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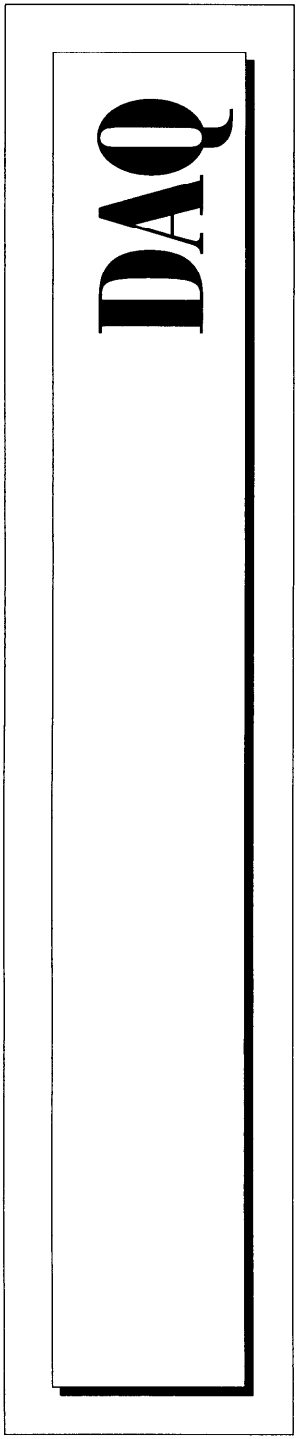
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PC-516/DAQCard-516 User Manual

Multifunction I/O Devices

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Table of Contents

About This Manual

Organization of this Manual ix
Conventions Used in This Manual x
National Instruments Documentation xi
Related Documentation xii
Customer Communication xii

Chapter 1 Introduction

About Your PC-516 and DAQCard-516 1-1
What You Need to Get Started 1-2
Software Programming Choices 1-3
    LabVIEW and LabWindows/CVI Application Software 1-3
    NI-DAQ Driver Software 1-3
    Register-Level Programming 1-5
Optional Equipment 1-5
Cabling 1-5
Unpacking 1-6

Chapter 2 Installation and Configuration

Installation 2-1
Hardware Configuration 2-3
    Bus-Related Configuration (PC-516 only) 2-4
        Plug and Play Mode 2-4
        Switchless Mode 2-5
        Base I/O Address Selection 2-5
    Data-Acquisition-Related Configuration 2-5
        Analog Input Configuration 2-5
            RSE Input (Eight Channels, Default Setting) 2-6
            DIFF Input (Four Channels) 2-6
        Digital I/O Configuration 2-7
        Counter Configuration 2-7

Chapter 3
Signal Connections

I/O Connectors 3-1
Signal Connection Descriptions 3-3
Analog Input Signal Connections 3-4
Analog Input Signal Connection Considerations 3-4
Types of Signal Sources and Measurement Systems 3-5
Ground-Referenced Signal Sources 3-5
Floating Signal Sources 3-5
Input Configurations 3-5
SE Input 3-7
DIFF Input 3-7
Single-Ended Connection Considerations 3-7
Differential Connection Considerations 3-9
Differential Connections for Grounded Signal Sources 3-10
Differential Connections for Floating Signal Sources 3-11
Common-Mode Signal Rejection Considerations 3-12
Digital I/O Signal Connections 3-13
Timing Connections 3-14
Data Acquisition Counter and Timing Connections 3-15
General-Purpose Counter and Timing Signal Connections 3-15

Chapter 4
Theory of Operation

Functional Overview 4-1
Bus Interface Circuitry 4-3
Analog Input and Data Acquisition Circuitry 4-3
Analog Input Circuitry 4-4
Data Acquisition Timing Circuitry 4-5
Single-Channel Data Acquisition 4-6
Multichannel (Scanned) Data Acquisition 4-6
Data Acquisition Rates 4-6
Digital I/O Circuitry 4-7
Timing I/O Circuitry 4-7

Appendix A
Specifications

Appendix B
Custom Cable Design

Appendix C
PC Card Questions and Answers

Appendix D
Power-Management Modes

Appendix E
Customer Communication

Glossary

Index

Figures

Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware 1-4

Figure 2-1. A Typical Configuration for the DAQCard-516 2-3

Figure 3-1. I/O Connector Pin Assignments 3-2
Figure 3-2. Onboard Instrumentation Amplifier 3-6
Figure 3-3. Single-Ended Analog Input Signal Connections 3-8
Figure 3-4. Differential Input Connections for Grounded Signal Sources 3-10
Figure 3-5. Differential Input Connections for Floating Sources 3-11
Figure 3-6. Digital I/O Signal Connections 3-14
Figure 3-7. EXTCONV* Signal Timing 3-15
Figure 3-8. Event-Counting Application with External Switch Gating 3-16
Figure 3-9. Frequency Measurement Application 3-17
Figure 3-10. General-Purpose Timing Signals 3-19

Figure 4-1. 516 Device Block Diagram 4-2
Figure 4-2. Bus Interface Circuitry Block Diagram 4-3
Figure 4-3. Analog Input and Data Acquisition Circuitry Block Diagram 4-4
Figure 4-4. Digital I/O Circuitry Block Diagram 4-7
Figure 4-5. Timing I/O Circuitry Block Diagram 4-8
Figure 4-6. Counter Block Diagram 4-9

Figure B-1. DAQCard-516 I/O Connector Pin Assignments B-2

Tables

Table 2-1. Analog Input Modes for the 516 Device 2-6

Table 3-1. Recommended Input Configurations for Ground-Referenced and Floating Measurement Systems 3-6

Table D-1. DAQCard-516 Power-Management Modes D-2

This manual describes the mechanical and electrical aspects of the PC-516 and DAQCard-516 and contains information concerning their installation and operation. The PC-516 and DAQCard-516 are compact, low-cost, low-power analog input, digital I/O, and timing I/O devices.

Organization of this Manual

The *PC-516/DAQCard-516 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the PC-516 and DAQCard-516; lists the optional software and optional equipment; and explains how to unpack your 516 device.
- Chapter 2, *Installation and Configuration*, describes how to install and software configure your 516 device.
- Chapter 3, *Signal Connections*, describes how to make input and output signal connections to your PC-516 and DAQCard-516. If you are making your own cables, see Appendix B, *Custom Cable Design*.
- Chapter 4, *Theory of Operation*, includes an overview of the PC-516 and DAQCard-516 and explains the operation of each functional unit making up your 516 device.
- Appendix A, *Specifications*, lists the specifications of the PC-516 and DAQCard-516.
- Appendix B, *Custom Cable Design*, describes the pin connections on the PC-516 and DAQCard-516, which you will need only if you are designing your own cable.
- Appendix C, *PC Card Questions and Answers*, contains a list of common questions and answers relating to PC Card (PCMCIA) operation.
- Appendix D, *Power-Management Modes*, describes the power-management modes of the DAQCard-516.
- Appendix E, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.

- The *Glossary* contains an alphabetical list and description of terms used in this manual, including acronyms, abbreviations, metric prefixes, mnemonics, and symbols.
- The *Index* alphabetically lists topics covered in this manual, including the page number where you can find the topic.

Conventions Used in This Manual

The following conventions are used in this manual:

< >	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit, port, or signal name (for example, ACH<0..7> stands for ACH0 through ACH7).
516 device	516 device is a generic term to denote both the PC-516 and DAQCard-516.
bold	Bold text denotes menus, menu items, or dialog box buttons or options.
bold italic	Bold italic text denotes a note, caution, or warning.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
Macintosh	Macintosh refers to Macintosh and PowerBook computers equipped with a Type II PCMCIA +5 V-capable slot.
monospace	Text in this font denotes text or characters that are to be literally input from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, variables, file names, and extensions, and for statements and comments taken from program code.
NI-DAQ	NI-DAQ refers to the NI-DAQ software for PC compatibles or Macintosh unless otherwise noted.
PC	PC refers to the IBM PC/XT, PC AT, Personal System/2, and laptop compatible computers that are equipped with a PCMCIA standard version 2.0 or later bus interface and Type II +5 V-capable slot. PC also refers to PCMCIA when referring to a Macintosh system.

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

National Instruments Documentation

The *PC-516/DAQCard-516 User Manual* is one piece of the documentation set for your data acquisition (DAQ) system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the manuals you have as follows:

- *Getting Started with SCXI*—If you are using SCXI, this is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.
- Your SCXI user manuals—If you are using SCXI, read these manuals next for detailed information about signal connections and module configuration. They also explain in greater detail how the module works and contain application hints.
- Your DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to your computer. Use these manuals for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software documentation—Examples of software documentation you may have are the LabVIEW and LabWindows®/CVI manual sets and the NI-DAQ documentation. After you set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) manuals or the NI-DAQ documentation to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software documentation before you configure your hardware.
- Accessory manuals—If you are using accessory products, read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.
- SCXI chassis manuals—If you are using SCXI, read these manuals for maintenance information on the chassis, installation instructions, and information about making custom modules.

Related Documentation

The following documents contain information that you may find helpful as you read this manual:

- Your NI-DAQ software documentation
- Your computer operating manual, which explains how to insert cards into your system

The following National Instruments manual contains detailed information for the register-level programmer:

- *DAQCard-500/516 and PC-516 Register-Level Programmer Manual*

This manual is available from National Instruments by request. If you are using NI-DAQ, LabVIEW, or LabWindows/CVI, you should not need the register-level programmer manual. Using NI-DAQ, LabVIEW, or LabWindows/CVI is as easy and as flexible as using the low-level programming described in the register-level programmer manual. Refer to *Software Programming Choices* in Chapter 1, *Introduction*, of this manual to learn more about your programming options.

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix E, *Customer Communication*, at the end of this manual.

Chapter 1

Introduction

This chapter describes the PC-516 and DAQCard-516; lists the optional software and optional equipment; and explains how to unpack your 516 device.

About Your PC-516 and DAQCard-516

Thank you for purchasing the National Instruments PC-516 or DAQCard-516. Each 516 device contains a 16-bit, successive-approximation ADC with eight single-ended or four differential analog inputs, four lines of TTL-compatible digital input, and four lines of digital output. Each 516 device also contains two 16-bit counter/timer channels for timing I/O. The optional 27-pin I/O connector enables you to easily connect all your signals directly to the 516 device. Each 516 device is fully software configurable and calibrated so that you can easily install the 516 device and begin your acquisition.

Both 516 devices ship with NI-DAQ, National Instruments' complete DAQ driver that handles every function listed on the data sheet for our DAQ hardware. Using NI-DAQ, you can quickly and easily start your application without having to program the card on the register level.

In addition, the low cost of a system based on the PC-516 or DAQCard-516 makes it ideal for laboratory work in industrial and academic environments. The multichannel analog input is useful in signal analysis and data logging. The 16-bit ADC is useful in high-resolution applications such as chromatography, temperature measurement, and DC voltage measurement. You can use the eight TTL-compatible digital I/O lines for switching external devices such as transistors and solid-state relays, and for reading the status of external digital logic. You can use the counter/timers to synchronize events, generate pulses, and measure frequency and time. The PC-516 and DAQCard-516, used in conjunction with your computer, are versatile, cost-effective platforms for laboratory test, measurement, and control.

- DAQCard-516

  The DAQCard-516 is a low-cost, low-power analog input, digital I/O, and timing I/O card for computers equipped with a Type II PCMCIA slot. The small size and weight of the DAQCard-516 coupled with its low-power consumption make this card ideal for use in portable computers, making remote data acquisition practical. The card requires very little power when operating and has a standby mode that uses even less power, thus extending the life of your computer batteries.

Detailed specifications for the PC-516 and DAQCard-516 are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your 516 device, you will need the following:

- ❑ One of the following 516 devices:
  - PC-516
  - DAQCard-516
- ❑ One of the following I/O connectors with 0.5 or 1 m connector cable:
  - PR27-30F (DAQCard-516)
  - R30-30 (PC-516)
- ❑ *PC-516/DAQCard-516 User Manual*
- ❑ One of the following software packages and documentation:
  - NI-DAQ for PC compatibles
  - NI-DAQ for NEC PC-9800 Series
  - NI-DAQ for Macintosh
  - LabVIEW for Windows
  - LabVIEW for Macintosh
  - LabWindows/CVI for Windows
- ❑ Your computer

Software Programming Choices

There are several options to choose from when programming your National Instruments DAQ and SCXI hardware. You can use LabVIEW, LabWindows/CVI, or NI-DAQ.

LabVIEW and LabWindows/CVI Application Software

LabVIEW and LabWindows/CVI are innovative program development software packages for data acquisition and control applications. LabVIEW uses graphical programming, whereas LabWindows/CVI enhances traditional programming languages. Both packages include extensive libraries for data acquisition, instrument control, data analysis, and graphical data presentation.

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition VI Library, a series of VIs for using LabVIEW with National Instruments DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to the NI-DAQ software.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI Data Acquisition Library, a series of functions for using LabWindows/CVI with National Instruments DAQ hardware, is included with the NI-DAQ software kit. The LabWindows/CVI Data Acquisition library is functionally equivalent to the NI-DAQ software.

Using LabVIEW or LabWindows/CVI software will greatly reduce the development time for your data acquisition and control application.

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ hardware. NI-DAQ is not packaged with SCXI or accessory products, except for the SCXI-1200. NI-DAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for analog input (A/D conversion), buffered data acquisition (high-speed A/D conversion), analog output (D/A conversion), waveform generation, digital I/O, counter/timer operations, SCXI, RTSI, self-calibration, messaging, and acquiring data to extended memory.

NI-DAQ has both high-level DAQ I/O functions for maximum ease of use and low-level DAQ I/O functions for maximum flexibility and performance. Examples of high-level functions are streaming data to disk or acquiring a certain number of data points. An example of a low-level function is writing directly to registers on the DAQ device. NI-DAQ does not sacrifice the performance of National Instruments DAQ devices because it lets multiple devices operate at their peak performance.

NI-DAQ also internally addresses many of the complex issues between the computer and the DAQ hardware such as programming interrupts and DMA controllers. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Whether you are using conventional programming languages, LabVIEW, or LabWindows/CVI, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

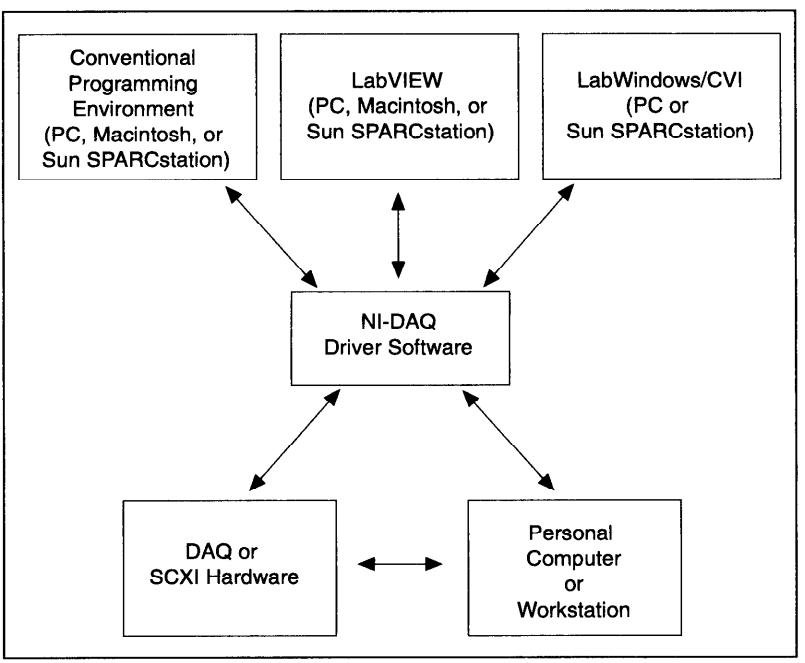


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

Register-Level Programming

The final option for programming any National Instruments DAQ hardware is to write register-level software. Writing register-level programming software can be very time-consuming and inefficient and is not recommended for most users.

