAC, Clk, Trig connector.

Table 3: C/T, DAC, Clk, Trig Connector

Pin Assignment	Signal Description	Pin Assignment	Signal Description
1	Analog Output 0	2	Analog Output 1
3	Analog Output 2	4	Analog Output 3
5	Digital Ground	6	External DAC Clock
7	External ADC Clock	8	Counter 0 Clock
9	Counter 0 Out	10	Counter 1 Clock
11	Counter 1 Out	12	Counter 2 Clock
13	Counter 2 Out	14	Counter 3 Clock
15	Counter 3 Out	16	Counter 4 Clock
17	Counter 4 Out	18	Digital Ground
19	Not Used	20	Analog Output 0 Return

Table 3: C/T, DAC, Clk, Trig Connector (cont.)

Pin Assignment	Signal Description	Pin Assignment	Signal Description
21	Analog Output 1 Return	22	Analog Output 2 Return
23	Analog Output 3 Return	24	Digital Ground
25	External DAC Trigger	26	External ADC Trigger
27	Digital Ground	28	Counter 0 Gate
29	Digital Ground	30	Counter 1 Gate
31	Digital Ground	32	Counter 2 Gate
33	Digital Ground	34	Counter 3 Gate
35	Digital Ground	36	Counter 4 Gate
37	Digital Ground		

Connecting Analog Input Signals

The KUSB-3116 module supports 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.
- **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 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, the number of analog input channels available is the same as for single-ended configuration.
- **Differential** –Choose this configuration when you want to measure low-level signals, noise is a significant part of the signal, or common-mode voltage exists.

This section describes how to connect single-ended, pseudo-differential, and differential voltage inputs, as well as current loops, to the KUSB-3116 module.

Connecting Single-Ended Voltage Inputs

Note: If you are using single-ended inputs, make sure that bias return resistance is disabled in the Open Layers Control Panel applet. Refer to page 16 for more information.

Figure 6 shows how to connect single-ended voltage inputs (channels 0 and 1, in this case) to the BNC connectors on the KUSB-3116 module.

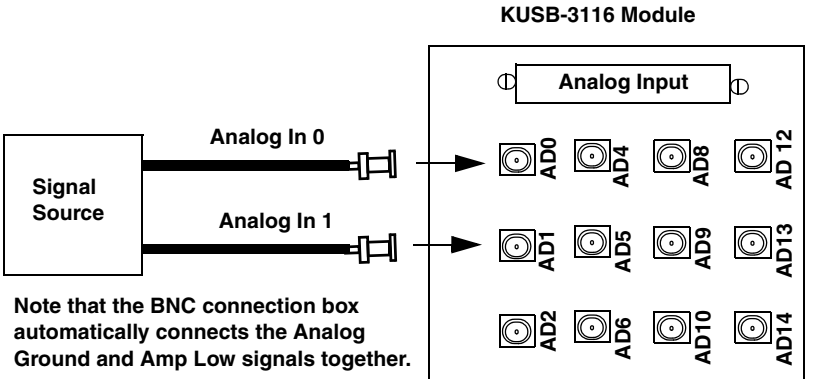


Figure 6: Connecting Single-Ended Inputs to the BNC Connectors

Figure 7 shows how to connect single-ended voltage inputs (channels 0 and 1, in this case) using your own cable/screw terminal panel.

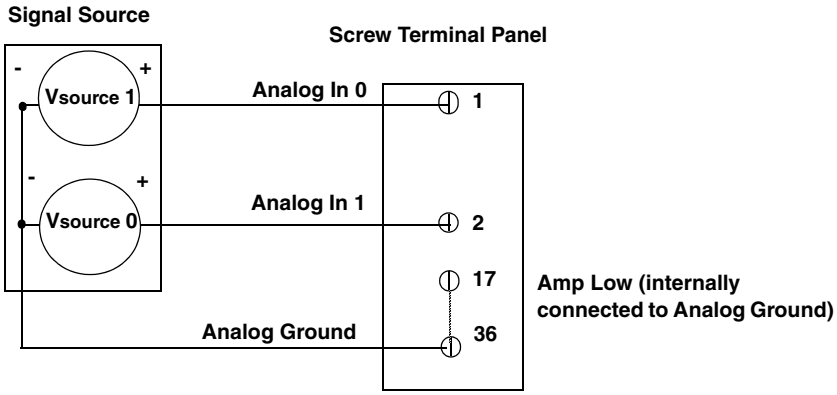


Figure 7: Connecting Single-Ended Inputs to a Screw Terminal Panel

Connecting Pseudo-Differential Voltage Inputs

Figure 8 shows how to connect pseudo-differential voltage inputs (channels 0 and 1, in this case) to the BNC connectors on the KUSB-3116 module.

