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DAQCard™-700
User Manual

Multifunction I/O Board for the PCMCIA Bus

January 1996 Edition

Part Number 320676C-01

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About This Manual

This manual describes the mechanical and electrical aspects of the DAQCard-700 and contains information concerning its installation and operation. The DAQCard-700 is a compact, low-cost, low-power analog input, digital, and timing I/O card for computers that are equipped with a Type II PCMCIA socket.

Organization of This Manual

The *DAQCard-700 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the DAQCard-700; lists what you need to get started, software programming choices, and optional equipment; and explains how to unpack the DAQCard-700.
- Chapter 2, *Installation and Configuration*, describes how to install and software configure the DAQCard-700.
- Chapter 3, *Signal Connections*, describes the signals on the DAQCard-700 I/O connector, as well as typical cable setups.
- Chapter 4, *Theory of Operation*, includes an overview of the DAQCard-700 and explains the operation of each functional unit making up the DAQCard-700.
- Appendix A, *Specifications*, lists the specifications of the DAQCard-700.
- Appendix B, *Differences between the PC-LPM-16 and the DAQCard-700*, contains a summary of differences between these two products that may be relevant to you.
- Appendix C, *PC Card Questions and Answers*, contains a list of common questions and answers relating to PC Card operation.
- Appendix D, *Power-Management Modes*, describes the power-management modes of the DAQCard-700.
- 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:

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 all Macintosh II, Macintosh Quadra, and Macintosh Centris computers except the Centris 610 unless otherwise noted.
NI-DAQ	NI-DAQ is used throughout this manual to refer to the NI-DAQ software for Macintosh computers or PC compatibles unless otherwise stated.
PC	PC refers to the IBM PC/XT, PC AT, Personal System/2, and laptop compatible computers which are equipped with a PCMCIA standard version 2.0 or later bus interface and a Type II, 5 V-capable slot.
< >	Angle brackets containing numbers separated by an ellipses represent a range of values associated with a bit, signal, or port (for example, ACH<0..7> stands for ACH0 through ACH7).

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

National Instruments Documentation

The *DAQCard-700 User Manual* is one piece of the documentation set for your data acquisition 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 board 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 (a 4.6.1 or earlier version of NI-DAQ supports LabWindows for DOS). 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 the PCMCIA slot

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

- *DAQCard-700 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 quicker and easier than 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 DAQCard-700; lists what you need to get started, software programming choices, and optional equipment; and explains how to unpack the DAQCard-700.

About the DAQCard-700

Thank you for your purchase of the National Instruments DAQCard-700. The DAQCard-700 is a low-cost, low-power analog input, digital, and timing I/O card for computers equipped with a Type II PCMCIA slot. The card contains a 12-bit, successive-approximation ADC with 16 single-ended or 8 differential analog inputs, 8 lines of TTL-compatible digital input, and 8 lines of digital output. The DAQCard-700 also contains two 16-bit counter/timer channels for timing I/O. The optional 50 pin I/O connector for the DAQCard-700 enables you to easily connect all your analog, digital, and timing signals directly to the card. The DAQCard-700 is fully software configurable and calibrated so that you can easily install the card and begin your acquisition without having to spend time configuring or calibrating the card.

The DAQCard-700 ships with NI-DAQ, National Instruments complete DAQ driver which 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.

The small size and weight of the DAQCard-700 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.

In addition, the low cost of a system based on the DAQCard-700 makes it ideal for laboratory work in industrial and academic environments. The multichannel analog input is useful in signal analysis and data logging. The 12-bit ADC is useful in high-resolution applications such as chromatography, temperature measurement, and DC voltage measurement. The 16 TTL-compatible digital I/O line can be used for switching external devices such as transistors and solid-state relays, for reading the status of external digital logic, and for generating interrupts. The counter/timers can be used to synchronize events, generate pulses, and measure frequency and time. The DAQCard-700, used in conjunction with your computer, is a versatile, cost-effective platform for laboratory test, measurement, and control.

Detailed specifications of the DAQCard-700 are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your DAQCard-700, you will need the following:

- ❑ DAQCard-700
- ❑ One of the following I/O cables (must be purchased separately):
  PR50-50M ribbon cable (6 in.)
  PR50-50F ribbon cable (0.5, 1, or 2 m)
- ❑ Connector block for signals
- ❑ *DAQCard-700 User Manual*
- ❑ NI-DAQ software with documentation
- ❑ 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 Libraries are 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 libraries are 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—up to 500 kS/s on ISA computers and up to 1 MS/s on EISA computers.

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. Figure 1-1 illustrates the relationship between NI-DAQ and LabVIEW and LabWindows/CVI. You can see that the data acquisition parts of LabVIEW and LabWindows/CVI are functionally equivalent to the NI-DAQ software.