Even if you are an experienced register-level programmer, consider using NI-DAQ, LabVIEW, or LabWindows/CVI to program your National Instruments DAQ hardware. Using the NI-DAQ, LabVIEW, or LabWindows/CVI software is as easy and as flexible as register-level programming and can save weeks of development time.

Optional Equipment

Listed below are some of the optional accessories that work with your 516 device. New accessories are always being added to our product family. See your National Instruments catalog or call the National Instruments office nearest you for more information about optional equipment.

- CB-27 I/O connector block
- R30-30 I/O connector with 0.5 or 1 m connector cable (PC-516)
- PR27-30F I/O connector with 0.5 or 1 m connector cable (DAQCard-516)

Cabling

National Instruments currently offers a cable termination accessory, the CB-27, for use with your PC-516 or DAQCard-516. You can attach signal input and output wires to screw terminals on the connector block and, therefore, to your 516 device I/O connector.

The CB-27 is useful for the initial prototyping of an application or in situations in which the 516 device interconnections are frequently changed. After you develop a final field wiring scheme, however, you may want to develop your own cable. Refer to Appendix B, *Custom Cable Design*, for information and guidelines for the design of custom cables.

Unpacking

- PC-516

  Your board is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, take the following precautions:

  - Ground yourself via a grounding strap or by holding a grounded object.
  - Touch the antistatic package to a metal part of your computer chassis before removing the board from the package.
  - Remove the board from the package and inspect the board for loose components or any other sign of damage. Notify National Instruments if the board appears damaged in any way. *Do not* install a damaged board into your computer.
  - *Never* touch the exposed pins of connectors.

- DAQCard-516

  Your PC card is shipped in an antistatic vinyl case; when you are not using the card, you should store it in this case. Because the card is enclosed in a fully shielded case, no additional electrostatic precautions are necessary. However, for your own safety and to protect the card, never attempt to touch the pins of the connectors.

Installation and Configuration

Chapter 2

This chapter describes how to install and software configure your 516 device.

Installation

☞ **Note:** ***You should install your driver software before installing your hardware. Refer to your NI-DAQ Release Notes for software installation instructions.***

- PC-516

  You can install the PC-516 in any available 8-bit or 16-bit expansion slot in your computer. The following are general installation instructions, but consult your PC user manual or technical reference manual for specific instructions and warnings.

  1. Turn off your computer.
  2. Remove the top cover or access port to the I/O channel.
  3. Remove the expansion slot cover on the back panel of the computer.
  4. Record the PC-516 serial and revision numbers on the *Hardware and Software Configuration* form in Appendix E, *Customer Communication*. You will need these numbers when you install and configure your board.
  5. Insert the PC-516 into an 8-bit or a 16-bit slot.
  6. Screw the mounting bracket of the PC-516 to the back panel rail of the computer.
  7. Check the installation.
  8. Replace the cover.
  9. Attach the I/O cable. The optional R30-30 cable available for the PC-516 plugs into the 30-pin I/O connector on the other end of the card. This cable connects the PC-516 to other National Instruments products. When plugging and unplugging the cable, always grasp the cable by the connector. Never pull directly on the I/O cable to unplug it from the PC-516.

The PC-516 device is installed. You are ready to make the appropriate connections to the I/O connector cable as described in Chapter 3, *Signal Connections,* and to install and configure your software.

- DAQCard-516

  You can install your DAQCard-516 in any available Type II PCMCIA slot in your computer. You must have Card and Socket Services 2.0 or later installed in your computer.

  The PC card software configures the card for your computer and automatically determines the base address. The following are general installation instructions, but consult your PC user manual or technical reference manual for specific instructions and warnings.

  1. Turn off your computer. If your computer supports hot insertion, you may insert or remove the DAQCard-516 at any time, whether the computer is powered on or off.
  2. Remove the PCMCIA slot cover on your computer.
  3. Insert the 68-pin PCMCIA bus connector of the DAQCard-516 into the PCMCIA slot. The card is keyed so that you can insert it only one way.
  4. Attach the I/O cable. The optional PR27-30F cable available for the DAQCard-516 plugs into the 27-pin I/O connector on the other end of the card. This cable connects the DAQCard-516 to other National Instruments products. Be very careful not to put strain on the I/O cable when inserting it into and removing it from the DAQCard-516. When plugging and unplugging the cable, always grasp the cable by the connector. *Never* pull directly on the I/O cable to unplug it from the DAQCard-516.

  The DAQCard-516 is installed. You are ready to make the appropriate connections to the I/O connector cable as described in Chapter 3, *Signal Connections,* and to install and configure your software.

  Figure 2-1 shows an example of a typical configuration.

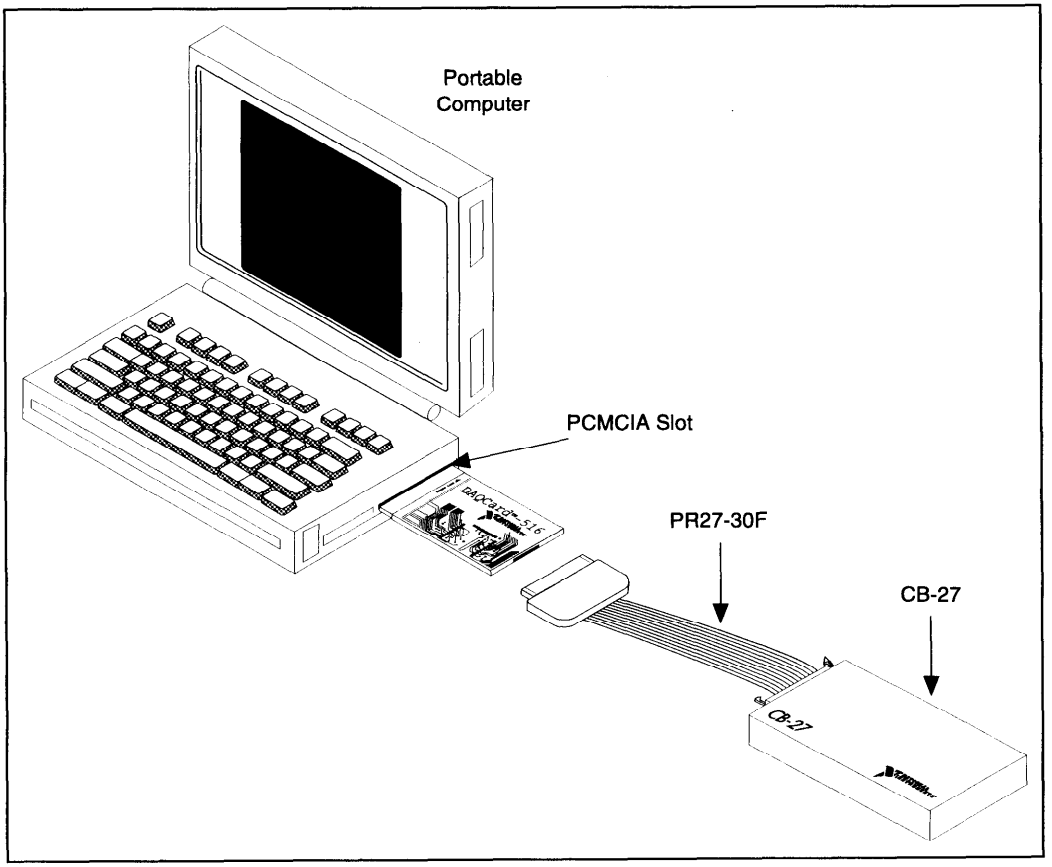


Figure 2-1. A Typical Configuration for the DAQCard-516

Hardware Configuration

- DAQCard-516

  The DAQCard-516 is completely software configurable; refer to your software documentation to install and configure the software.

  If you are using NI-DAQ for PC compatibles or NI-DAQ for NEC PC-9800 Series computers, refer to your NI-DAQ release notes. Find the installation and system configuration section for your operating system and follow the instructions given there.

  If you are using NI-DAQ for Macintosh, refer to the NI-DAQ software reference manual. Find the installation and system

configuration section for your operating system and follow the instructions given there.

If you are using LabVIEW, the software installation instructions are in your LabVIEW release notes. After you have installed LabVIEW, refer to the *Configuring LabVIEW* section of Chapter 1 of your LabVIEW user manual for software configuration instructions.

If you are using LabWindows/CVI, the software installation instructions are in your LabWindows/CVI release notes. After you have installed LabWindows/CVI, refer to Chapter 1, *Configuring LabWindows/CVI*, of the *LabWindows/CVI User Manual* for software configuration instructions.

If you are a register-level programmer, refer to the *DAQCard-500/516 and PC-516 Register-Level Programmer Manual.*

- PC-516

  The PC-516 is completely software configurable. Two types of configuration are performed on the PC-516—bus related and data acquisition related. Bus-related configuration includes setting the base I/O address. Data acquisition-related configuration includes such settings as analog input mode, digital I/O configuration, and counter configuration.

Bus-Related Configuration (PC-516 only)

The PC-516 works in either a Plug and Play mode or a switchless mode. These modes dictate how the base I/O address is determined and assigned to the device.

Plug and Play Mode

The PC-516 is fully compatible with the industry-standard Intel/Microsoft Plug and Play Specification version 1.0. A Plug and Play system arbitrates and assigns resources through software, freeing you from manually setting switches and jumpers. These resources include the device base I/O address. The PC-516 is configured at the factory to request these resources from the Plug and Play Configuration Manager.

The Configuration Manager receives all of the resource requests at start up, compares the available resources to those requested, and assigns the available resources as efficiently as possible to the Plug and Play devices. Application software can query the Configuration Manager to determine the resources assigned to each device without your

involvement. The Plug and Play software is installed as a device driver or as an integral component of the computer BIOS.

If you have the Windows 95 operating system on your PC, it will configure your PC-516. Refer to your NI-DAQ documentation for more information.

Switchless Mode

You can use the PC-516 in a non-Plug and Play system as a switchless DAQ device. A non-Plug and Play system is a system in which the Configuration Manager has not been installed and which does not contain any non-National Instruments Plug and Play products. You use a configuration utility to enter the base address, and the application software assigns it to the device.

☞ **Note:** ***Avoid resource conflicts with non-National Instruments devices. For example, do not configure two devices for the same base address.***

Base I/O Address Selection

You can configure the PC-516 to use base addresses in the range of 100 to FFF0 hex. The PC-516 occupies 16 bytes of address space and must be located on a 16-byte boundary. Therefore, valid addresses include 100, 110, 120, FFE0, FFF0 hex. This selection is software configured and does not require you to manually change any settings on the device.

Data-Acquisition-Related Configuration

Analog Input Configuration

At startup, your device defaults to the following configuration:

- Single-ended input mode referenced to analog ground
- ±5 V analog range

Software can configure the device for differential input mode.

The device has two different input modes—referenced single-ended (RSE) input and differential (DIFF) input. The single-ended input

configuration provides eight channels. The DIFF input configuration provides four channels. Table 2-1 describes these configurations.

Table 2-1. Analog Input Modes for the 516 Device

Analog Input Modes	Description
RSE	Referenced single-ended mode provides eight single-ended inputs referenced to analog ground (default setting).
DIFF	Differential mode provides four differential inputs with the positive (+) input of the instrumentation amplifier tied to channels 0, 1, 2, or 3 and the negative (-) input tied to channels 4, 5, 6, or 7 respectively, thus choosing channel pairs (0, 4), (1, 5), (2, 6), (3, 7).

While reading the following paragraphs, you may find it helpful to refer to the *Analog Input Signal Connections* section of Chapter 3, *Signal Connections*, which contains diagrams showing the signal paths for the two configurations. These two modes are software selectable.

RSE Input (Eight Channels, Default Setting)

RSE input means that all input signals are referenced to a common ground point that is also tied to the device analog input ground. The RSE configuration is useful for measuring floating signal sources. See the *Types of Signal Souces and Measurement Systems* section of Chapter 3, *Signal Connections*, for more information. With this input configuration, the device can monitor eight different analog input channels.

Considerations for using the RSE configuration are discussed in Chapter 3, *Signal Connections*. Notice that in this mode, the return path of the signal is analog ground at the connector through the AIGND pin.

DIFF Input (Four Channels)

DIFF input means that each input signal has its own reference, and the difference between each signal and its reference is measured. The signal and its reference are each assigned an input channel. With this input configuration, the device can monitor four differential analog input signals.

Considerations for using the DIFF configuration are discussed in Chapter 3, *Signal Connections*. Notice that the signal return path is through the negative terminal of the instrumentation amplifier and through channel 4, 5, 6, or 7, depending on which channel pair you select.

Digital I/O Configuration

The device always uses one 4-bit digital output port and one 4-bit digital input port.

Counter Configuration

You can use the MSM82C54 counter/timers for general-purpose applications, such as pulse and square wave generation, event counting, and pulsewidth, time-lapse, and frequency measurement. For information about configuring the MSM82C54, see the *Timing Connections* section of Chapter 3, *Signal Connections*.

Chapter 3

Signal Connections

This chapter describes how to make input and output signal connections to your PC-516 and DAQCard-516. If you are making your own cables, see Appendix B, *Custom Cable Design.*

I/O Connectors

Figure 3-1 shows the pin assignments for your I/O connector and CB-27 connector block. Although the pin arrangements on these connectors differ, notice that the signal names and pin numbers are the same.