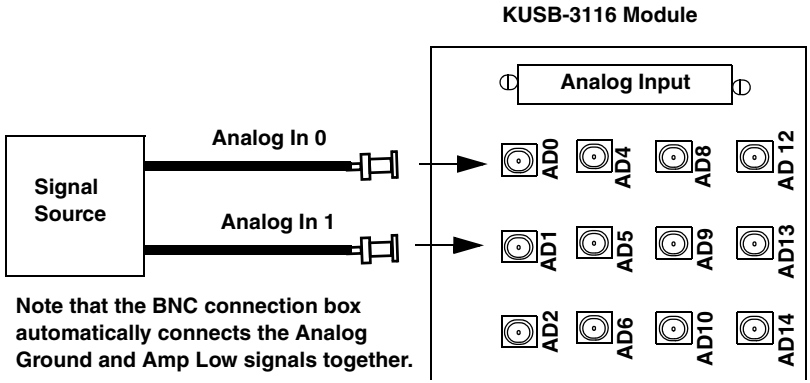


Figure 8: Connecting Pseudo-Differential Inputs to the BNC Connectors

Figure 9 shows how to connect pseudo-differential voltage inputs (channels 0 and 1, in this case) using your own cable/screw terminal panel.

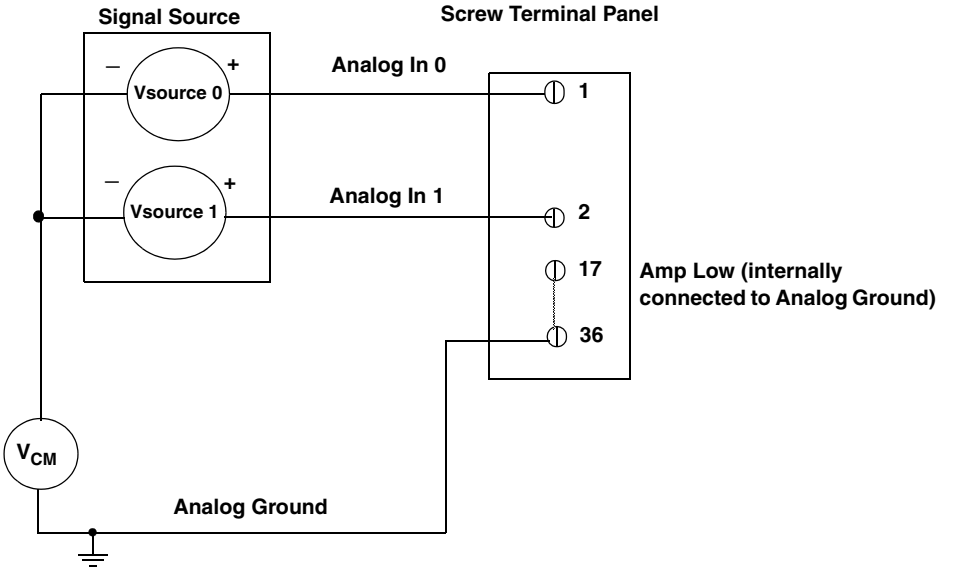


Figure 9: Connecting Pseudo-Differential Inputs to a Screw Terminal Panel

Connecting Differential Voltage Inputs

Figure 10 shows how to connect differential voltage inputs (channels 0 and 1, in this case) to the BNC connectors on a KUSB-3116 module.

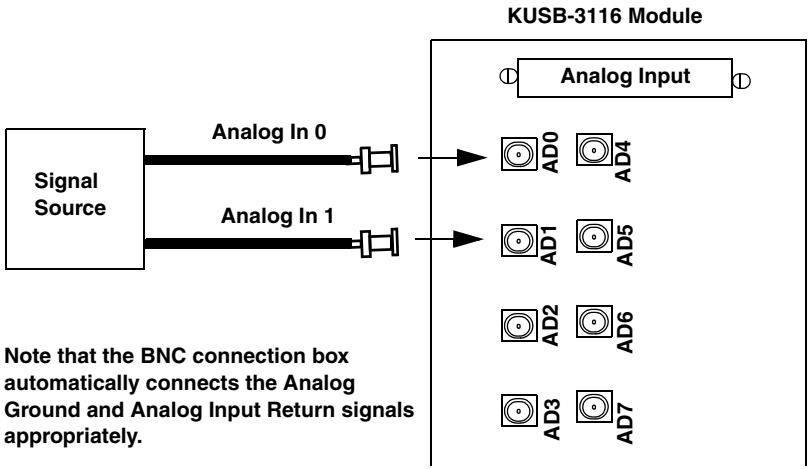


Figure 10: Connecting Differential Inputs to the BNC Connectors

Figure 11A shows how to connect a floating signal source to your own screw terminal panel 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 using the Open Layers Control Panel applet to enable 10 kΩ of termination resistance. For more information, refer to page 16.