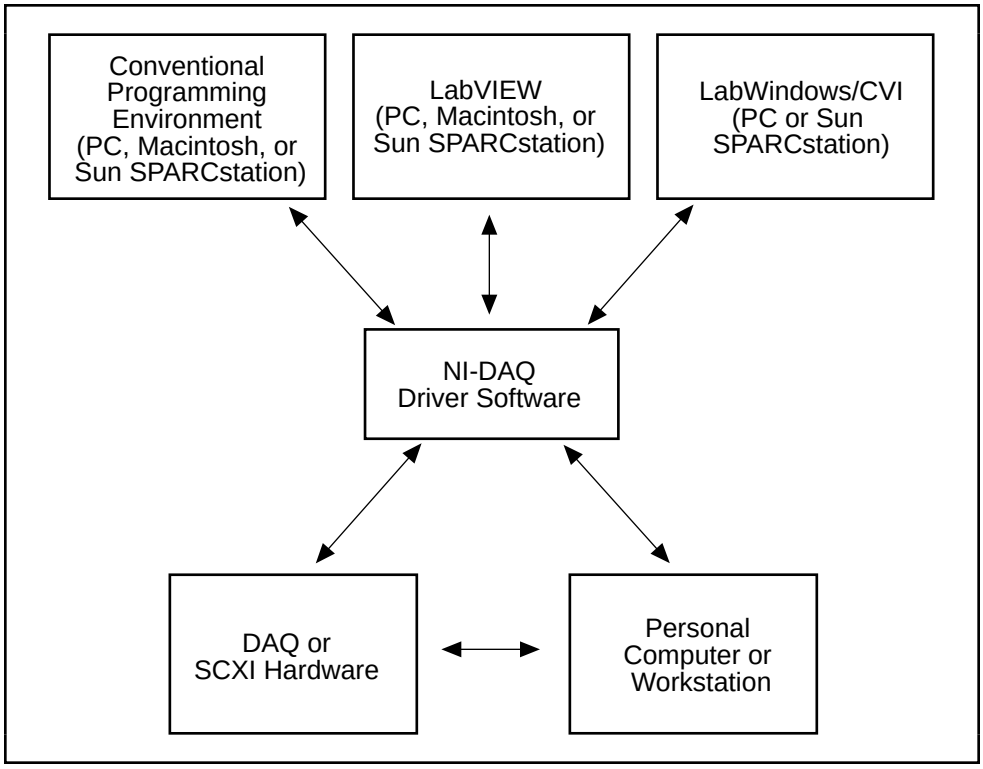


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

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.

Unpacking

The DAQCard-700 is shipped in an antistatic vinyl envelope; when you are not using the DAQCard-700, you should store it in this envelope.

Because the DAQCard-700 is enclosed in a fully shielded case, no additional electrostatic precautions are necessary. However, for your own safety and to protect the DAQCard-700, never attempt to touch the pins of the connectors.

Chapter 2
Installation and Configuration

This chapter describes how to install and software configure the DAQCard-700.

Installation

Your computer should be equipped with Card and Socket Services 2.0 or later. The DAQCard-700 requires a 32-byte I/O address window and one interrupt level.

This manual assumes that you are using one of the optional cables from National Instruments. Notice that the cable is keyed so that you can insert it only one way.

Insert the DAQCard-700 and attach the I/O cable.

The DAQCard-700 has two connectors—a 68-pin PCMCIA bus connector on one end and a 50-pin I/O connector on the other end. Insert the PCMCIA bus connector into any available Type II PCMCIA slot until the connector is seated firmly. Notice that the card is keyed so that it can be inserted only one way. If your computer supports hot insertion, you may insert or remove the DAQCard-700 at any time, whether your computer is powered on or off.

The optional I/O cables available for the DAQCard-700 plug into the 50-pin I/O connector and connect to National Instruments products such as the CB-50 and the BNC-2080. Notice that the cable is keyed so that you can insert it only one way. Be very careful not to put strain on the I/O cable when inserting it into and removing it from the DAQCard-700. Always grasp the cable by the connector you are plugging or unplugging. *Never* pull directly on the I/O cable to unplug it from the DAQCard-700.

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

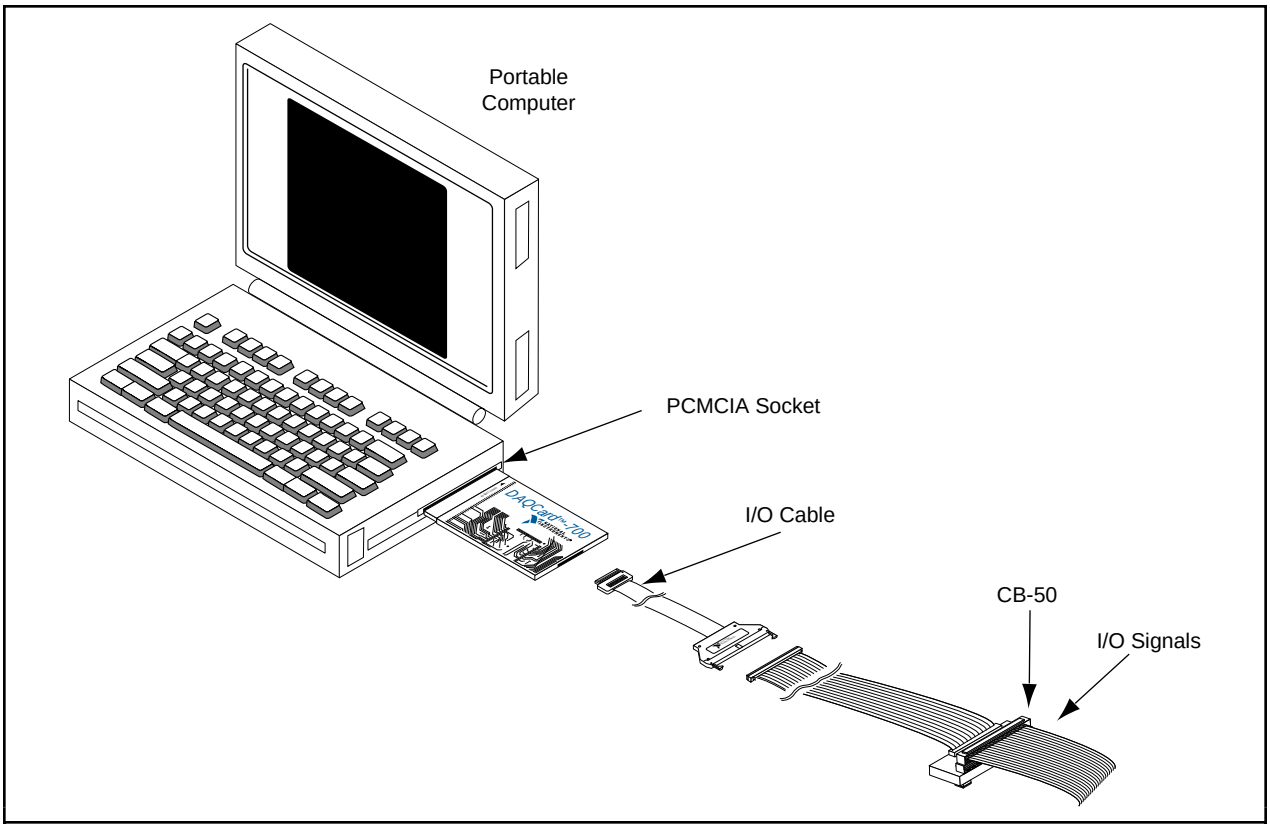


Figure 2-1. A Typical Configuration for the DAQCard-700

The DAQCard-700 is now 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.