Warning: ***Connections that exceed any of the maximum ratings of input or output signals on the 516 device can damage your 516 device and your computer. This includes connecting any power signals to ground and vice versa. National Instruments is NOT liable for any damages resulting from such signal connections.***

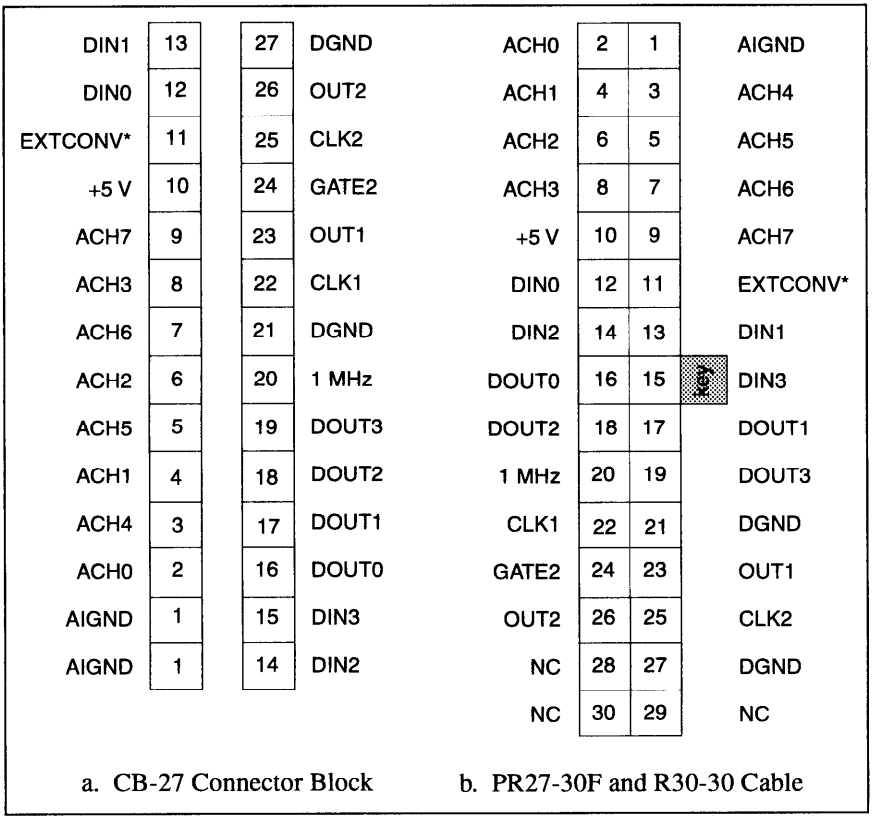


Figure 3-1. I/O Connector Pin Assignments

Signal Connection Descriptions

Pin	Signal Name	Ref	Description
1	AIGND	AIGND	Analog Input Ground—This signal is the common ground tie-in point for all analog signals.
2-9	ACH<0..7>	AIGND	Analog Input Channels 0 through 7—These signals are single-ended analog input signals. The differential pairs are (0,4), (1,5), (2,6) and (3,7).
10	+5 V	DGND	+5 Volts—This pin provides +5 VDC. The +5 V supply is fused at 0.75 A, which is the maximum current available.
11	EXTCONV*	DGND	External Convert Signal—This input signal externally controls A/D conversions.
12-15	DIN<0..3>	DGND	Digital Input Data Lines—These signals are TTL-compatible, digital input lines. DIN3 is the MSB; DIN0 is the LSB.
16-19	DOUT<0..3>	DGND	Digital Output Data Lines—These signals are TTL-compatible digital output lines. DOUT3 is the MSB; DOUT0 is the LSB.
20	1 MHz	DGND	1 MHz Square Wave Output of Oscillator—This signal is a 1 MHz square wave for use with the internal counter or for external timing needs.
21, 27	DGND	DGND	Digital Ground—This is the common ground tie-in point for all digital signals.
22	CLK1	DGND	Clock Input of Counter 1—This signal is the clock input of counter 1.
23	OUT1	DGND	Output of Counter 1—This signal outputs the programmed waveform of counter 1.
24	GATE2	DGND	Gate Input of Counter 2—This signal controls the starting, interruption, and restarting of counter 2.
25	CLK2	DGND	Clock Input of Counter 2—This signal is the clock input of counter 2.

Pin	Signal Name	Ref	Description
26	OUT2	DGND	Output of Counter 2—This signal outputs the programmed waveform of counter 2.
28-30	NC	—	Not Connected—These signals are not connected. (Not available on the CB-27)

Note: ***An asterisk (*) indicates that the signal is active low.***

The connector pins are grouped into analog input signal pins, digital I/O signal pins, and timing I/O signal pins. Signal connection guidelines for each of these groups are included in this chapter.

Analog Input Signal Connections

Pins 1 through 9 are analog input signal pins for the ADC. Pin 1, AIGND, is an analog common signal. You can use this pin as a general analog power ground tie to your 516 device. Pins 2 through 9 are the ACH<0..7> signal pins. These pins are tied to the analog input channels of your 516 device through 4.7 kΩ series resistors. These resistors limit the input current to the multiplexer. The following input range and maximum ratings apply to inputs ACH<0..7>:

- Input signal range ±5 V
- Maximum input voltage rating ±25 V powered on or off

Warning: ***Exceeding the input signal range distorts input signals. Exceeding the maximum input voltage rating may damage your 516 device and computer. National Instruments IS NOT liable for any damages resulting from any such signal connections.***

Analog Input Signal Connection Considerations

When making analog signal connections to your 516 device, you should first determine whether the signal source and the measurement system are floating or ground referenced. The two types of signal sources are described as follows, and the types of measurement systems are described in later sections.

Types of Signal Sources and Measurement Systems

Ground-Referenced Signal Sources

A ground-referenced signal source or measurement system is one that is connected in some way to the building system ground. Nonisolated outputs of instruments and devices that plug into the building power system fall into this category.

The difference in ground potential between two instruments connected to the same building power system is typically between 1 and 100 mV but can be much higher if power distribution circuits are not properly connected. The connection instructions described later in this chapter for grounded signal sources are designed to eliminate this ground potential difference from the measured signal.

Floating Signal Sources

A floating signal source or measurement system is one that is not connected in any way to the building ground system but rather has an isolated ground-reference point. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolator outputs, and isolation amplifiers. A floating measurement system will float to the level of the signals being measured. The ground reference of a floating signal must be tied to the analog input ground to establish a local or onboard reference for the signal. Otherwise, the measured input signal varies or appears to float. An instrument that provides an isolated output falls into the floating signal source category.

Depending on the power connection, a portable computer can represent either a floating or ground-referenced measurement system. If a portable computer is entirely battery powered, it is a floating system. If it is operated from an AC/DC wall adapter, it may or may not be ground referenced, depending on the connection. You should determine from your computer documentation whether any of the power connections are tied to the building power system ground.

Input Configurations

To measure the different types of input signals, you can configure your 516 device for one of two input modes—DIFF or RSE—by changing the configuration of the onboard instrumentation amplifier. Table 3-1 summarizes the recommended input configurations for both types of

signal sources. Figure 3-2 shows a diagram of the instrumentation amplifier.

Table 3-1. Recommended Input Configurations for Ground-Referenced and Floating Measurement Systems

System Type	Type of Signal	Recommended Input Configurations
Ground-referenced system, such as a desktop computer	Ground referenced (nonisolated outputs, plug-in instruments)	DIFF
	Floating (batteries, thermocouples, isolated outputs)	DIFF with bias resistors RSE
Floating system, such as a battery-powered computer	Ground referenced (nonisolated outputs, plug-in instruments)	DIFF with bias resistors RSE
	Floating (batteries, thermocouples, isolated outputs)	DIFF with bias resistors RSE

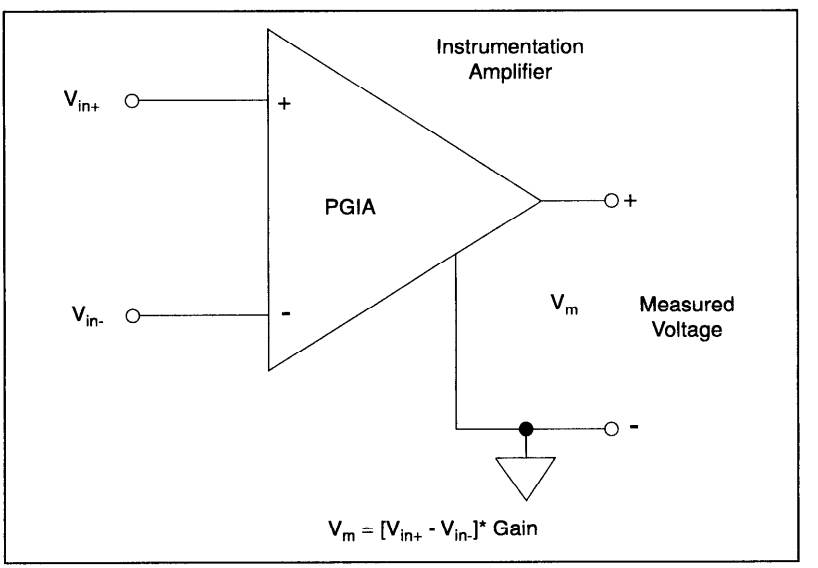


Figure 3-2. Onboard Instrumentation Amplifier

The instrumentation amplifier applies common-mode voltage rejection and presents a high-input impedance to the analog input signals connected to the 516 device. Signals are routed to the positive and

negative inputs of the instrumentation amplifier through input multiplexers. The instrumentation amplifier converts two input signals to a signal that is the difference between the two input signals multiplied by the gain setting of the amplifier. The amplifier output voltage is referenced to the 516 device ground. The 516 device ADC measures this output voltage when it performs A/D conversions.

SE Input

In single-ended mode, the signals connected to ACH<7..0> are routed to the positive terminal of the instrumentation amplifier, and the negative terminal of the instrumentation amplifier is connected to the analog ground reference of the 516 device. Thus, the voltage measured by the 516 device in single-ended mode is the difference between an input signal and the 516 device analog ground reference.

DIFF Input

In differential mode, signals connected to ACH<3..0> are routed to the positive input of the instrumentation amplifier, and signals connected to ACH<7..4> are routed to the negative input of the instrumentation amplifier. Thus, the voltage measured by the 516 device in differential mode is the difference between two of the input signals.

Single-Ended Connection Considerations

Single-ended connections are those in which all 516 device analog input signals are referenced to one common ground. The input signals are tied to the positive input of the instrumentation amplifier that is referenced to their common ground point.

When your 516 device is configured for single-ended input, eight analog input channels are available. You can use single-ended input connections when the following criteria are met by all input signals.

- Input signals are high level (greater than 1 V).
- Leads connecting the signals to the 516 device are less than 15 ft.
- All input signals share a common reference signal (at the source).

If any one of the preceding criteria is not met, use the DIFF input configuration.

The 516 device single-ended configuration is referenced. You can use this mode for nonreferenced signal sources. In addition, if the computer

using the 516 device is not ground referenced, you can use this mode for ground-referenced signal sources.

Figure 3-3 shows how to connect a signal source to your 516 device in single-ended mode. When you connect grounded signal sources to a 516 device in a ground-referenced computer, carefully observe the polarity to avoid shorting the signal source output. A laptop operating from a battery is not grounded. A laptop powered from an AC/DC adapter may or may not be grounded.

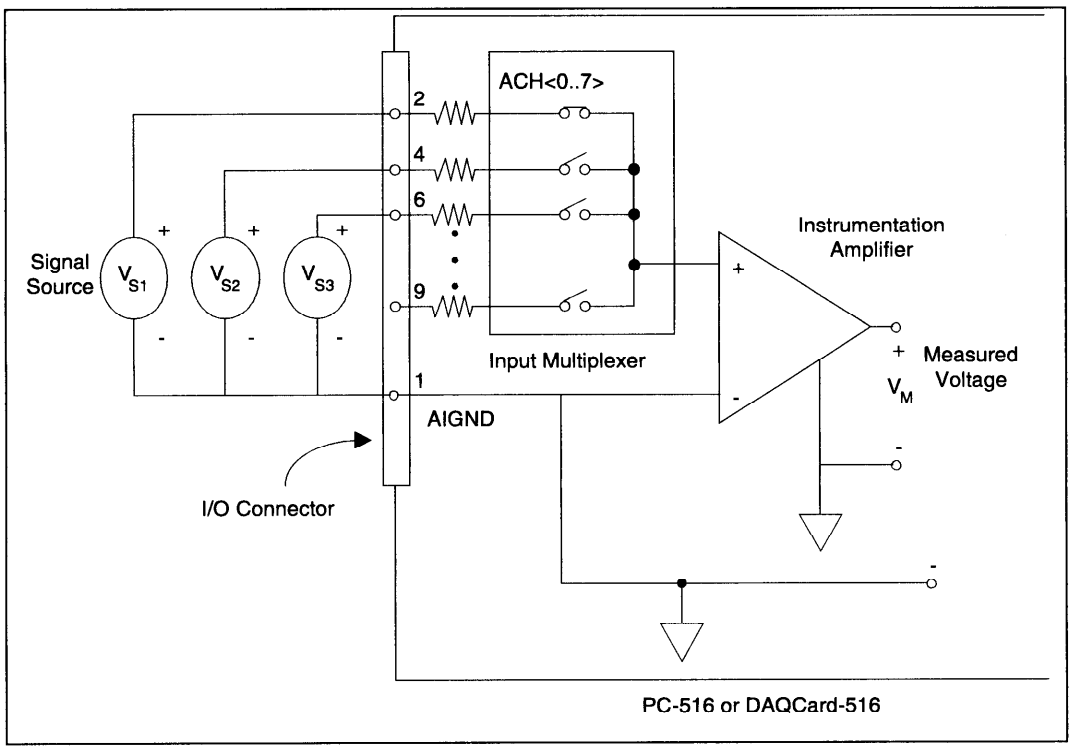


Figure 3-3. Single-Ended Analog Input Signal Connections

Differential Connection Considerations

Differential connections are those in which each 516 device analog input signal has its own reference signal or signal return path. These connections are available when the 516 device is configured in the DIFF mode. Each input signal is tied to the positive input of the instrumentation amplifier, and its reference signal, or return, is tied to the negative input of the instrumentation amplifier.

When your 516 device is configured for DIFF input, each signal uses two of the multiplexer inputs—one for the signal and one for its reference signal. Therefore, only four analog input channels are available when you use the DIFF configuration. Use the DIFF input configuration when any of the following conditions is present:

- Input signals are low level (less than 1 V).
- Leads connecting the signals to the 516 device are greater than 15 ft.
- Any of the input signals requires a separate ground reference point or return signal.
- The signal leads travel through noisy environments.

Differential signal connections reduce picked-up noise and increase common-mode signal and noise rejection. With these connections, input signals can float within the common-mode limits of the input instrumentation amplifier.

Differential Connections for Grounded Signal Sources

Figure 3-4 shows how to connect a ground-referenced signal source to your 516 device configured for DIFF input.