Figure 11B illustrates how to connect a nonfloating signal source to your own screw terminal panel 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.

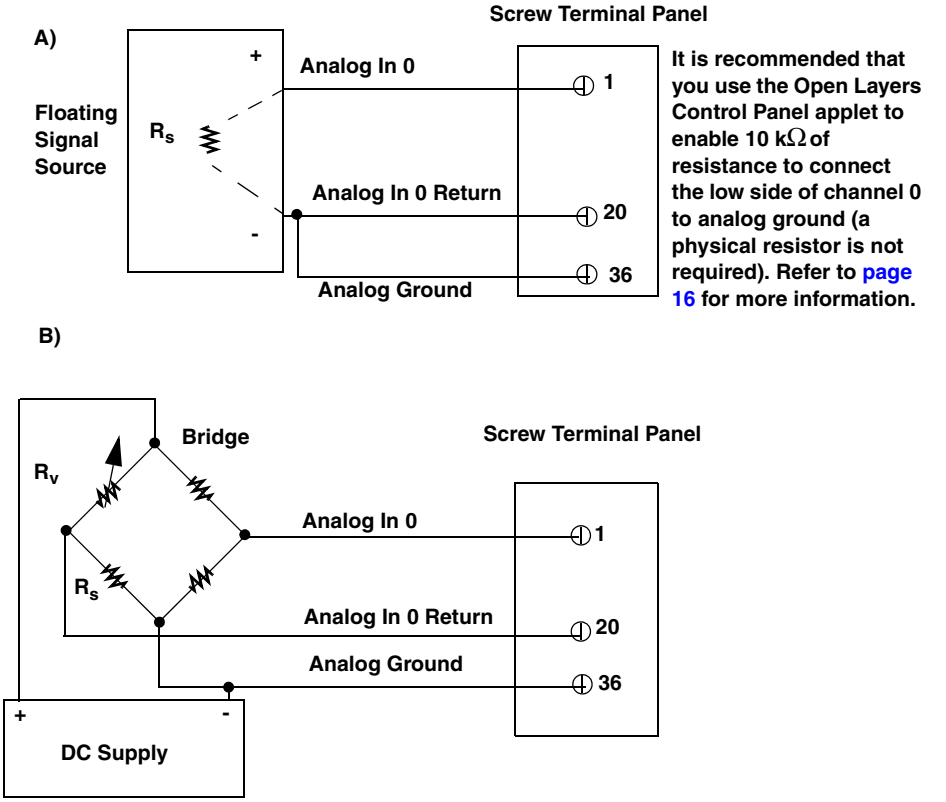


Figure 11: Connecting Differential Inputs to a Screw Terminal Panel

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 as shown as Figure 12. In this case, make sure that the low side of the signal (-) is connected to ground at the signal source, not at the screw terminal panel, and do not tie the two grounds together.

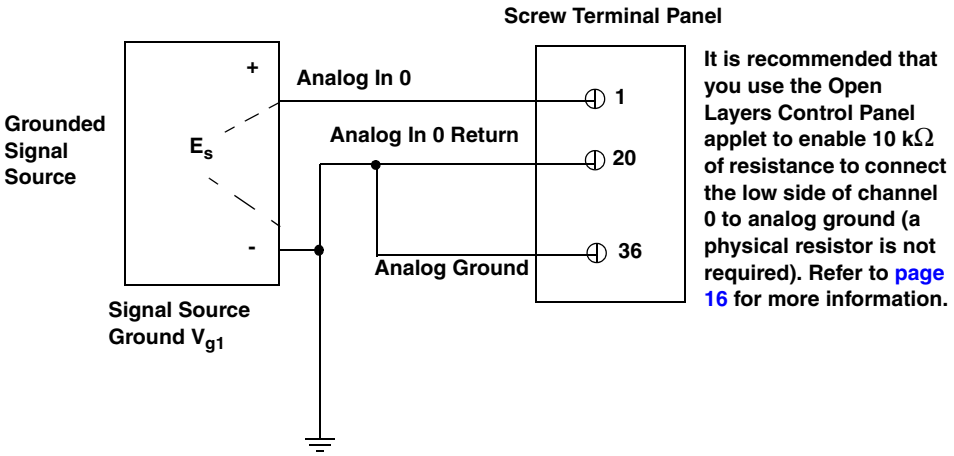
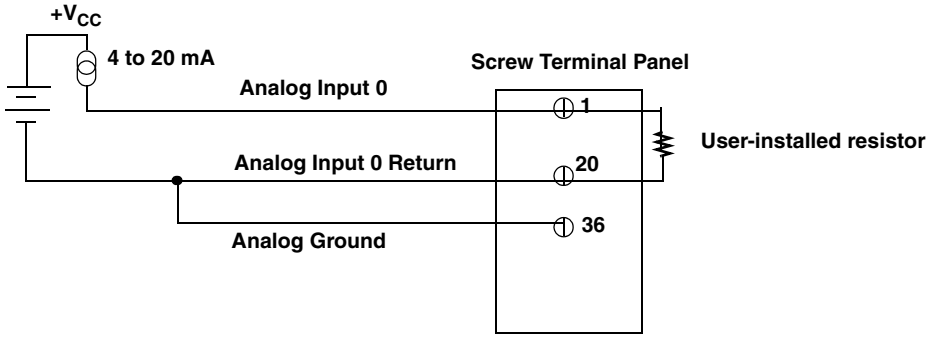