Configuration

The DAQCard-700 is completely software configurable; refer to your software documentation to install and configure the software.

If you are using NI-DAQ for PC compatibles, refer to the 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 documentation. 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 Part 1, *Introduction to LabWindows/CVI*, of the *Getting Started with LabWindows/CVI* manual. After you have installed LabWindows/CVI, refer to Chapter 1, *Configuring LabWindows/CVI*, of the *LabWindows/CVI User Manual* for software configuration instructions.

Analog I/O Configuration

At startup, the DAQCard-700 defaults to the following configuration:

- Referenced single-ended input mode
- ±10 V analog input range

Table 2-1 lists the available analog I/O configurations for the DAQCard-700 and shows the default settings.

Table 2-1. Analog I/O Settings

Parameter	Configuration
Analog Input Polarity	Bipolar—±10 V (default setting) Bipolar—±5 V Bipolar—±2.5 V
Analog Input Mode	Referenced single-ended (RSE) (default setting) Differential (DIFF)

The analog input circuitry is software configurable.

Warning: ***Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the DAQCard-700 can result in damage to the DAQCard-700 card. National Instruments is NOT liable for any damages or injuries resulting from incorrect signal connections.***

Analog Input Mode

The DAQCard-700 has two different input modes–referenced single-ended (RSE) input and differential (DIFF) input. The single-ended input configuration provides 16 channels. The DIFF input configuration provides eight channels. Table 2-2 describes these configurations.

Table 2-2. Analog Input Modes for the DAQCard-700

Analog Input Modes	Description
RSE	Referenced single-ended mode provides 16 single-ended inputs referenced to analog ground (default setting).
DIFF	Differential mode provides eight differential inputs with the positive (+) input of the instrumentation amplifier tied to channels 0, 1, 2, 3, 4, 5, 6, or 7 and the negative (-) input tied to channels 8, 9, 10, 11, 12, 13, 14, or 15, respectively, thus choosing channel pairs (0, 8), (1, 9), (2, 10), (3, 11), (4, 12), (5, 13), (6, 14), or (7, 15).

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

RSE Input (16 Channels, Default Setting)

RSE input means that all input signals are referenced to a common ground point that is also tied to the DAQCard-700 analog input ground. The RSE configuration is useful for measuring floating signal sources. See the *Types of Signal Sources* section of Chapter 3 for more information. With this input configuration, the DAQCard-700 can monitor 16 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 (Eight 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 DAQCard-700 can monitor eight 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 8, 9, 10, 11, 12, 13, 14, or 15, depending on which channel pair you select.

Digital I/O Configuration

The DAQCard-700 always uses one 8-bit digital output port and one 8-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 pulse-width, 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

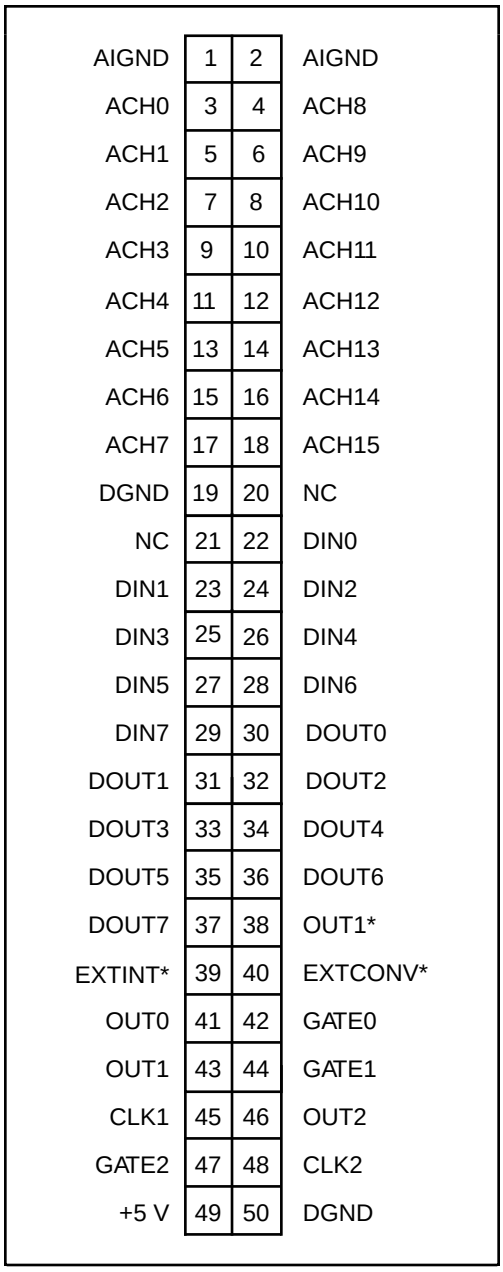
This chapter describes the signals on the DAQCard-700 I/O connector, as well as typical cable setups.

I/O Connector

Figure 3-1 shows the pin assignments for the DAQCard-700 I/O connector. This connector is attached to the ribbon cable that extends from the PCMCIA slot when the card is installed and the cable is connected.