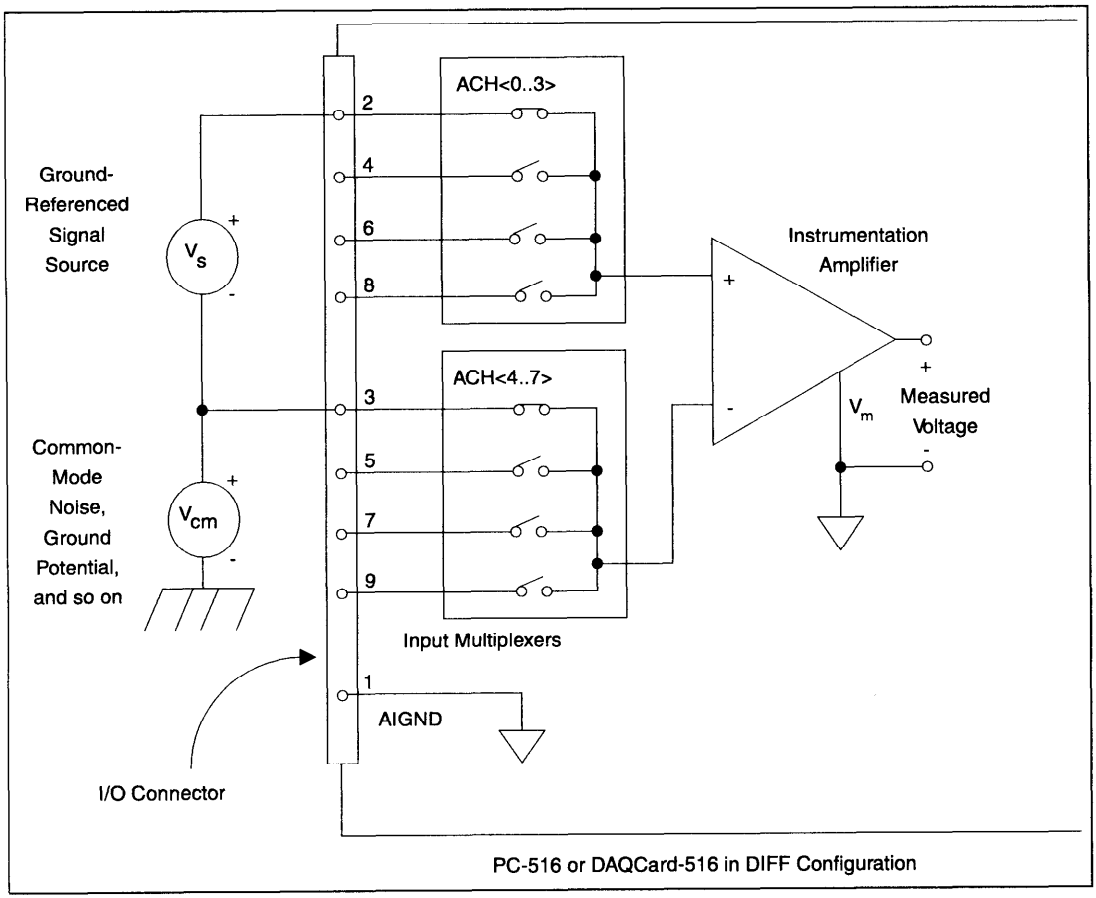


Figure 3-4. Differential Input Connections for Grounded Signal Sources

With this type of connection, the instrumentation amplifier rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the 516 device ground (shown as V_{cm} in Figure 3-4).

Differential Connections for Floating Signal Sources

Figure 3-5 shows how to connect a floating signal source to your 516 device configured for DIFF input. Configuration instructions are included in the *Input Configurations* section earlier in this chapter.

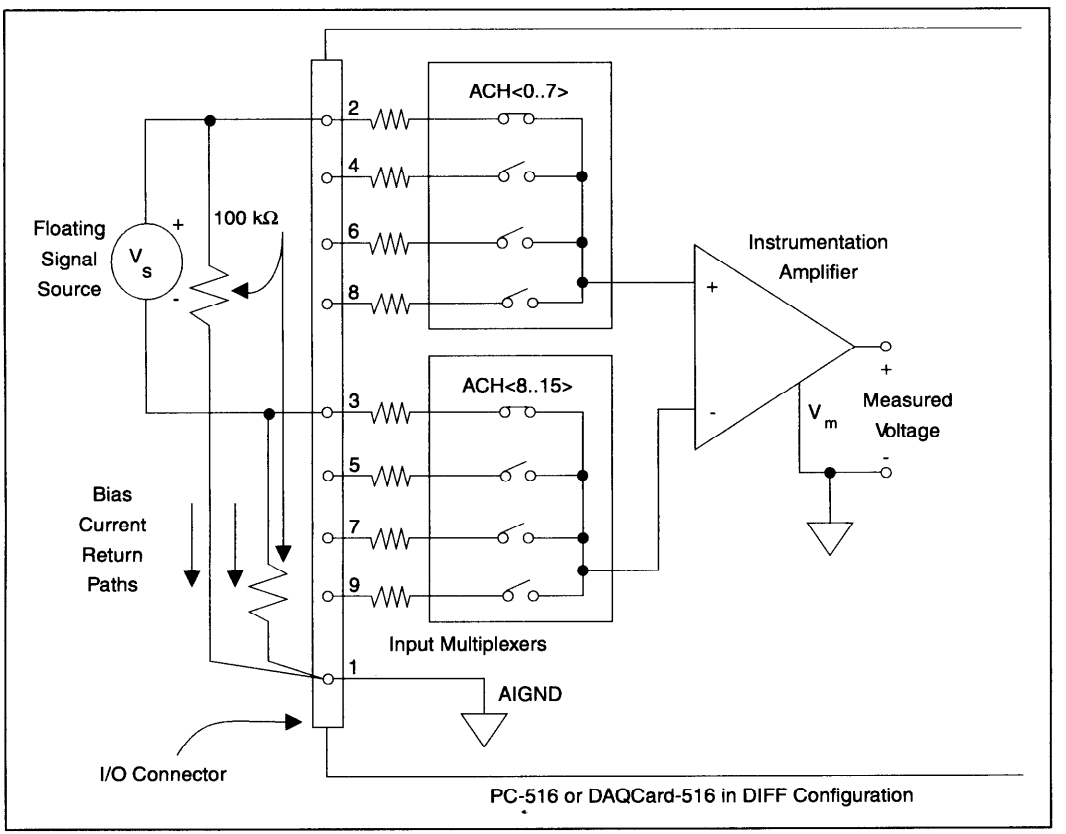


Figure 3-5. Differential Input Connections for Floating Sources

The 100 kΩ resistors shown in Figure 3-5 create a return path to ground for the bias currents of the instrumentation amplifier. If a return path is not provided, the instrumentation amplifier bias currents charge up stray capacitances, resulting in uncontrollable drift and possible saturation in the amplifier. Typically, values from 10 to 100 kΩ are used.

A resistor from each input to ground, as shown in Figure 3-5, provides bias current return paths for an AC-coupled input signal. This solution, although necessary for AC-coupled signals, lowers the input impedance

of the analog input channel. In addition, the input offset current of the instrumentation amplifier contributes a DC offset voltage at the input. The amplifier has a maximum input offset current of ±0.75 nA and a typical offset current drift of ±1.5 pA/°C.

Multiplied by the 100 kΩ resistor, this current contributes a maximum offset voltage of 75 μV and a typical offset voltage drift of 150 nV/°C at the input. Thus, the offset is unlikely to be more than an LSB, so it can usually be ignored.

If the input signal is DC-coupled, only the resistor connecting the negative signal input to ground is needed. This connection does not lower the input impedance of the analog input channel.

Common-Mode Signal Rejection Considerations

Figures 3-4 and 3-5 show connections for signal sources that are already referenced to some ground point with respect to your 516 device. In these cases, the instrumentation amplifier can reject any voltage due to ground potential differences between the signal source and the 516 device. In addition, with differential input connections, the instrumentation amplifier can reject common-mode noise pickup in the leads connecting the signal sources to the 516 device.

The common-mode input range of the 516 device instrumentation amplifier is defined as the magnitude of the greatest common-mode signal that can be rejected. The 516 device can reject common-mode input signals so long as V^+_{in} and V^-_{in} are both in the range ±4.9 V.

The common-mode input range for the 516 device depends on the size of the differential input signal ($V_{diff} = V^+_{in} - V^-_{in}$). The formula for the permissible common-mode input range is as follows:

$$V_{cm\text{-}max} = \pm (4.9\ V - V_{diff}/2)$$

Thus, for a differential voltage as large as 8 V, the largest common-mode voltage that can be rejected is ±0.9 V. However, if the differential signal is 2.5 V, ±3.65 V common-mode voltage can be rejected.

The common-mode voltage is measured with respect to the 516 device ground and can be calculated by the following formula:

$$V_{cm\text{-}actual} = (V^+_{in} + V^-_{in})/2$$

where V^+_{in} is the signal at the positive input of the instrumentation amplifier and V^-_{in} is the signal at the negative input of the instrumentation amplifier.

If the input signal common-mode range exceeds the maximum computed above with respect to the 516 device ground, you need to limit the amount of floating that occurs between the signal ground and the 516 device ground.

Digital I/O Signal Connections

Pins 12 through 19 of the I/O connector are digital I/O signal pins. Pins 12 through 15 are digital input pins. Pins 16 through 19 are digital output pins. Pin 27 is the digital ground pin.

The following specifications and ratings apply to the digital I/O lines.

- Absolute maximum voltage input rating — +5.5 V with respect to DGND
- Absolute minimum voltage input rating — -0.5 V with respect to DGND
- Digital input compatibility — TTL-compatible
- Input current (high or low level) — 1 µA
- Digital output compatibility — TTL-compatible
- Output current source capability — 4 mA, at $V_{OH} = 3.5$ V
- Output current sink capability — 4 mA, at $V_{OL} = 0.5$ V

Figure 3-6 shows an example of connections to the digital input and output ports. Digital input applications include receiving TTL signals and sensing external device states such as the switch in Figure 3-6. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 3-6.

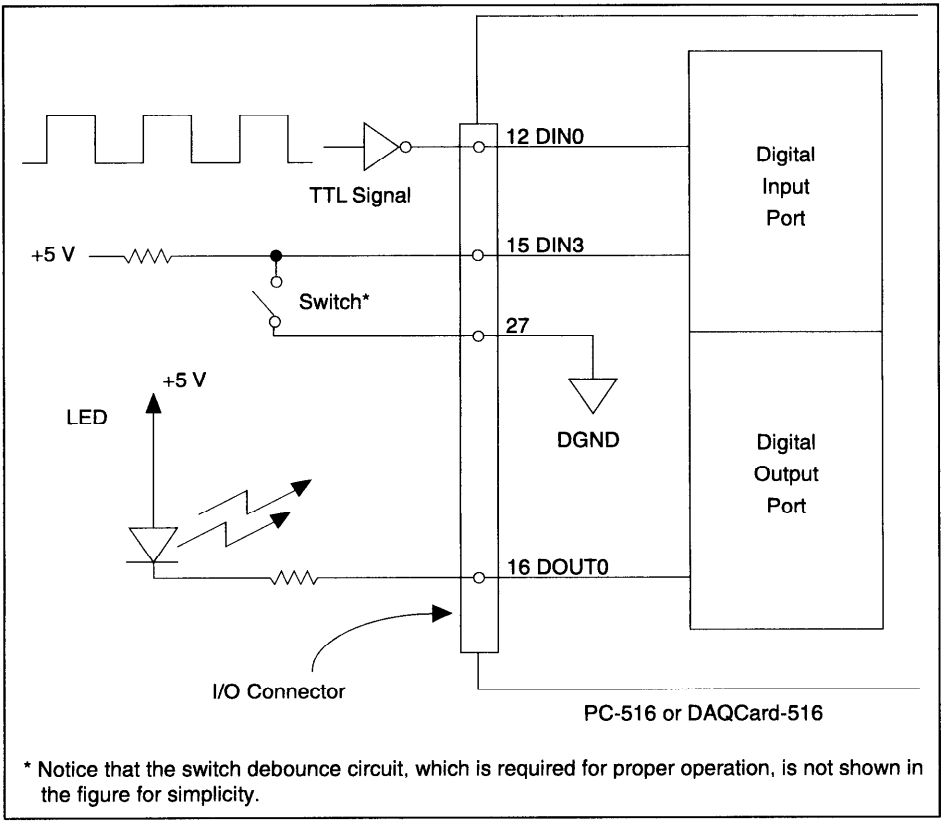


Figure 3-6. Digital I/O Signal Connections

☞ **Note:** ***Pin numbers in this figure refer only to the PR27-30F cable.***

Timing Connections

Pins 20 through 26 and pin 11 of the I/O connector are for timing I/O signals. The 516 device uses an MSM82C54 counter/timer integrated circuit. Counters 1 and 2 are available at the I/O connector. Counter 0 is dedicated for data acquisition timing. Pin 11 carries an external signal, EXTCONV*, that can be used for data acquisition timing in place of counter 0 of the MSM82C54. This signal is explained in the *Data Acquisition Counter and Timing Connections* section of this chapter. Pin 20 carries the 1 MHz square-wave oscillator signal. This signal can be used as a timebase for the counter clock inputs. Pins 22 through 26 carry general-purpose timing signals from the MSM82C54. These signals are explained under *General-Purpose Counter and Timing Signal Connections* later in this chapter.

Data Acquisition Counter and Timing Connections

Counter 0 on the MSM82C54 counter/timer is used as a sample-interval counter in timed A/D conversions. In addition to counter 0, you can use pin 11, EXTCONV*, to externally time conversions. If you need to program this chip directly, refer to the optional *DAQCard-500/516 and PC-516 Register-Level Programmer Manual* for the programming sequence needed to enable this input. Figure 3-7 shows the timing requirements for the EXTCONV* input. An A/D conversion is initiated by a rising edge on the EXTCONV*. The data from this conversion is latched into the FIFO memory within 20 µs. The EXTCONV* input is a TTL-compatible signal.

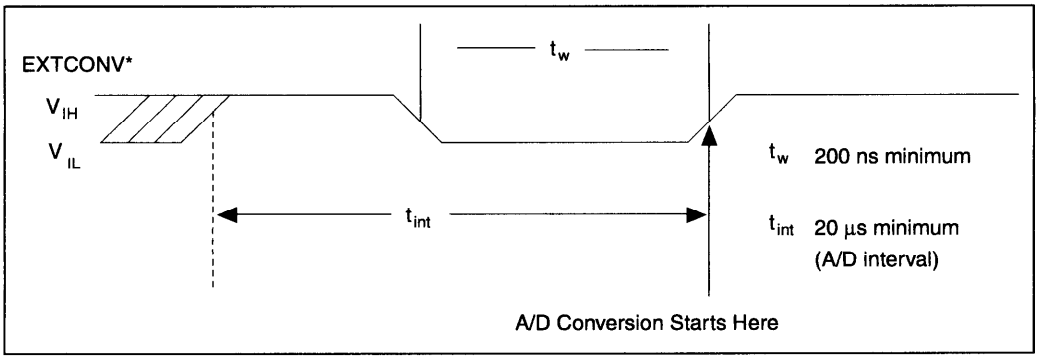


Figure 3-7. EXTCONV* Signal Timing

Notice that EXTCONV* can only cause conversions to occur; you cannot use it as a monitor to detect conversions caused by the onboard sample-interval timer.