Figure 12: Connecting Differential Voltage Inputs from a Grounded Signal Source to a Screw Terminal Panel

Connecting Current Loop Inputs

Note: You cannot connect a current loop input using the BNC connectors.

Figure 13 shows how to connect a current loop input (channel 0, in this case) to your own screw terminal panel.



The user-installed resistor connects the high side of the channel to the low side of the corresponding channel, thereby acting as a shunt. For example, if you add a 250 Ω resistor and then connect a 4 to 20 mA current loop input to channel 0, the input range is converted to 1 to 5 V.

It is recommended that you use the Open Layers Control Panel applet to enable 10 kΩ of termination resistance to connect the low side of channel 0 to analog ground (a physical resistor is not required). Refer to page 16 for more information.

Figure 13: Connecting Current Inputs to a Screw Terminal Panel

Connecting Analog Output Signals

Figure 14 shows how to connect an analog output voltage signal (channel 0, in this case) to the BNC connectors on the KUSB-3116 module.

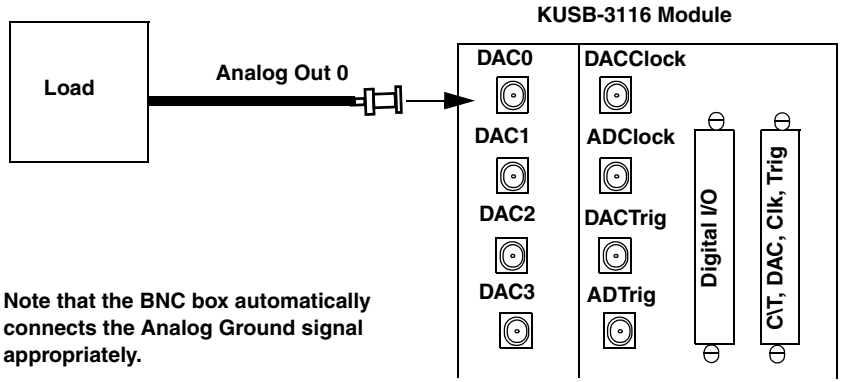


Figure 14: Connecting Analog Outputs to the BNC Connectors

Figure 15 shows how to connect analog outputs to your own screw terminal panel.

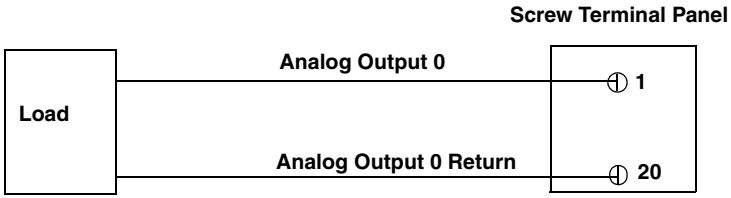


Figure 15: Connecting Analog Outputs to a Screw Terminal Panel

Connecting Digital I/O Signals

Figure 16 shows how to connect digital input signals (lines 0 and 1, in this case) to your own screw terminal panel.

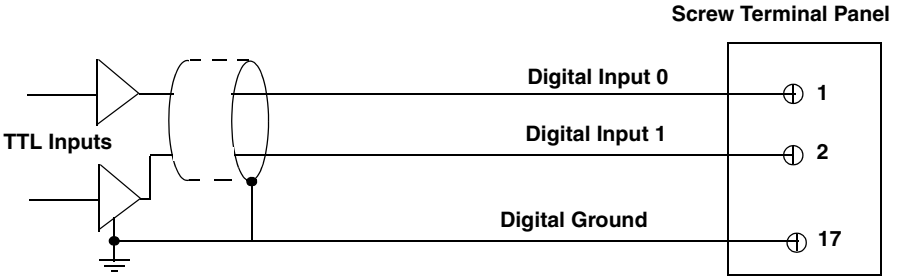


Figure 16: Connecting Digital Inputs to a Screw Terminal Panel

Figure 17 shows how to connect a digital output (line 0, in this case) to your own screw terminal panel.