Warning: ***Connections that exceed any of the maximum ratings of input or output signals on the DAQCard-700 can damage the DAQCard-700 card and the computer. This includes connecting any power signals to ground and vice versa. National Instruments is NOT liable for any damages resulting from any such signal connections.***

Figure 3-1 shows the DAQCard-700 I/O connector pin assignments.



AIGND	1	2	AIGND
ACH0	3	4	ACH8
ACH1	5	6	ACH9
ACH2	7	8	ACH10
ACH3	9	10	ACH11
ACH4	11	12	ACH12
ACH5	13	14	ACH13
ACH6	15	16	ACH14
ACH7	17	18	ACH15
DGND	19	20	NC
NC	21	22	DIN0
DIN1	23	24	DIN2
DIN3	25	26	DIN4
DIN5	27	28	DIN6
DIN7	29	30	DOUT0
DOUT1	31	32	DOUT2
DOUT3	33	34	DOUT4
DOUT5	35	36	DOUT6
DOUT7	37	38	OUT1*
EXTINT*	39	40	EXTCONV*
OUT0	41	42	GATE0
OUT1	43	44	GATE1
CLK1	45	46	OUT2
GATE2	47	48	CLK2
+5 V	49	50	DGND

Figure 3-1. DAQCard-700 I/O Connector Pin Assignments

Signal Connection Descriptions

Pin	Signal Name	Direction	Description
1–2	AIGND	—	Analog Input Ground—These pins are connected to the analog input ground signal.
3–18	ACH<0..15>	Input	Analog Input Channels 0 through 15—These channels are in single-ended mode.
19	DGND	—	Digital Ground—This pin is connected to the digital ground signal.
20–21	NC	—	Not Connected—These pins are not connected.
22–29	DIN<0..7>	Input	Input Digital Data Lines 0 through 7—DIN7 is the MSB, DIN0 the LSB.
30–37	DOUT<0..7>	Output	Output Digital Data Lines 0 through 7—DOUT7 is the MSB, DOUT0 the LSB.
38	OUT1*	Output	Counter 1 Output—This pin is the inversion of counter 1 output.
39	EXTINT*	Input	External Interrupt—This pin is used for input of the external interrupt signal.
40	EXTCONV*	Input	External Control—This pin is used for input of the external control signal to trigger A/D conversions.
41	OUT0	Output	Counter 0 Output—This pin is the output of counter 0.
42	GATE0	Input	Counter 0 Gate Input—This pin is the gate input for counter 0.
43	OUT1	Output	Counter 1 Output—This pin is the output of counter 1.
44	GATE1	Input	Counter 1 Gate Input—This pin is the gate input for counter 1.
45	CLK1	Input	Counter 1 Clock Input—This pin is the clock input for counter 1.
46	OUT2	Output	Counter 2 Output—This pin is the output of counter 2.
47	GATE2	Input	Counter 2 Gate Input—This pin is the gate input for counter 2.
48	CLK2	Input	Counter 2 Clock Input—This pin is the clock input for counter 2.
49	+5 V	Output	+5 Volts—This pin provides +5 VDC. The +5 V supply is fused at 1 A, which is the maximum current available.
50	DGND	—	Digital Ground—This pin is connected to the digital ground signal.

***** ***Indicates that the signal is active low.***

The connector pins can be 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 the following pages.

Analog Input Signal Connections

Pins 1 through 18 are analog input signal pins for the ADC. Pins 1 and 2, AIGND, are an analog common signal. You can use these pins for a general analog power ground tie to the DAQCard-700. Pins 3 through 18 are the ACH<15..0> signal pins. These pins are tied to the analog input channels of the DAQCard-700 through 4.7 kΩ series resistors. These resistors limit the input current to the multiplexer. The following input ranges and maximum ratings apply to inputs ACH<0..15>:

- Input signal range ±2.5 V, ±5 V, or ±10 V
- Maximum input voltage rating ±30 V powered on or off

Warning: ***Exceeding the input signal range distorts input signals. Exceeding the maximum input voltage rating may damage the DAQCard-700 card and the computer. National Instruments is NOT liable for any damages resulting from any such signal connections.***

Types of Signal Sources

When configuring the input mode of the DAQCard-700 and making signal connections, 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.

Ground-Referenced Signal Sources

A ground-referenced signal source 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 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. The ground reference of a floating signal must be tied to the DAQCard-700 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 or device that provides an isolated output falls into the floating signal source category.

Types of Measurement Systems

In addition to determining the type of signal source, you also need to determine whether your measurement system is floating or ground referenced. These two types of measurement systems are described below. 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.

Ground-Referenced Measurement System

A ground-referenced measurement system is one that is connected in some way to the building system ground. Instruments that plug into the building power system fall into this category.

Floating Measurement System

A floating 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 measurement systems are battery-powered instruments, instruments powered with a nonground-referenced power adapter, and instruments with differential inputs. A floating measurement system will float to the level of the signals being measured.

Input Configurations

To measure the different types of input signals, you can configure the DAQCard-700 for one of two input modes–DIFF or RSE. These two modes, differential and referenced single-ended, can be implemented by changing the configuration of the instrumentation amplifier onboard the DAQCard-700. Figure 3-2 shows a diagram of the DAQCard-700 instrumentation amplifier.