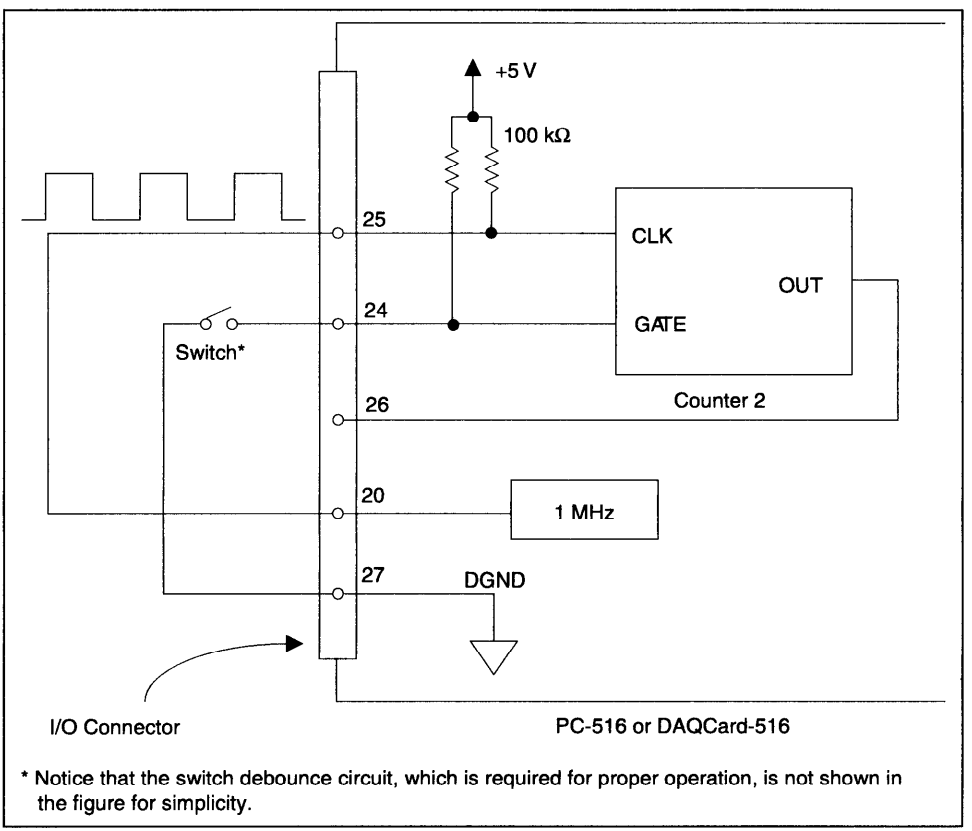
General-Purpose Counter and Timing Signal Connections

The general-purpose timing signals include CLK and OUT signals for counter 1 and GATE, CLK, and OUT signals for counter 2 of the MSM82C54. Counter 0 is not available on the I/O connector. You can use the MSM82C54 counter/timers for general-purpose applications such as pulse and square wave measurement. For these applications, CLK and GATE signals are sent to the counters and the counters are programmed for various operations. The only exceptions are counter 0, which has an internal 1 MHz clock and its gate is always enabled, and counter 1, which has its gate always enabled.

The MSM82C54 counter/timer is described briefly in Chapter 4, *Theory of Operation.*

To perform pulse and square wave generation, program a counter to generate a timing signal at its OUT output pin.

To count events, program a counter to count rising or falling edges applied to any of the MSM82C54 CLK inputs. You can then read the counter value to determine the number of edges that have occurred. You can gate counter operation on and off during event counting. Figure 3-8 shows connections for a typical event-counting operation in which a switch is used to gate counter 2 on and off.



* Notice that the switch debounce circuit, which is required for proper operation, is not shown in the figure for simplicity.

Figure 3-8. Event-Counting Application with External Switch Gating

Use level gating to measure pulse width. Apply the pulse to be measured to the GATE2 input. Load the counter with the known count and program the counter to count down while the signal at the GATE2

input is high. The pulse width equals the counter difference (loaded value minus read value) multiplied by the CLK2 period.

To measure time lapse, program counter 2 to be edge gated. Apply an edge to the GATE2 input to start the counter. Program counter 2 to start counting after receiving a low-to-high edge. The time lapse since receiving the edge equals the counter value difference (loaded value minus the read value) multiplied by the CLK2 period.

To measure frequency, program counter 2 to be level gated and count the number of falling edges in a signal applied to the CLK2 input. The gate signal you applied to the GATE2 input is of a known duration. In this case, program counter 2 to count falling edges at the CLK2 input while the gate is applied. The frequency of the input signal then equals the count value divided by the gate period. Figure 3-9 shows the connections for a frequency measurement application. You could also use counter 1 to generate the gate signal in this application.

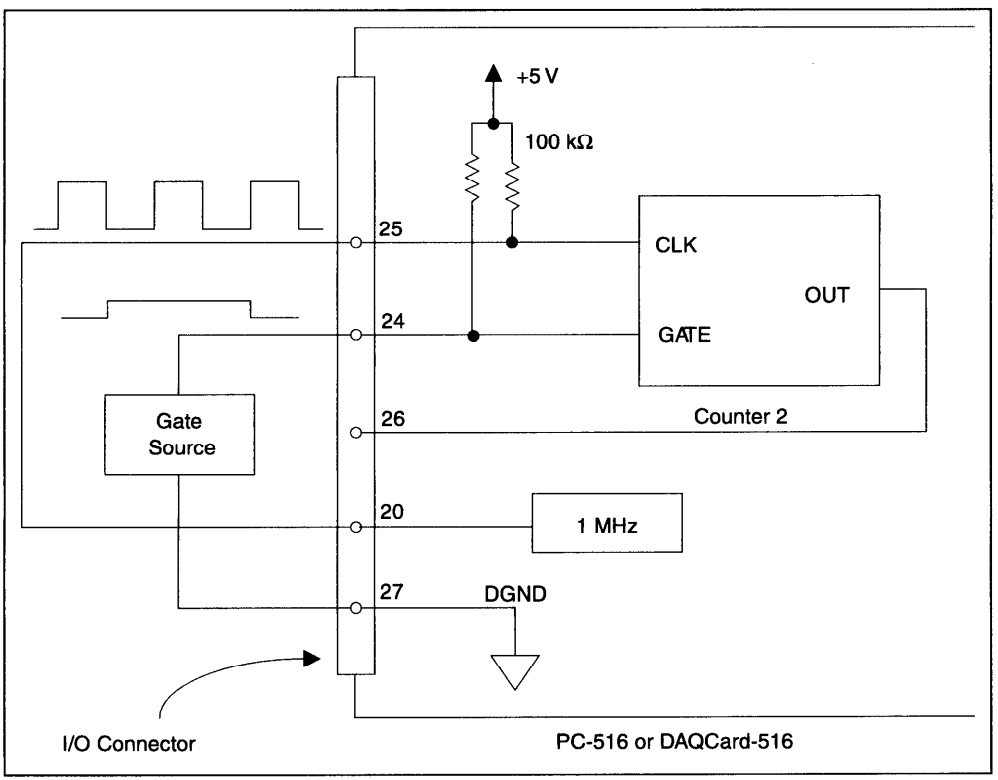
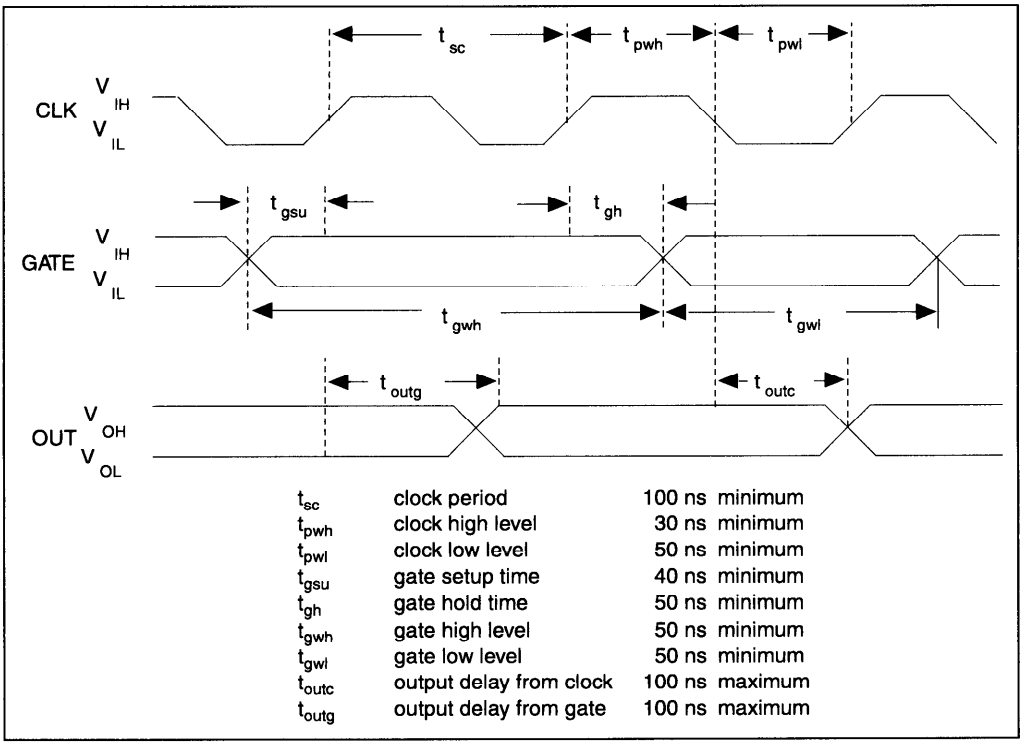


Figure 3-9. Frequency Measurement Application

The CLK and OUT signals for counter 1 are available at the I/O connector. The GATE, CLK, and OUT signals for counter 2 are available at the I/O connector. In addition, the GATE and CLK pins are pulled up to +5 V through a 100 kΩ resistor.

Figure 3-10 shows the timing requirements for the GATE and CLK input signals and the timing specifications for the OUT output signals of the MSM82C54.

- Absolute maximum voltage input rating of -0.5 to 5.0 V with respect to DGND
- MSM82C54 digital input specifications (referenced to DGND):
  - V_{IH} input logic high voltage — 2.2 V minimum
  - V_{IL} input logic low voltage — 0.8 V maximum
  - Input load current — ±10.0 μA maximum
- MSM82C54 digital output specifications (referenced to DGND):
  - V_{OH} output logic high voltage — 3.0 V minimum
  - V_{OL} output logic low voltage — 0.40 V maximum
  - I_{OH} output source current, at V_{OH} — 2.5 mA maximum
  - I_{OL} output sink current, at V_{OL} — 2.5 mA maximum



t_{sc}	clock period	100 ns minimum
t_{pwh}	clock high level	30 ns minimum
t_{pwl}	clock low level	50 ns minimum
t_{gsu}	gate setup time	40 ns minimum
t_{gh}	gate hold time	50 ns minimum
t_{gwh}	gate high level	50 ns minimum
t_{gwl}	gate low level	50 ns minimum
t_{outc}	output delay from clock	100 ns maximum
t_{outg}	output delay from gate	100 ns maximum

Figure 3-10. General-Purpose Timing Signals

The GATE and OUT signals in Figure 3-10 are referenced to the rising edge of the CLK signal.

Chapter 4

Theory of Operation

This chapter includes an overview of the PC-516 and DAQCard-516 and explains the operation of each functional unit making up your 516 device.

Functional Overview

The block diagram in Figure 4-1 shows a functional overview of the PC-516 and DAQCard-516.

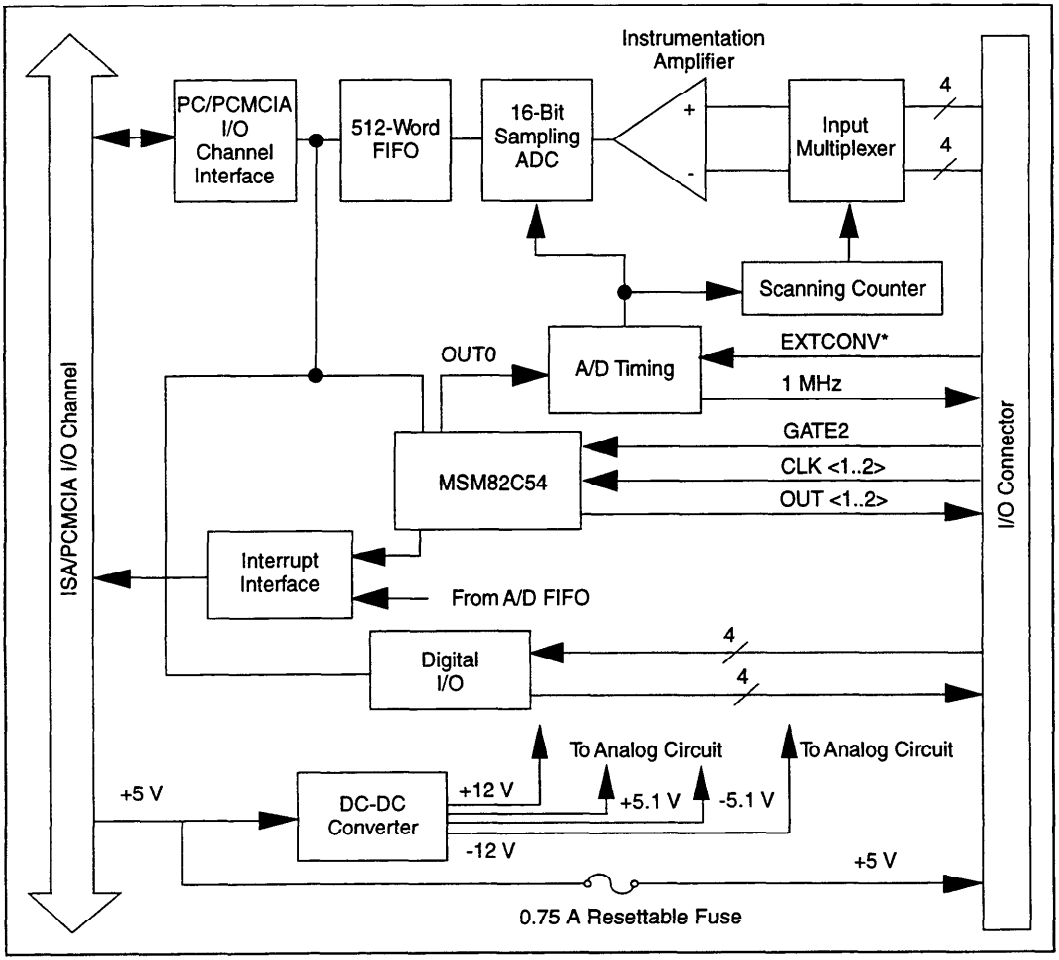


Figure 4-1. 516 Device Block Diagram

The following are the major components of the 516 device:

- Bus interface circuitry
- Analog input circuitry
- Digital I/O circuitry
- Timing I/O circuitry

You can execute data acquisition functions by using the analog input circuitry and some of the timing I/O circuitry. The internal data and control buses interconnect the components. The theory of operation for

each of these components is explained in the remainder of this chapter. The theory of operation for the data acquisition circuitry is included with the discussion of the analog input circuitry.

Bus Interface Circuitry

The bus interface circuitry consists of an address bus, a data bus, interrupt lines, and several control and support signals. The components making up the bus interface circuitry are shown in Figure 4-2.