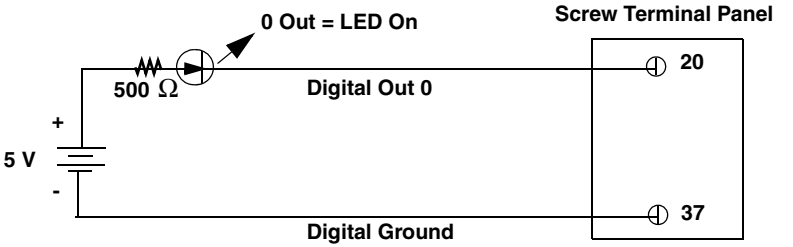


Figure 17: Connecting Digital Outputs to a Screw Terminal Panel

Connecting Counter/Timer Signals

The KUSB-3116 module provides five counter/timer channels that you can use to perform the following operations:

- Event counting,
- Up/down counting,
- Frequency measurement,
- Pulse width/period measurement,
- Edge-to-edge measurement, and
- Pulse output (continuous, one-shot, and repetitive one-shot).

This section describes how to connect counter/timer signals. Refer to the *KUSB-3116 User's Manual* for more information about using the counter/timers.

Connecting Signals for Event Counting Operations

Figure 18 shows how to connect counter/timer signals either to your own screw terminal panel to perform an event counting operation on counter/timer 0 using an external gate. The counter counts the number of rising edges that occur on the Counter 0 Clock input when the Counter 0 Gate signal is in the active state (as specified by software). Refer to the *KUSB-3116 User's Manual* for more information.

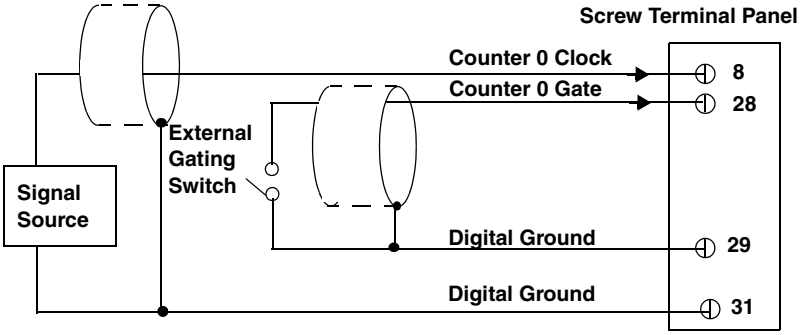


Figure 18: Connecting Counter/Timer Signals to a Screw Terminal Panel for an Event Counting Operation Using an External Gate

Figure 19 shows how to connect counter/timer signals either to your own screw terminal panel to perform an event counting operation on counter/timer 0 without using a gate. The counter counts the number of rising edges that occur on the Counter 0 Clock input.

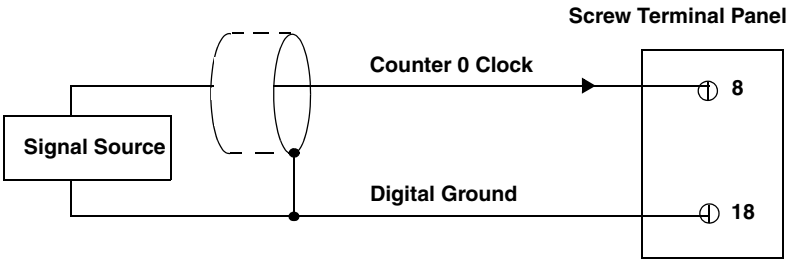


Figure 19: Connecting Counter/Timer Signals to a Screw Terminal Panel for an Event Counting Operation Without Using a Gate

Connecting Signals for Up/Down Counting Operations

Figure 20 shows how to connect counter/timer signals to your own screw terminal panel to perform an up/down counting operation on counter/timer 0. The counter keeps track of the number of rising edges that occur on the Counter 0 Clock input. The counter increments when the Counter 0 Gate signal is high and decrements when the Counter 0 Gate signal is low.