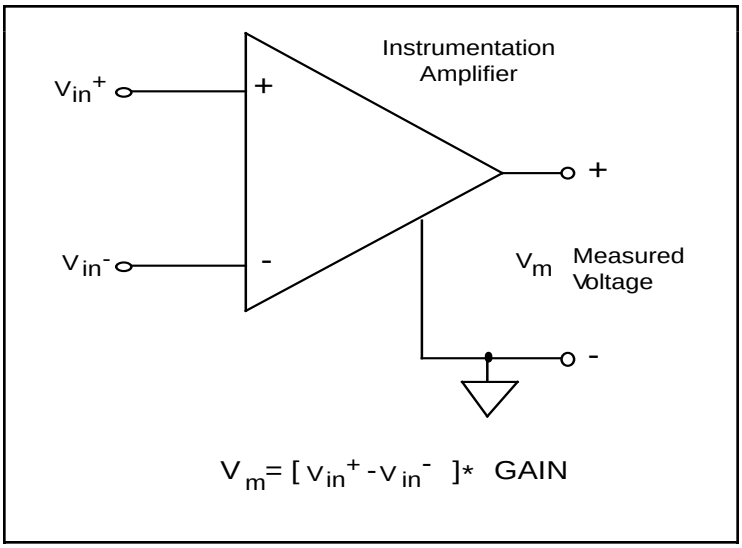


Figure 3-2. DAQCard-700 Instrumentation Amplifier

The DAQCard-700 instrumentation amplifier applies common-mode voltage rejection and presents a high-input impedance to the analog input signals connected to the DAQCard-700. Signals are routed to the positive and negative inputs of the instrumentation amplifier through input multiplexers on the DAQCard-700. 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 DAQCard-700 ground. The DAQCard-700 ADC measures this output voltage when it performs A/D conversions.

Single-Ended Mode

Although the instrumentation amplifier on the DAQCard-700 is actually bypassed in single-ended mode, the effect of this mode is the same as if signals connected to ACH<15..0> were routed to the positive terminal of the instrumentation amplifier and the negative terminal of the instrumentation amplifier were connected to the analog ground reference of the DAQCard-700. Thus, the voltage measured by the DAQCard-700 in single-ended mode is the difference between an input signal and the DAQCard-700 analog ground reference.

Differential Mode

In differential mode, signals connected to ACH<7..0> are routed to the positive input of the instrumentation amplifier, and signals connected to ACH<15..8> are routed to the negative input of the instrumentation amplifier. Thus, the voltage measured by the DAQCard-700 in differential mode is the difference between two of the input signals.

Recommended Input Configurations

The following sections discuss the use of single-ended and differential measurements and considerations for measuring both floating and ground-referenced signal sources. Table 3-1 summarizes the recommended input configurations for both types of signal sources.

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

Single-Ended Connection Considerations

Single-ended connections are those in which all DAQCard-700 analog input signals are referenced to one common ground. The input signals are tied to the positive input of an operational amplifier that is referenced to their common ground point.

When the DAQCard-700 is configured for single-ended input, 16 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 DAQCard-700 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 DAQCard-700 single-ended configuration is referenced. You can use this mode for nonreferenced signal sources. In addition, if the computer using the DAQCard-700 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 a DAQCard-700 in single-ended mode. When you connect grounded signal sources to a DAQCard-700 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.

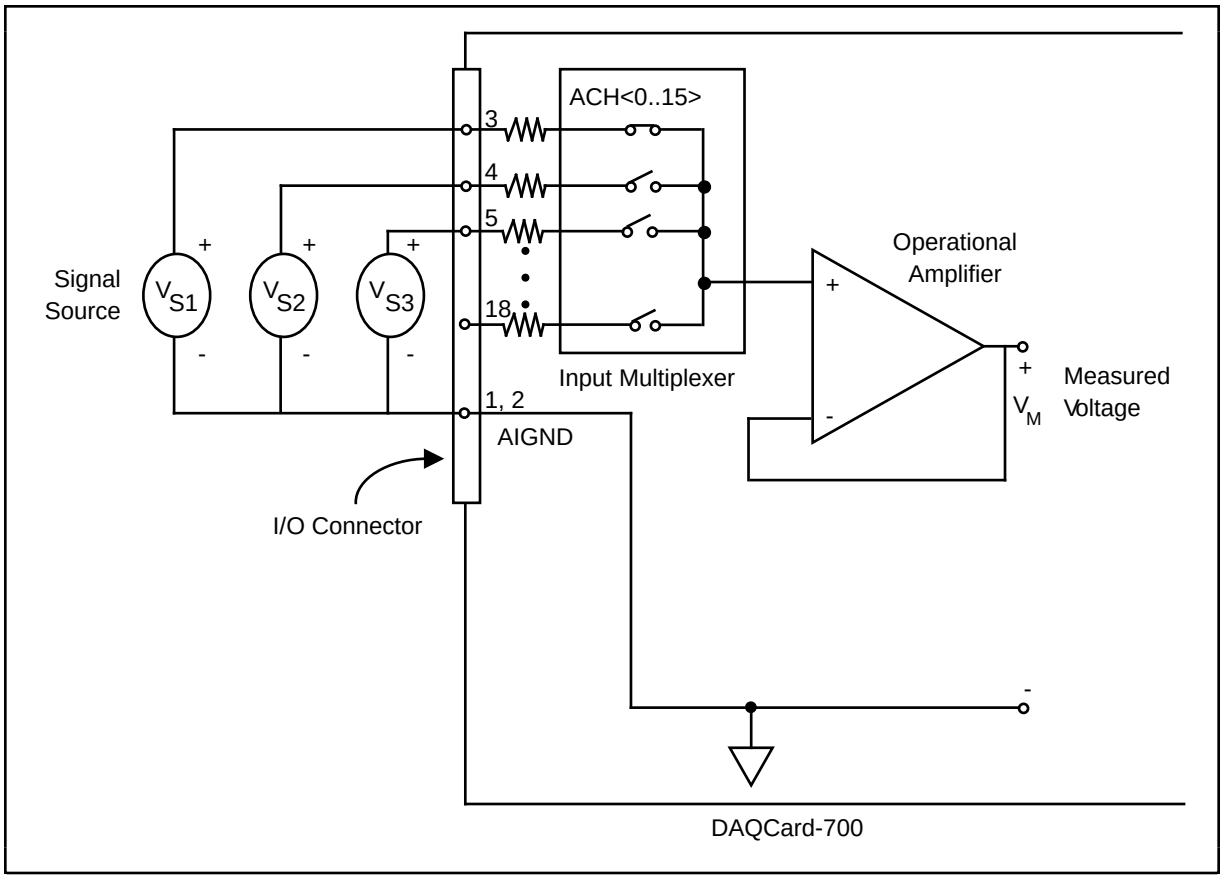


Figure 3-3. Single-Ended Analog Input Signal Connections

Differential Connection Considerations (DIFF Configuration)

Differential connections are those in which each DAQCard-700 analog input signal has its own reference signal or signal return path. These connections are available when the DAQCard-700 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 the DAQCard-700 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 eight analog input channels are available when using the DIFF configuration. The DIFF input configuration should be used when any of the following conditions are present:

- Input signals are low level (less than 1 V).
- Leads connecting the signals to the DAQCard-700 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 a DAQCard-700 card configured for DIFF input.