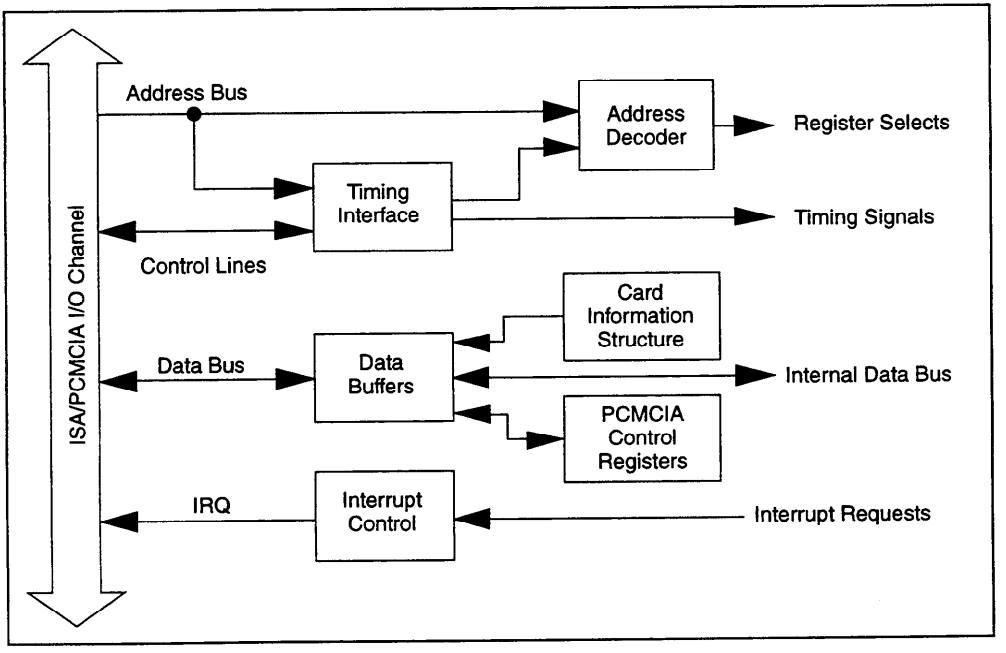


Figure 4-2. Bus Interface Circuitry Block Diagram

Analog Input and Data Acquisition Circuitry

Each 516 device has 8 channels of analog input with 16-bit A/D conversion. Using the timing circuitry, each 516 device can also automatically time multiple A/D conversions. Figure 4-3 shows a block diagram of the analog input and data acquisition circuitry.

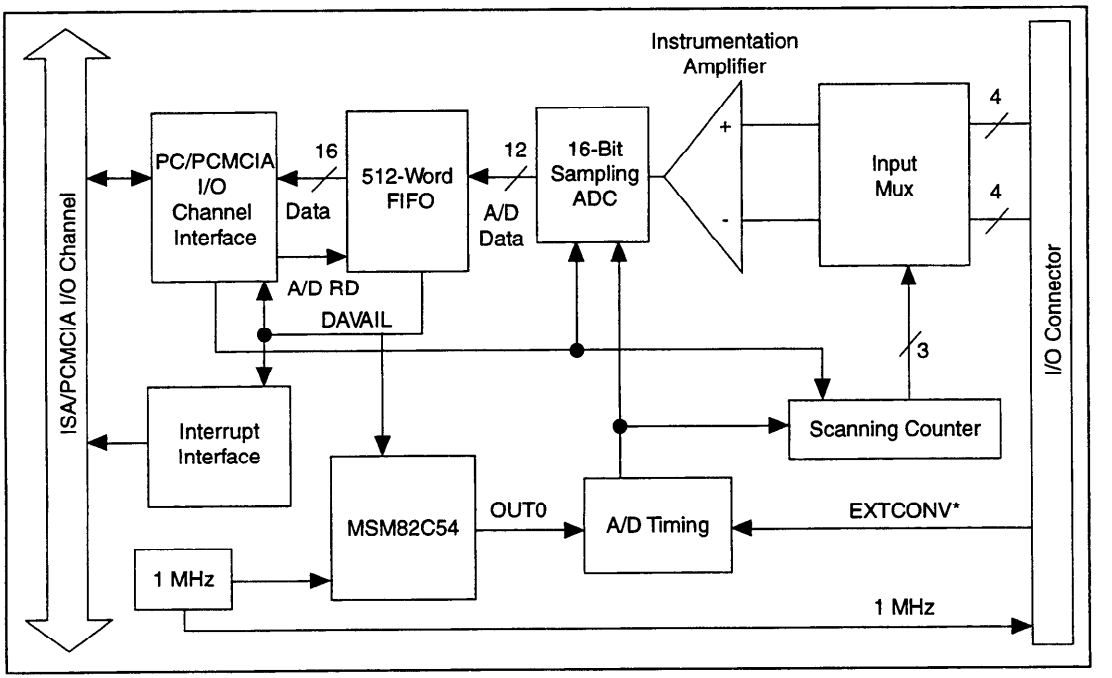


Figure 4-3. Analog Input and Data Acquisition Circuitry Block Diagram

Analog Input Circuitry

The analog input circuitry consists of an input multiplexer, a buffer, and a 16-bit sampling ADC. The data is stored in a 512-word-deep FIFO memory.

The input multiplexer is an 8-channel CMOS analog input multiplexer. In single-ended mode, the input multiplexer selects one of eight analog input channels (channels 0 through 7). In differential mode, the input multiplexer switches between differential pairs (0, 4), (1, 5), (2, 6), (3, 7). With the input multiplexer stage, input overvoltage protection of ± 25 V is available, powered on or off.

Each 516 device uses a 16-bit successive-approximation ADC. The ADC has a fixed input range of ±5 V.

When an A/D conversion is complete, the ADC clocks the result into the A/D FIFO. The A/D FIFO is 16 bits wide and 512 words deep. This FIFO serves as a buffer to the ADC and has two benefits. First, when an A/D conversion is complete, the value is saved in the A/D FIFO for later reading, and the ADC is free to start a new conversion. Secondly, the

A/D FIFO can collect up to 512 A/D conversion values before any information is lost, thus giving the software some extra time (512 times the sample interval) to catch up with the hardware. If more than 512 values are stored in the A/D FIFO without the A/D FIFO being read from, an error condition called A/D FIFO overflow occurs and A/D conversion information is lost.

The A/D FIFO generates a signal that indicates when it contains A/D conversion data. The state of this signal can be read from the Status Register.

The output from the ADC is a two's complement number ranging from -32,768 to 32,767.

Data Acquisition Timing Circuitry

A data acquisition operation refers to the process of obtaining a series of successive A/D conversions at a carefully timed interval. This interval is called the sample interval. The data acquisition timing circuitry consists of various clocks and timing signals that perform this timing. The 516 device can perform two types of data acquisition—single-channel data acquisition and multichannel (scanned) data acquisition. Scanned data acquisition uses a counter to automatically switch between analog input channels during data acquisition.

Data acquisition timing consists of signals that initiate a data acquisition operation and generate scanning clocks. One of the three counters of the onboard MSM82C54 is reserved for this purpose.

An A/D conversion can be initiated during data acquisition by a low-to-high transition on the counter 0 output (OUT0) of the MSM82C54 onboard counter/timer chip on the 516 device, or by a low-to-high transition on EXTCONV* input.

The sample-interval timer is a 16-bit down counter that uses the onboard 1 MHz clock to generate sample intervals from 2 µs to 65,535 µs (see *Timing I/O Circuitry* later in this chapter). Each time the sample-interval timer reaches zero, it generates a pulse and reloads with the programmed sample-interval count. This operation continues until you reprogram the counter.

Notice that only counter 0 is required for data acquisition operations. The software must track the number of conversions that have occurred and turn off counter 0 after the required number has been obtained.

Single-Channel Data Acquisition

During single-channel data acquisition, you set a control register to select the analog input channel before data acquisition starts. This multiplexer setting remains constant during the entire data acquisition process; therefore, you read all A/D conversion data from a single channel.

Multichannel (Scanned) Data Acquisition

You can perform multichannel data acquisition by enabling scanning during data acquisition. A scan counter controls multichannel scanning.

For scanning operations, the 516 device decrements from the highest numbered channel, which you select, through channel 0 and then repeats the sequence. The 516 device can scan any number of channels from 2 to 8.

Data Acquisition Rates

The maximum data acquisition rate (number of samples per second) is determined by the conversion period of the ADC plus the acquisition time of its track-and-hold stage. During multichannel scanning, the data acquisition rate is further limited by the settling time of the input multiplexer and operational amplifier. After the input multiplexer is switched, the amplifier must be able to settle to the new input signal value to within 16-bit accuracy before an A/D conversion is performed, or 16-bit accuracy cannot not be achieved.

If your chosen data acquisition rate does not allow the specified settling time, the analog input circuitry may not perform at 16-bit accuracy. Furthermore, if the maximum data acquisition rate is exceeded, A/D conversions may be lost. The maximum data acquisition rate and settling time specifications are listed in Appendix A, *Specifications*.

These settling time specifications assume that voltage levels on all the channels included in the scan sequence are within range and are driven by low-impedance sources. Signal levels outside the ranges on the channels included in the scan sequence adversely affect the input settling time. Similarly, greater settling time may be required for channels driven by high-impedance signal sources.

Digital I/O Circuitry

Each 516 device has eight digital I/O lines that are TTL-compatible. Pins DIN<0..3> of the I/O connector are digital input lines, and pins DOUT<0..3> are digital output lines. These lines are monitored or driven by the Digital Input Register or the Digital Output Register, respectively. Reading the Digital Input Register returns the current state of DIN<0..3> lines. Writing to the Digital Output Register drives the new value onto the DOUT<0..3> lines. Figure 4-4 shows a diagram of this circuitry.

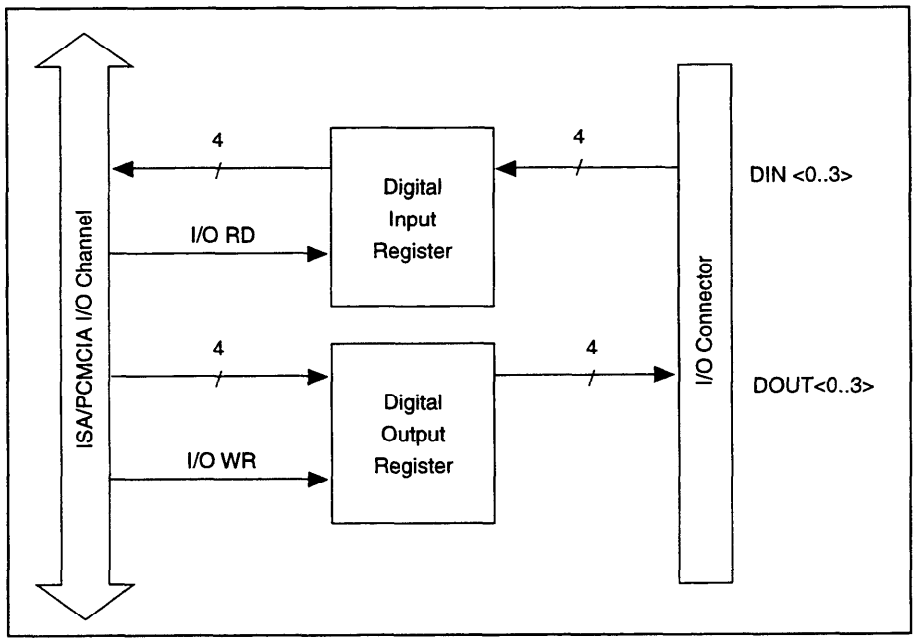


Figure 4-4. Digital I/O Circuitry Block Diagram

Timing I/O Circuitry

Each 516 device uses an MSM82C54 counter/timer integrated circuit for data acquisition timing and for general-purpose timing I/O functions. Counters 1 and 2 of the MSM82C54 are available for general use, but counter 0 is used internally for data acquisition timing. The gate signal of counter 1 is internally pulled up and is always active. Figure 4-5 shows a block diagram of both groups of timing I/O circuitry.

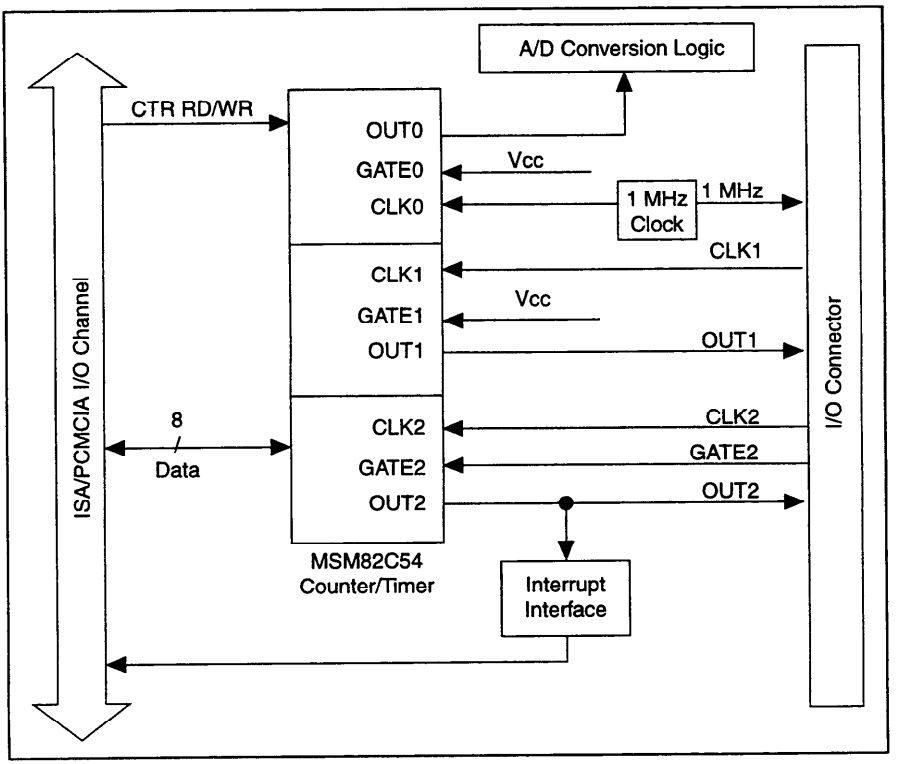


Figure 4-5. Timing I/O Circuitry Block Diagram

The MSM82C54 contains three independent 16-bit counter/timers and one 8-bit Mode Register. As shown in Figure 4-5, counter 0 is used for data acquisition timing, and counters 1 and 2 are free for general use. All three counter/timers can be programmed to operate in several useful timing modes. The programming and operation of the MSM82C54 is presented in detail in the optional *DAQCard-500/516 and PC-516 Register-Level Programmer Manual.*

The MSM82C54 for counter 0 uses a 1 MHz clock generated from the onboard oscillator. This 1 MHz clock is also available on the cable I/O connector, which you can use as a timebase for counters 1 and 2. The 16-bit counters in the MSM82C54 can be diagrammed as shown in Figure 4-6.