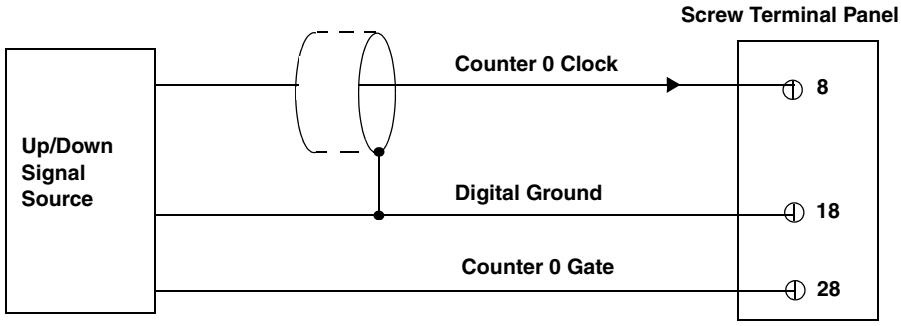


Figure 20: Connecting Counter/Timer Signals to a Screw Terminal Panel for an Up/Down Counting Operation

Connecting Signals for Frequency Measurement Operations

One way to measure frequency is to use the same wiring as a standard event counting application that does not use a gate (see Figure 19 on page 44), then use the Windows timer to determine the duration of the frequency measurement. The frequency of the Counter 0 Clock signal is the number of counts divided by the duration of the Windows timer.

If you need more accuracy than the Windows timer can provide, you can connect a pulse of a known duration (such as a one-shot output of counter/timer 1) to the Counter 0 Gate input. Figure 21 shows how to connect counter/timer signals to your own screw terminal panel. In this case, the frequency of the Counter 0 clock input is the number of counts divided by the period of the Counter 0 Gate input signal.

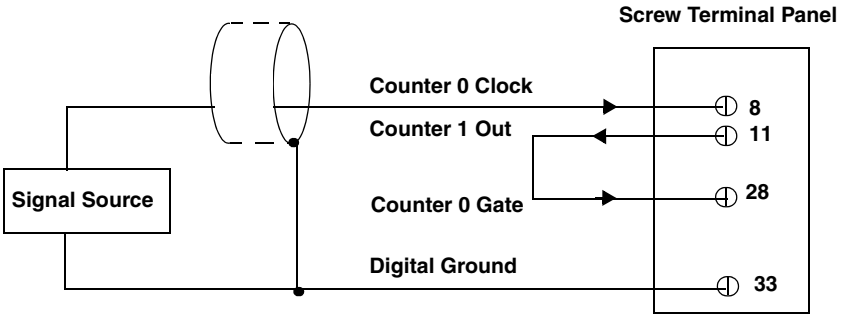


Figure 21: Connecting Counter/Timer Signals to a Screw Terminal Panel for a Frequency Measurement Operation Using an External Pulse

Connecting Signals for Period/Pulse Width Measurement Operations

Figure 22 shows how to connect counter/timer signals to your own screw terminal panel to perform a period/pulse width measurement operation on counter/timer 0. You specify the active pulse (high or low) in software. The pulse width is the percentage of the total pulse period that is active. Refer to the *KUSB-3116 User's Manual* for more information about pulse periods and pulse widths.

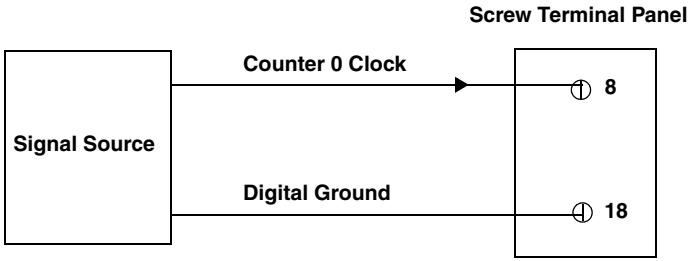


Figure 22: Connecting Counter/Timer Signals to a Screw Terminal Panel for a Period/Pulse Width Measurement Operation

Connecting Signals for Edge-to-Edge Measurement Operations

Figure 23 shows how to connect counter/timer signals to your own screw terminal panel to perform an edge-to-edge measurement operation on two signal sources. The counter measures the time interval between the start edge (in this case, a rising edge on the Counter 0 Clock signal) and the stop edge (in this case, a falling edge on the Counter 0 Gate signal).

You specify the start edge and the stop edge in software. Refer to the *KUSB-3116 User's Manual* for more information.