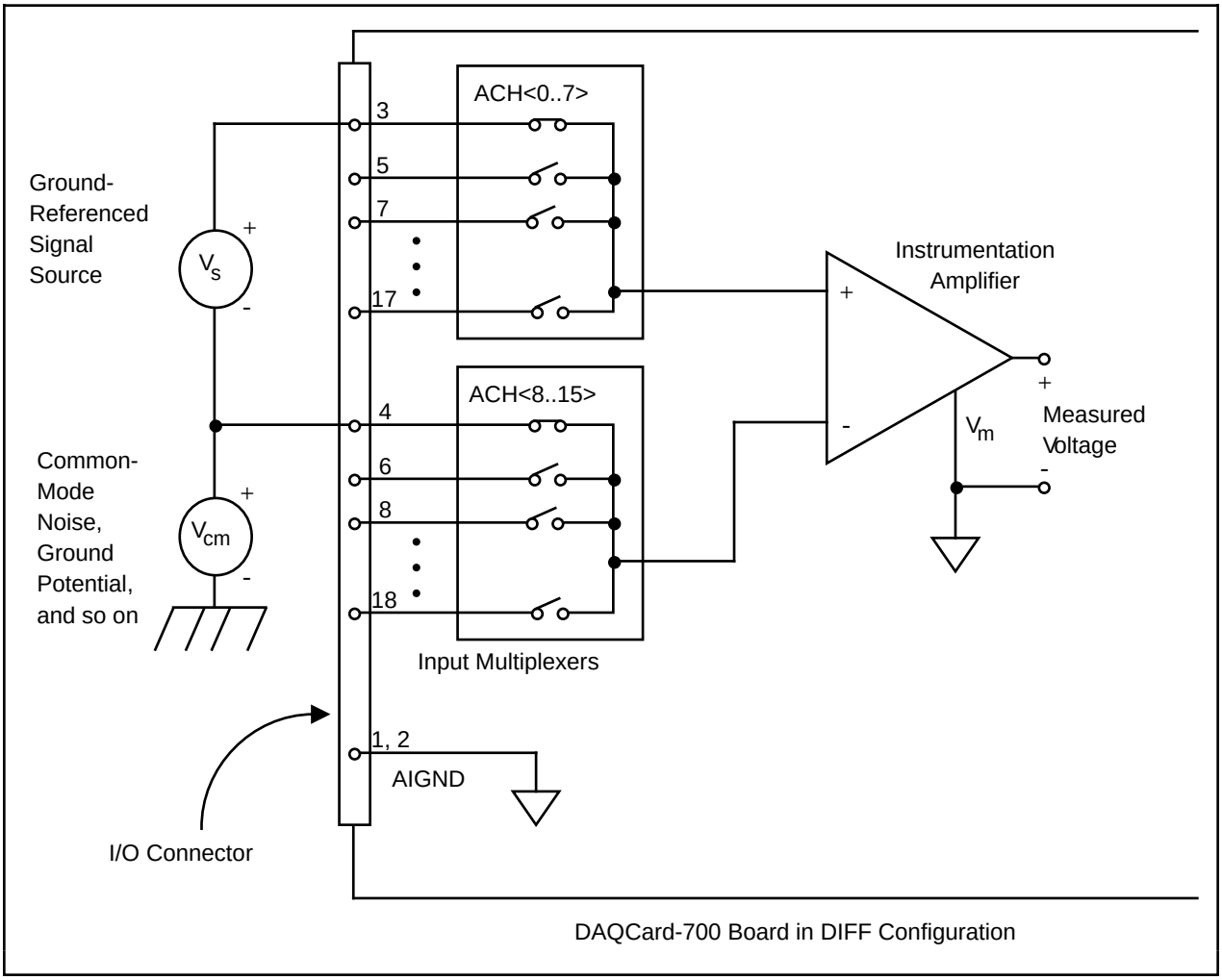


Figure 3-4. Differential Input Connections for Grounded Signal Sources

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 DAQCard-700 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 an DAQCard-700 card configured for DIFF input. Configuration instructions are included in the *Input Configurations* section earlier in this chapter.