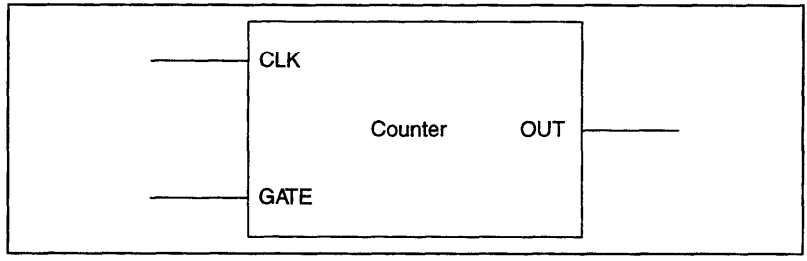


Figure 4-6. Counter Block Diagram

Each counter has a clock input pin, a gate input pin, and an output pin labeled CLK, GATE, and OUT, respectively. The MSM82C54 counters are numbered zero through two, and their GATE, CLK, and OUT pins are labeled GATE *N*, CLK *N*, and OUT *N*, where *N* is the counter number.

Appendix A

Specifications

This appendix lists the specifications of the PC-516 and DAQCard-516. These specifications are typical at 25° C unless otherwise specified.

Analog Input

Input Characteristics

Number of channels ..... 8 single-ended or 4 differential (software selectable)

Type of ADC..... Successive approximation

Resolution ..... 16 bits, worst-case code range -32,243 to +32,242 (due to software calibration)

Maximum sampling rate..... 50 kS/s

Input signal ranges ..... ±5 V

Input coupling ..... DC

Overvoltage protection ..... ±25 V powered on, ±25 V powered off

Inputs protected..... ACH<0..7>

FIFO buffer size ..... 512 S

Data transfers ..... Interrupts, programmed I/O

Transfer Characteristics

DNL ..... ±3 LSB max

No missing codes ..... 15 bits, guaranteed

Offset error

After software calibration .....±1 LSB

Before software calibration .....±20 LSB typ, ±45 LSB max

Gain error (relative to calibration reference)

After software calibration ..... ±0.045% of reading typ, ±0.09% max

Before software calibration ..... ±0.87% of reading typ, ±1.5% max

Amplifier Characteristics

Input impedance ..... 10 GΩ in parallel with 20 pF

CMRR (all input ranges) ..... 70 dB, DC to 60 Hz

Dynamic Characteristics

Settling time to ±0.0015% (±1 LSB) for full-scale step ..... 20 µs

System noise ..... 1 LSBrms typ

Stability

Recommended warm-up time ..... 15 min

Offset temperature coefficient ..... 20 ppm/°C max

Gain temperature coefficient ..... 30 ppm/°C max

Digital I/O

Number of channels ..... 4 input and 4 output

Compatibility ..... TTL

Digital logic levels .....

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2 V	5 V
Input low current (V_{in} = 0 V)	—	-50 µA
Input high current (V_{in} = 5 V)	—	1 µA
Output low voltage (I_{out} = 4 mA)	—	0.5 V
Output high voltage (I_{out} = 4 mA)	3.5 V	—

Timing I/O

Number of channels ..... 3 counter/timers (1 dedicated to analog input)

Resolution ..... 16 bits

Compatibility ..... TTL, gate and source pulled high with 100 kΩ resistors

Basc clocks availablc ..... 1 MHz

Base clock accuracy ..... ±0.01%

Max source frequency ..... 10 MHz

Min source pulse duration ..... 50 ns

Min gate pulse duration ..... 50 ns

Data transfers ..... Programmed I/O

Bus Interface

Type ..... Slave

Power Requirement

- PC-516
  +5 VDC (±5%) ..... 80 mA max
  ±12 VDC (±5 %)..... 20 mA max
- DAQCard-516
  +5 VDC (±5%) ..... 60 mA in operational mode
  20 mA in power-down mode

☞ **Note:** ***These power usage figures do not include the power used by external devices that you have connected to the fused supply present on the I/O connector.***

Physical

- PC-516
  Dimensions ..... 12 by 10.7 cm (4.25 by 4.3 in.)
  I/O connector ..... 27-pin male
- DAQCard-516
  PC Card type..... Type II
  I/O connector ..... 27-pin male

Environment

Operating temperature ..... 0° to 70° C
Storage temperature..... -55° to 150° C
Relative humidity ..... 5% to 90% noncondensing

Custom Cable Design

Appendix B

This appendix describes the pin connections on the PC-516 and DAQCard-516, which you will need only if you are designing your own cable.

- DAQCard-516

  The recommended cable for the DAQCard-516 is the National Instruments PR27-30F. This cable has a 27-pin male connector that mates with the 27-pin female connector on the device. Figure B-1 shows the pin assignment for the 27-pin female connector on the DAQCard-516. Use the pin assignment in Figure B-1 only for custom cable design.

  If you are using the National Instruments PR27-30F cable, you should use the pin assignment shown in Figure 3-1a.

  The other end of the cable uses a 30-pin, insulation displacement, male ribbon-cable header connector. National Instruments uses a polarized (keyed) connector to prevent inadvertent upside-down connection to the CB-27. The recommended manufacturer part number for this mating connector is as follows:

  - AMP Manufacturing (part number 746288-7)

  The following are the standard ribbon cables (30-conductor, 28 AWG, stranded) that work with the 30-pin connectors:

  - Electronic Products Division/3M (part number 3365-30)
  - T&B/Ansley Corporation (part number 171-30)

- PC-516

  The recommended cable for the PC-516 is the National Instruments R30-30. This cable is a standard 30-conductor ribbon cable with a polarized, 30-pin, insulation displacement, male ribbon-cable header connector on each end. Figure 3-1b shows the pin assignment for the 30-pin connector on the PC-516. Recommended manufacturer part numbers for the standard ribbon cables that work with the 30-pin connectors are listed above.

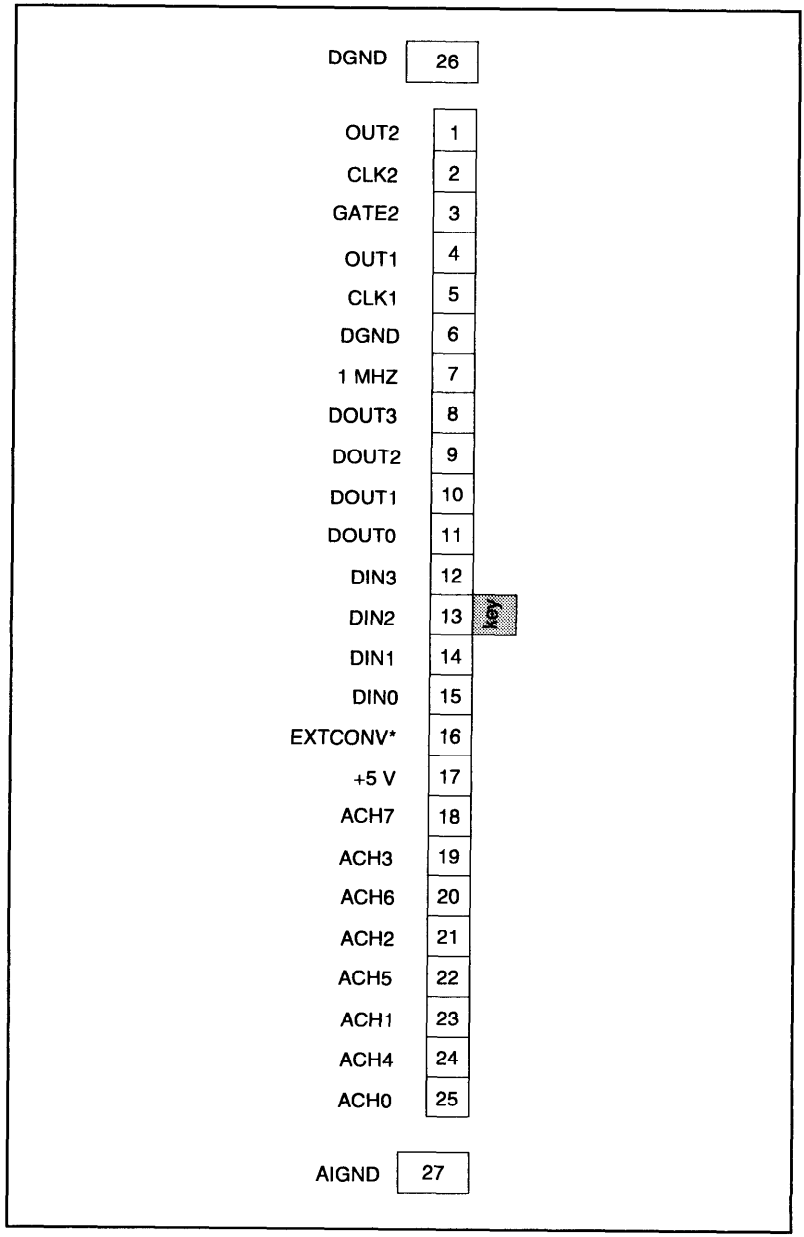


Figure B-1. DAQCard-516 I/O Connector Pin Assignments

Note: ***Use this pin assignment figure only if you are designing custom-made cables for your device.***

PC Card Questions and Answers

Appendix C

This appendix contains a list of common questions and answers relating to PC Card (PCMCIA) operation. The questions are grouped according to the type of information requested. You may find this information useful if you are having difficulty with the PCMCIA system software configuration and you are using Windows 3.1.

Note: ***If you are using Windows 95, the operation system will automatically configure your PC Card. All questions in this appendix are specific to Windows 3.1, with the exception of question 3 in the Operations section.***

Configuration

1. **Do I need to use my PCMCIA configuration utility to configure the National Instruments PC Cards?**

   No. We recommend that you do not configure our PC Cards using PC Card Control or an equivalent PC Card configuration utility. Use the configuration utilities included with the NI-DAQ driver software to properly configure your card. The appropriate utility is the NI-DAQ Configuration Utility (formerly called `WDAQCONF`) for Windows 3.1 users.

2. **What should I do if my computer does not have Card and Socket Services version 2.0 or later?**

   Contact the manufacturer of your computer or of your PCMCIA adapter and request the latest Card and Socket PCMCIA driver. Our NI-DAQ software will work with any Card and Socket Service driver that is compliant to version 2.0 or later.

Operation

1. **My PC Card works when inserted before power-on time, but it does not work when hot inserted. What is wrong?**

   You may have an interrupt conflict. If you have a utility such as MSD.EXE, run it to determine the allocated interrupts, then refer to question 5 in the *Resources* section. MSD.EXE is usually shipped with Microsoft Windows.

2. **My computer locks up when I use a PC Card. What should I do?**

   This usually happens because Card Services allocated an unusable interrupt level to the PC Card. For example, on some computers, interrupt level 11 is not routed to PC Cards. If Card Services is not aware of this, it may assign interrupt 11 to a PC Card even though the interrupt is not usable. When a call uses the interrupt, the interrupt never occurs, and the computer locks up waiting for a response. For information about how to locate an interrupt that is free to be used, refer to question 4 in the *Resources* section.

3. **Is there a way I can conserve power on my PC Card when it is not in use?**

   Yes. If you are using NI-DAQ for PC compatibles version 4.8.0 or later, a utility called DAQPOWER.EXE will switch National Instruments PC Cards between normal mode and power-down mode. Run DAQPOWER from the command line to view instructions on the proper usage. See Appendix D, *Power-Management Modes*, for more information.

Resources

1. **How do I determine if I have a memory conflict?**

   If no PC Cards are working at all, it is probably because a memory window is not usable. Card Services uses a 4 KB memory window for its own internal use. If the memory cannot be used, then Card Services cannot read the Card Information Structure (CIS) from the card EPROM, which means it cannot identify cards.

   There are two different methods you can use when Card Services has a problem reading the CIS. First, you can determine which memory window Card Services is using, and then exclude that window from use

by Card Services and/or the memory manager. Second, you can attempt to determine all of the memory that Card Services can possibly use and then exclude all but that memory from use by Card Services.

2. How do I determine all of the memory that Card Services can use?

One way to find out which memory addresses Card Services can use is to run a utility such as MSD.EXE that scans the system and tells you how the system memory is being used. For example, if you run such a memory utility and it tells you that physical addresses C0000 to C9FFF are being used for ROM access, then you know that C8000–D3FFF is an invalid range for Card Services and should be changed to CA000–D3FFF.

3. How can I find usable I/O addresses?

Finding usable I/O addresses is done by trial and error. Of the three resources used—memory, I/O, interrupts—I/O conflicts will be low. You can use WDAQCONF in Windows to diagnose I/O space conflicts. When you have configured DAQCONF or WDAQCONF for a particular I/O space, save the configuration. If there is a conflict, the configuration utility will report an error describing the conflict.

4. How do I find usable interrupt levels?

Some utilities, such as MSD.EXE, will scan the system and display information about what is using hardware interrupts. If you have such a utility, you can run it to determine what interrupts Card Services can use. Card Services needs an interrupt for itself as well as one interrupt for each PCMCIA socket in the system. For example, in a system with two PCMCIA sockets, at least three interrupts should be allocated for use by Card Services.

Keep in mind that utilities such as MSD.EXE will sometimes report that an interrupt is in use when it really is not. For example, if the computer has one serial port, COM1, and one parallel port, LPT1, you know that IRQs 4 and 7 are probably in use. In general, IRQ5 is used for LPT2, but if the computer does not have two parallel ports, IRQ5 should be usable. IRQ3 is used for COM2, but if the computer has only has one serial port, IRQ3 should be usable.

5. I run a memory utility, and it appears there is no memory available for Card Services. What should I do?

You should remove your memory manager by commenting it out of the CONFIG.SYS file. Next, you can rerun the memory utility. Memory

managers often consume an enormous amount of memory, and you will need to determine what memory is really usable by Card Services. When you have determined what memory is available for Card Services, reinstall your memory manager and make the necessary changes to provide Card Services with the memory needed. We suggest that you use the minimum amount of memory for Card Services, namely 4 to 12 KB, which frees more memory for the memory manager.

Resource Conflicts

1. **How do I resolve conflicts between my memory manager and Card Services?**

   Card Services can usually use memory space that is not being used for real RAM on the system. Even when this is the case, you should still exclude the memory addresses used by Card Services from use by any memory manager that may be installed.

Appendix D

Power-Management Modes

This appendix describes the power-management modes of the DAQCard-516.

- Normal Mode—This is the normal operating mode of the DAQCard-516 in which all the circuits are fully functional. This mode draws about 60 mA from the 5 V supply (about 300 mW).
- Power-Down Mode—In this mode, the digital circuitry is powered on and is functional. The analog input is powered down by setting the PWRDOWN bit in the PC Card Configuration and Status Register. You can set the PWRDOWN bit by using the `DAQPOWER` utility that is shipped with NI-DAQ. Use `DAQPOWER D` to power down and `DAQPOWER U` to power up the DAQCard-516. This utility is available in Windows and is installed whenever you install NI-DAQ. Typically, the analog supplies are not reduced to zero; negligible power is supplied to the analog circuits. This mode draws about 20 mA from the 5 V supply (about 100 mW).

Table D-1 shows the effects of different power-management modes on the DAQCard-516 circuits.