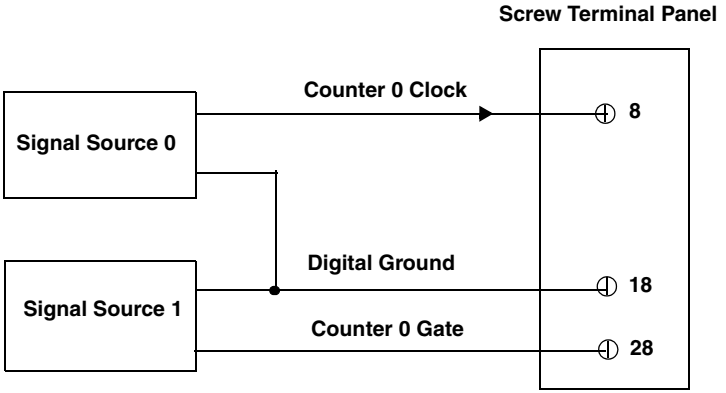


Figure 23: Connecting Counter/Timer Signals to a Screw Terminal Panel for an Edge-to-Edge Measurement Operation

Connecting Signals for Pulse Output Operations

Figure 24 shows how to connect counter/timer signals to your own screw terminal panel to perform a pulse output operation on counter/timer 0; in this example, an external gate is used.

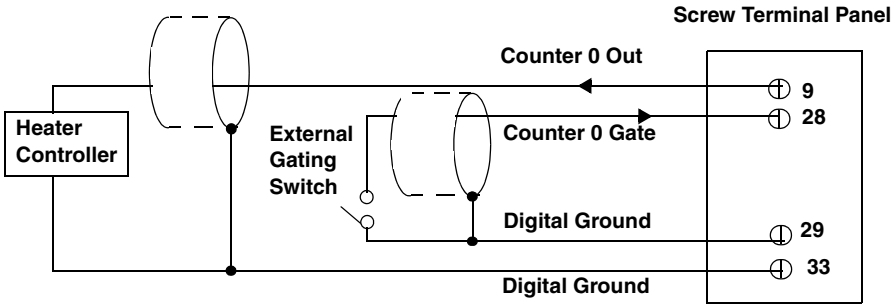
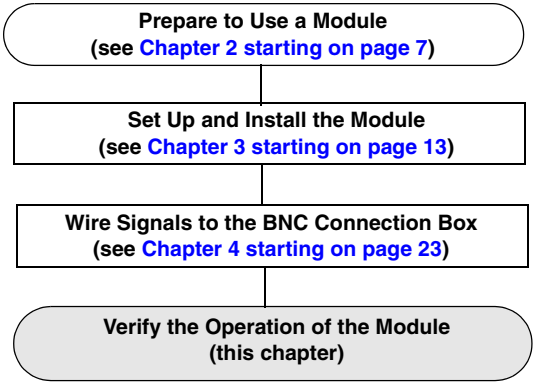


Figure 24: Connecting Counter/Timer Signals to a Screw Terminal Panel for a Pulse Output Operation Using an External Gate

Verifying the Operation of a Module


Prepare to Use a Module
(see Chapter 2 starting on page 7)
Set Up and Install the Module
(see Chapter 3 starting on page 13)
Wire Signals to the BNC Connection Box
(see Chapter 4 starting on page 23)
Verify the Operation of the Module
(this chapter)

Overview

You can verify the operation of a KUSB-3116 module using the Quick Data Acq application. 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 9.

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 about each of the supported features, use the online help for the Quick Data Acq application by pressing **F1** from any view or selecting the **Help** menu, or refer to the *KUSB-3116 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 KUSB-3116 module. Refer to page 37 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 KUSB-3116 module from the **Board** list box.
5. In the **Channel** list box, select analog input channel 0.
6. In the **Range** list box, select the range for the channel. The default is ±10 V.

7. Select **Differential**.
8. 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 analog output channel 0 on the module. Refer to page 41 for an example of how to connect analog output signals.
2. Click the **Control** menu.
3. Click **Single Analog Output**.
4. Select the appropriate KUSB-3116 module from the **Board** list box.
5. In the **Channel** list box, select analog output channel 0.
6. In the **Range** list box, select the output range of DAC0. 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 analog output channel 0.
   The value that is output is displayed both on the slider and in the text box.

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 KUSB-3116 module (differential mode). Refer to page 37 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 KUSB-3116 module from the **Board** list box.
5. In the **Sec/Div** list box, select the number of seconds per division (.1 to .00001) for the display.
6. In the **Channel** 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**.
10. Click **OK** to close dialog box
11. 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, or ±1.25 V). The default is ±10 V.
    The display changes to reflect the selected range for all the analog input channels on the module.
12. 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.

13. 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.
14. 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 on the KUSB-3116 module. Refer to page 42 for an example of how to connect a digital input.
2. Click the **Acquisition** menu.
3. Click **Digital Input**.
4. Select the appropriate KUSB-3116 module from the **Board** list box.
5. Click **Get**.
   The entire 16-bit digital input value (0 to FFFF) is displayed in both the Data box and the Digital Input box.

   In addition, the state of the lower eight digital input lines (lines 0 to 7) is shown in the graphical display. If an indicator light is lit (red), the line is high; if an indicator light is not lit (black), the line is low.