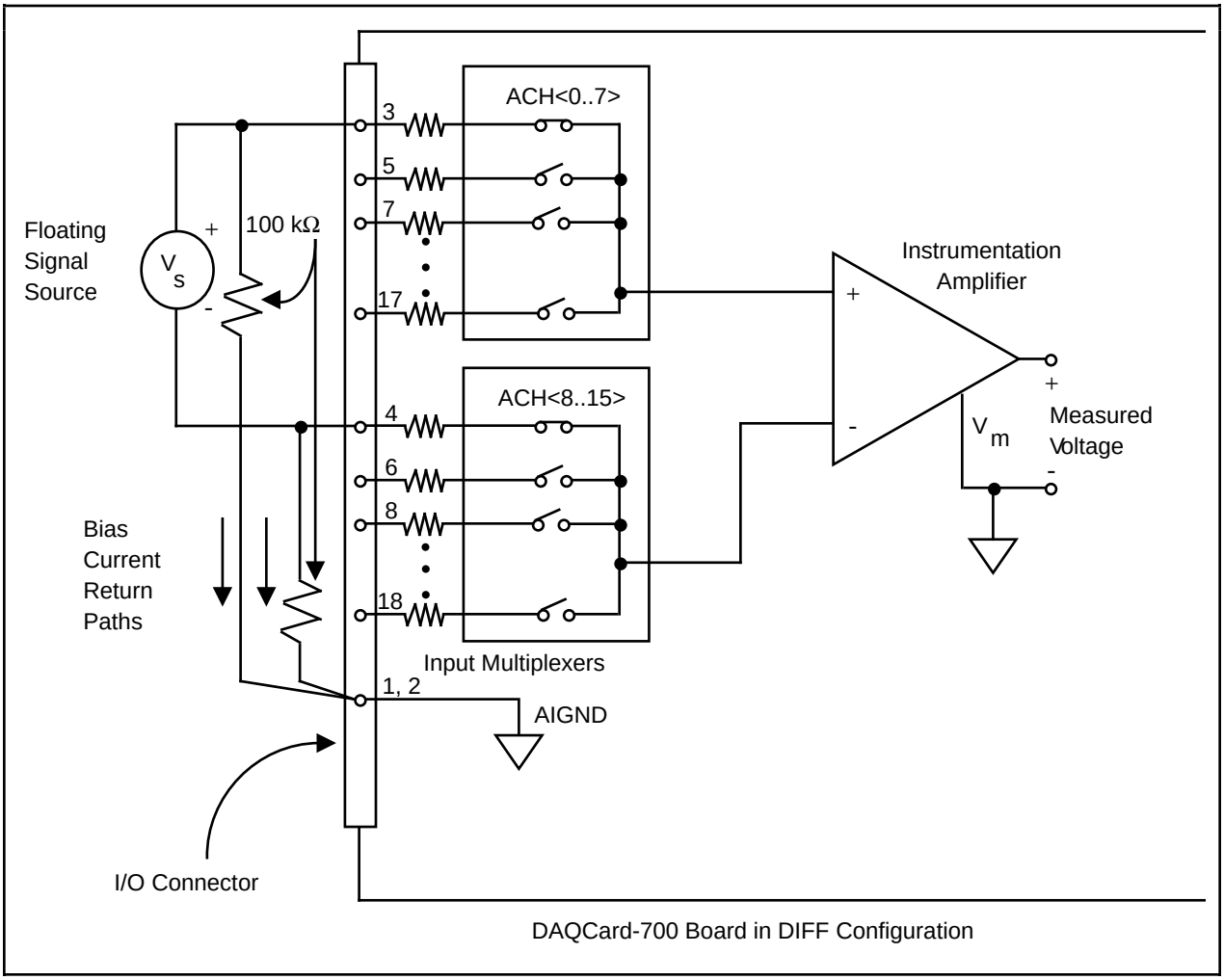


Figure 3-5. Differential Input Connections for Floating Sources

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 the DAQCard-700. In these cases, the instrumentation amplifier can reject any voltage due to ground potential differences between the signal source and the DAQCard-700. In addition, with differential input connections, the instrumentation amplifier can reject common-mode noise pickup in the leads connecting the signal sources to the DAQCard-700.

The common-mode input range of the DAQCard-700 instrumentation amplifier is defined as the magnitude of the greatest common-mode signal that can be rejected. The DAQCard-700 can reject common-mode input signals so long as V^+_{in} and V^-_{in} are both in the range ±9.5 V.

The common-mode input range for the DAQCard-700 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:

$$V_{cm\text{-}max} = \pm (9.5\ V - V_{diff}/2)$$

Thus, for a differential voltage as large as 10 V, the largest common-mode voltage that can be rejected is ±4.5 V. However, if the differential signal is 2.5 V, ±8.25 V common-mode voltage can be rejected.

The common-mode voltage is measured with respect to the DAQCard-700 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 DAQCard-700 ground, you need to limit the amount of floating that occurs between the signal ground and the DAQCard-700 ground.

Digital I/O Signal Connections

Pins 22 through 37 of the I/O connector are digital I/O signal pins. Pins 22 through 29 are digital input pins. Pins 30 through 37 are digital output pins. Pins 19 and 50 are digital ground pins.

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

- Absolute maximum voltage input rating — +5.5 V with respect to DGND
-0.5 V with respect to DGND
- Digital input compatibility — TTL-compatible
- Input current (high or low level) — 1 mA
- Digital output compatibility — TTL-compatible
- Output current source capability — 4 mA, at V_{OH} = 2.7 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.