Table D-1. DAQCard-516 Power-Management Modes

	Normal Mode	Power-Down Mode
Analog Input	Functional. Protected to ±25 V. Impedance > 10 GΩ.	Nonfunctional. Draws negligible power. Protected to ±25 V. Impedance = 4.7 kΩ, which is the input protection resistance.
Digital I/O	Functional. Protected from -0.5 to 5.5 V.	Functional. Protected from -0.5 to 5.5 V.
Counters	Functional. Initialize to undefined states. Individual counters of the 82C54 must be fully programmed before use. Protected from -0.5 to 5.5 V.	Functional. Initialize to undefined states. Individual counters of the 82C54 must be fully programmed before use. Protected from -0.5 to 5.5 V.

Customer Communication

Appendix E

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a FaxBack system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call (512) 795-6990. You can access these services at:

United States: (512) 794-5422 or (800) 327-3077
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 1 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as anonymous and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.



FaxBack Support

FaxBack is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access FaxBack from a touch-tone telephone at the following number:

(512) 418-1111



E-Mail Support (currently U.S. only)

You can submit technical support questions to the appropriate applications engineering team through e-mail at the Internet addresses listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

GPIB: gpib.support@natinst.com
DAQ: daq.support@natinst.com
VXI: vxi.support@natinst.com
LabWindows: lw.support@natinst.com
LabVIEW: lv.support@natinst.com
HiQ: hiq.support@natinst.com
VISA: visa.support@natinst.com

Fax and Telephone Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.



	Telephone	Fax
Australia	03 9 879 9422	03 9 879 9179
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Canada (Ontario)	519 622 9310	
Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	90 527 2321	90 502 2930
France	1 48 14 24 24	1 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	95 800 010 0793	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
U.K.	01635 523545	01635 523154

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

_____

Fax (___)_____ Phone (___) _____

Computer brand _____ Model _____ Processor _____

Operating system (include version number) _____

Clock speed _____MHz RAM _____MB Display adapter _____

Mouse ___yes ___no Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

_____

National Instruments hardware product model_____ Revision_____

Configuration _____

National Instruments software product_____ Version _____

Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem: _____

_____

_____

_____

_____

_____

PC-516/DAQCard-516 Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

National Instruments Products

PC-516 or DAQCard-516 Serial Number and Revision _____

DAQ hardware _____

Interrupt level of hardware _____

Base I/O address of hardware _____

Programming choice _____

NI-DAQ, LabVIEW, or LabWindows/CVI version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

Other Products

Computer make and model _____

Microprocessor _____

Clock frequency or speed _____

Type of video board installed _____

Operating system version _____

Operating system mode _____

Programming language _____

Programming language version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

PC card software _____

PC card software version _____

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: PC-516/DAQCard™-516 User Manual

Edition Date: May 1996

Part Number: 321178A-01

Please comment on the completeness, clarity, and organization of the manual.

If you find errors in the manual, please record the page numbers and describe the errors.

Thank you for your help.

Name _____

Title _____

Company _____

Address _____

_____

Phone ( ) _____

Mail to: Technical Publications
National Instruments Corporation
6504 Bridge Point Parkway
Austin, TX 78730-5039

Fax to: Technical Publications
National Instruments Corporation
(512) 794-5678

Prefix	Meaning	Value
m-	milli-	10^{-3}
μ-	micro-	10^{-6}
n-	nano-	10^{-9}

Numbers/Symbols

°	degrees
Ω	ohms
%	percent
1 MHz	1 MHz square wave oscillator signal

A

A	amperes
AC	alternating current
ACH	analog input channel signal
A/D	analog-to-digital
ADC	A/D converter
AIGND	analog input ground signal
AWG	American Wire Gauge

C

C	Celsius
CE	card enable signal
CLK	clock input signal
CMOS	complementary metallic oxide semiconductor
CMRR	common-mode rejection ratio
CTR	counter

D

D/A	digital-to-analog
DAQ	data acquisition
DAVAIL	data available signal
DC	direct current
DGND	digital ground signal
DIN	digital input signal
DOUT	digital output signal

E

EISA	Extended Industry Standard Architecture
EXTCONV	external convert signal to trigger A/D conversions

F

FIFO	first-in-first-out

G

GATE	gate input signal

H

Hz	hertz

I

I/O	input/output
I_{OH}	current, output high
I_{OL}	current, output low
I_{out}	output current
ISA	Industry Standard Architecture

L

LED	light-emitting diode
LSB	least significant bit

M

MB	megabytes of memory
MSB	most significant bit
mux	multiplexer

N

NC	not connected (signal)

O

OUT	output signal

P

PCMCIA	Personal Computer Memory Card International Association

R

RD	read
rms	root mean square

S

S	samples
s	seconds
SCXI	Signal Conditioning eXtensions for Instrumentation

T

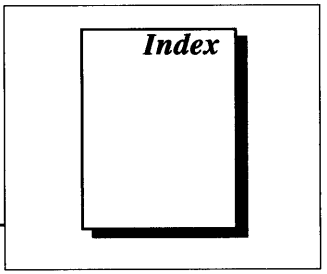
TTL	transistor-transistor logic

V

V	volts
VCC	positive supply voltage from the PCMCIA bus (usually +5V)
VDC	volts, direct current
V_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
V_{OH}	volts, output high
V_{OL}	volts, output low

W

WR	write



Numbers

1 MHz signal (table), 3-3
+5 V signal (table), 3-3

A

A/D FIFO, 4-4 to 4-5
ACH<0..7> signal
    analog input signal connections, 3-4
    description (table), 3-3
    differential mode, 3-7
    single-ended mode, 3-7
ADC, 15-bit sampling, 4-4
AIGND signal
    analog input signal connections, 3-4
    description (table), 3-3
analog input circuitry
    block diagram, 4-4
    theory of operation, 4-4 to 4-5
analog input configuration, 2-5 to 2-6
    DIFF input, 2-6 to 2-7
    RSE input, 2-6
analog input signal connections, 3-4 to 3-13
    differential connection considerations, 3-9 to 3-13
        common-mode signal rejection considerations, 3-12 to 3-13
        floating signal sources, 3-11 to 3-12
        grounded signal sources, 3-10
    DIFF input, 3-7
    exceeding input signal range (warning), 3-4
    floating signal sources, 3-5
    ground-referenced signal sources, 3-5
    input configurations, 3-5 to 3-7
    signal connection considerations, 3-4
    single-ended connection considerations, 3-7 to 3-8
    SE input, 3-7
    types of signal sources and measurement systems, 3-5
analog input specifications
    amplifier characteristics, A-2
    dynamic characteristics, A-2
    input characteristics, A-1
    stability, A-2
    transfer characteristics, A-1 to A-2

B

base I/O selection, PC-516, 2-4 to 2-5
bulletin board support, E-1
bus interface
    circuitry (figure), 4-3
    specifications, A-3
bus-related configuration, PC-516, 2-4 to 2-5

C

cables
    CB-27 cable termination accessory, 1-5
    custom cable design
        connector pin assignments, B-2
        DAQCard-516, B-1
        PC-516, B-1 to B-2
CLK, GATE, and OUT signal timing connections
    counter block diagram, 4-9
    event counting application (figure), 3-16
    frequency measurement application (figure), 3-17

timing requirements (figure), 3-19
timing specifications, 3-18
CLK1 signal (table), 3-3
CLK2 signal (table), 3-3
common-mode signal rejection considerations, 3-12 to 3-13
configuration. *See also* installation.
analog input, 2-5 to 2-7
DIFF input, 2-6 to 2-7
RSE input, 2-6
counter, 2-7
data acquisition-related, 2-5 to 2-7
digital I/O, 2-7
PC-516 configuration, 2-4 to 2-5
base I/O selection, 2-4 to 2-5
bus-related, 2-4
plug and play mode, 2-4 to 2-5
switchless mode, 2-5
PC card questions and answers, C-1
typical configuration for DAQCard-516 (figure), 2-3
counter block diagram, 4-9
counter configuration, 2-7
custom cable design. *See* cables.
customer communication, *xii*, E-1 to E-2

D

DAQCard-516. *See* PC-516/DAQCard-516.
data acquisition counter and timing connections, 3-15
data acquisition timing circuitry
block diagram, 4-5
data acquisition rates, 4-6
multichannel (scanned) data acquisition, 4-6
single channel data acquisition, 4-6
theory of operation, 4-5 to 4-6
DGND signal (table), 3-3
DIFF input
analog input configuration, 2-6 to 2-7
definition (table), 2-6
recommended input configurations (table), 3-6
differential connection considerations, 3-9 to 3-13
common-mode signal rejection considerations, 3-12 to 3-13
floating signal sources, 3-11 to 3-12
grounded signal sources, 3-10
DIFF input, 3-7
digital I/O
circuitry, 4-7
block diagram, 4-7
data-acquisition configuration, 2-7
signal connections, 3-13 to 3-14
I/O connections (figure), 3-14
pins, 3-13
specifications, 3-13
specifications, A-3
DIN <0..3> signal
description (table), 3-3
digital I/O circuitry, 4-7
documentation
conventions used in manual, *x*
National Instruments documentation, *xi*
organization of manual, *ix-x*
related documentation, *xii*
DOUT <0..3> signal
description (table), 3-3
digital I/O circuitry, 4-7

E

e-mail support, E-2
electronic technical support, E-1 to E-2
environment specifications, A-4
equipment, optional, 1-5
event-counting, 3-16
application with external switch gating (figure), 3-16

EXTCONV* signal
data acquisition counter and timing connections, 3-15
description (table), 3-3
signal timing (figure), 3-15

F

fax and telephone support, E-2
faxback support, E-2
floating signal sources
analog input signal connections, 3-5 to 3-7
differential input connections, 3-11 to 3-12
recommended input configurations (table), 3-6
frequency measurement, 3-17
application (figure), 3-17
FTP support, E-1

G

GATE signal timing connections. *See* CLK, GATE, and OUT signal timing connections.
GATE2 signal (table), 3-3
general-purpose counter and timing signal connections, 3-15 to 3-19
event-counting, 3-16
application with exterior switch gating (figure), 3-16
frequency measurement, 3-17
application (figure), 3-17
pulse and square wave generation, 3-16
pulse width measurement, 3-16
time lapse measurement, 3-17
ground-referenced signal sources
analog input signal connections, 3-5 to 3-7
differential connection considerations, 3-9
differential input connections, 3-10
recommended input configurations (table), 3-6

I

I/O connectors. *See also* signal connections.
custom cable pin assignments (figure), B-2
exceeding maximum ratings (warning), 3-1
pin assignments (figure), 3-2
signal connection descriptions (table), 3-3 to 3-4
input multiplexer, 4-4
installation. *See also* configuration.
procedure for installation, 2-1 to 2-2
unpacking the 516 device, 1-6
instrumentation amplifier (figure), 3-6

L

LabVIEW and LabWindows/CVI application software, 1-3

M

manual. *See* documentation.
MSM82C54 counter/timer, 4-7 to 4-8
multichannel (scanned) data acquisition, 4-6
multiplexer, input, 4-4

N

NC signal (table), 3-4
NI-DAQ driver software, 1-3 to 1-4

O

OUT signal timing connections. *See* CLK, GATE, and OUT signal timing connections.
OUT1 signal (table), 3-3
OUT2 signal (table), 3-4

P

PC-516/DAQCard-516. *See also* theory of operation.
cabling, 1-5
hardware and software requirements, 1-2
optional equipment, 1-5
overview and features, 1-1 to 1-2
software programming choices, 1-3 to 1-5
LabVIEW and LabWindows/CVI application software, 1-3
NI-DAQ driver software, 1-3 to 1-4
register-level programming, 1-5
PC card questions and answers, C-1 to C-4
configuration, C-1
operation, C-1 to C-2
resource conflicts, C-4
resources, C-2 to C-3
physical specifications, A-4
pin assignments
custom cabling, B-2
I/O connectors, 3-2
plug and play mode, PC-516, 2-4
power management modes of DAQCard-516
effects of power management (table), D-2
normal mode, D-1
power-down mode, D-1
power requirement specifications, A-4
pulse and square wave generation, 3-16
pulse width measurement, 3-16

R

referenced single-ended input. *See* RSE input.
register-level programming, 1-5
RSE input
analog input configuration, 2-6
definition (table), 2-6
recommended input configurations (table), 3-6
single-ended connection considerations, 3-7 to 3-8
SE input, 3-7

S

scanned (multichannel) data acquisition, 4-6
signal connections
analog input signal connections, 3-4 to 3-13
differential connection considerations, 3-9 to 3-13
common-mode signal rejection considerations, 3-12 to 3-13
floating signal sources, 3-11 to 3-12
grounded signal sources, 3-10
DIFF input, 3-7
exceeding input signal range (warning), 3-5
floating signal sources, 3-5
ground-referenced signal sources, 3-5
input configurations, 3-5 to 3-7
signal connection considerations, 3-4
single-ended connection considerations, 3-7 to 3-8
SE input, 3-7
types of signal sources and measurement systems, 3-5
digital I/O signal connections, 3-13 to 3-14
I/O connector pin assignments (figure), 3-2
signal connection descriptions (table), 3-3 to 3-4
timing connections, 3-14 to 3-19
data acquisition counter and timing connections, 3-15
general-purpose counter and timing signal connections, 3-15 to 3-19
single channel data acquisition, 4-6
single-ended connection considerations, 3-7 to 3-8
signal source connection (figure), 3-8
SE input, 3-7

software programming choices
LabVIEW and LabWindows/CVI application software, 1-3
NI-DAQ driver software, 1-3 to 1-4
register-level programming, 1-5
specifications
analog input
amplifier characteristics, A-2
dynamic characteristics, A-2
input characteristics, A-1
stability, A-2
transfer characteristics, A-1 to A-2
bus interface, A-3
digital I/O, A-3
environment, A-4
physical, A-4
power requirements, A-4
timing I/O, A-3
switchless mode, 2-4

T

technical support, E-1 to E-2
theory of operation
analog input and data acquisition circuitry, 4-3 to 4-6
analog input circuitry, 4-4 to 4-5
block diagram, 4-4
data acquisition rates, 4-6
data acquisition timing circuitry, 4-5 to 4-6
multichannel (scanned) data acquisition, 4-6
single-channel data acquisition, 4-6
block diagram of PC-516/DAQCard-516, 4-2
bus interface circuitry (figure), 4-3
digital I/O circuitry, 4-7
functional overview, 4-1 to 4-3
timing I/O circuitry, 4-7 to 4-9
block diagram, 4-8
counter block diagram, 4-9
time lapse measurement, 3-17
timing connections, 3-14 to 3-19
data acquisition counter and timing connections, 3-15
GATE, CLK, and OUT signal timing requirements, 3-18 to 3-19
general-purpose counter and timing signal connections, 3-15 to 3-19
event-counting, 3-16
frequency measurement, 3-17
pulse and square wave generation, 3-16
pulse width measurement, 3-16
time lapse measurement, 3-17
pins for timing I/O signals, 3-14
timing I/O circuitry, 4-7 to 4-9
block diagram, 4-8
counter block diagram, 4-9
timing I/O specifications, A-3

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