Note: Although the KUSB-3116 module contains 16 digital input lines, the Quick Data Acq application shows indicator lights for the lower eight digital input lines only. The 16-bit value is the correct value for all 16 lines.

Performing a Single-Value Digital Output Operation

Note: Although the KUSB-3116 module contains 16 digital output lines, the Quick Data Acq application allows you to perform a digital output operation on the lower eight digital output lines (lines 0 to 7) only.

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 on the KUSB-3116 module. Refer to page 42 for an example of how to connect a digital output.
2. Click the **Control** menu.
3. Click **Digital Output**.
4. Select the appropriate KUSB-3116 module from the **Board** list box.
5. Click the appropriate indicator lights to select the types of signals to write from the digital output lines. If you select a light, the module outputs a high-level signal; if you do not select a light, the module outputs a low-level signal. You can also enter an output value for the lower eight digital output lines (0 to FF) in the **Hex** text box.
6. Click **Send**.
   The values of the lower eight digital output lines are output appropriately.

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 KUSB-3116 module. Refer to page 59 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 **Measure Frequency**.
4. Select the appropriate KUSB-3116 module from the **Board** list box.
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.*
7. Click **Stop** to stop the frequency measurement operation.

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 KUSB-3116 module. Refer to page 49 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 KUSB-3116 module from the **Board** list box.
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. Under **Pulse Width**, 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.

Ground, Power, and Isolation Connections

Figure 25 illustrates how ground, power, and isolation are connected internally on a KUSB-3116 module.

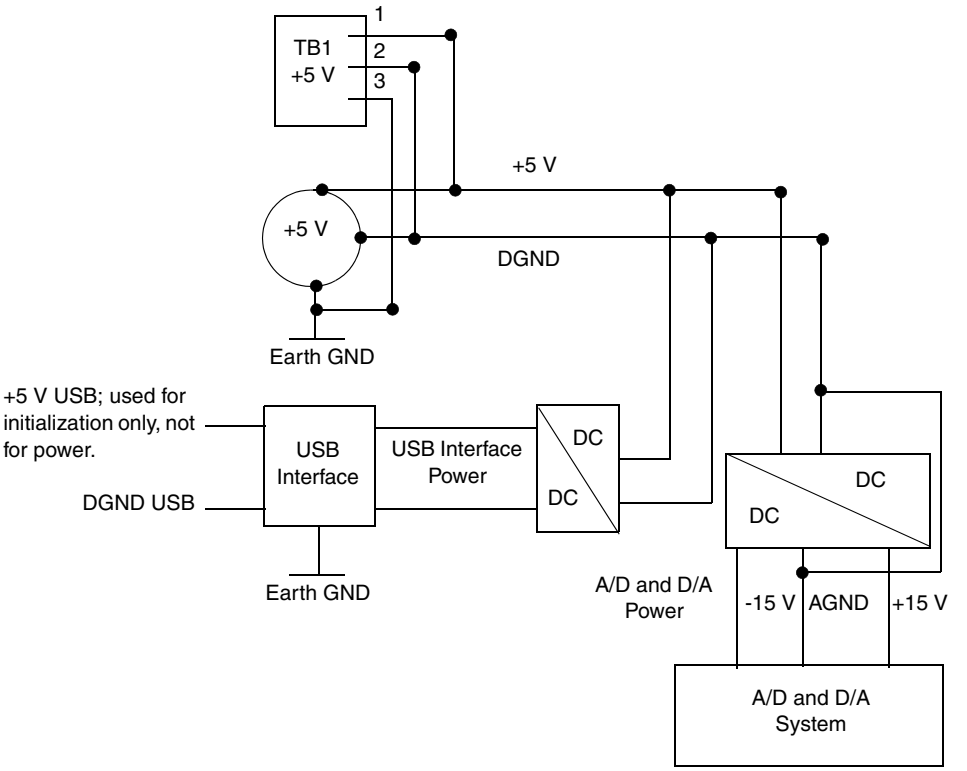


Figure 25: Ground, Power, and Isolation Connections

Keep the following in mind:

- Earth ground on the KUSB-3116 module is not connected to DGND or AGND.
- Earth ground is connected to the aluminum case of the BNC connection box.
- You should connect earth ground to the power supply earth.
- You should isolate the +5V/DGND input. Note that the power supply (shipped with the KUSB-3116 module) has no connection between +5V/DGND and earth ground.
- The USB connector case is connected to earth ground.
- The USB data lines and USB GND are not connected to earth ground.
- The USB DGND is connected to the USB GND of the PC USB port.

Index

A

B

C

S

U

W

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

12/04