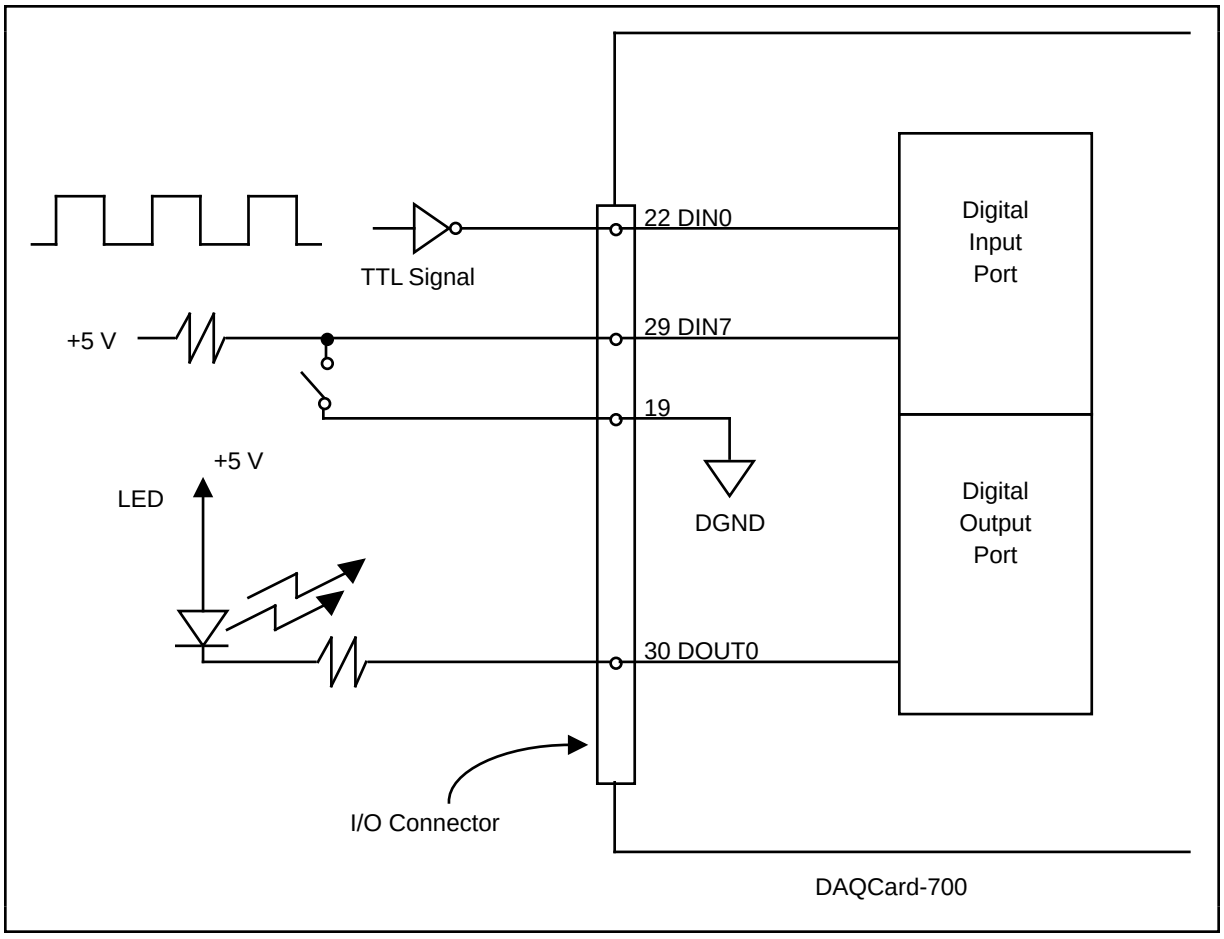


Figure 3-6. Digital I/O Signal Connections

Power Connections

Pin 49 of the I/O connector sends +5 V from the PCMCIA I/O channel power supply. This pin is referenced to DGND and can be used to power external digital circuitry that draws up to 1 A. Pin 49 is connected to a 1 A resettable fuse on the card. The actual current available from this signal may be less than 1 A, depending on the computer. Notice also that any current drawn from this line adds to the power requirements from the computer.

Warning: ***Do NOT exceed any of the maximum ratings of input or output signal connections on the DAQCard-700. Doing so can damage the DAQCard-700 and the computer. Exceeding the maximum connections includes connecting any power signals to ground and vice versa. National Instruments is NOT liable for any damages resulting from any such signal connections.***

Timing Connections

Pins 38 through 48 of the I/O connector are connections for timing I/O signals. The DAQCard-700 timing I/O uses an MSM82C54 counter/timer integrated circuit. All three counters of the MSM82C54 are available at the I/O connector. One of these counters, counter 0, is used for data acquisition timing. Pin 40 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 under *Data Acquisition Timing Connections*. Pins 38 and 41 through 48 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 40, EXTCONV*, to externally time conversions. If you need to program this chip directly, refer to the optional *DAQCard-700 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 10 µs. The EXTCONV* input is a TTL-compatible signal.

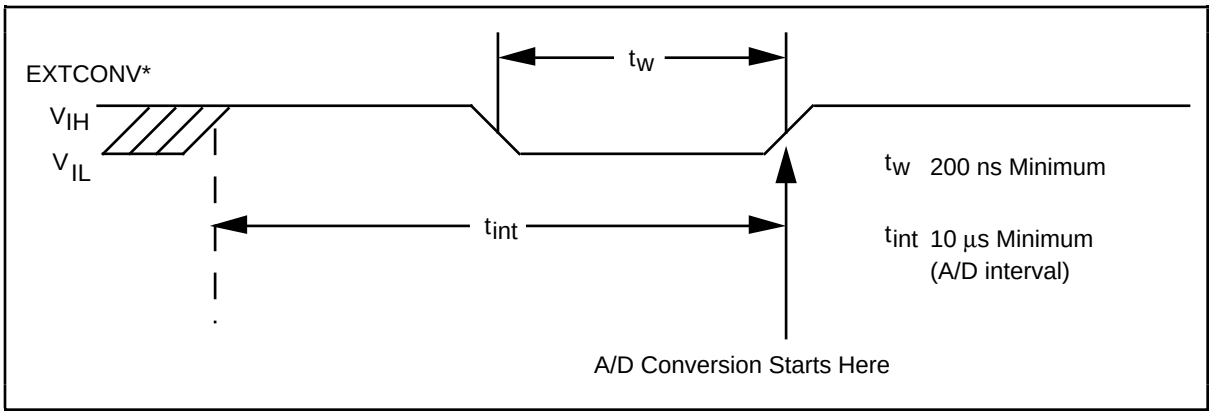


Figure 3-7. EXTCONV* Signal Timing

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 the GATE, CLK, and OUT signals for the three MSM82C54 counters, except CLK of 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 generation; event counting; and pulse-width, time-lapse, and frequency 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 counter 1, which can also be configured to use this clock.

The MSM82C54 counter/timer is described briefly in Chapter 4, *Theory of Operation.* For more detailed programming information, consult the *MSM82C54 Data Sheet* in the optional *DAQCard-700 Register-Level Programmer Manual*.

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 the counter on and off.

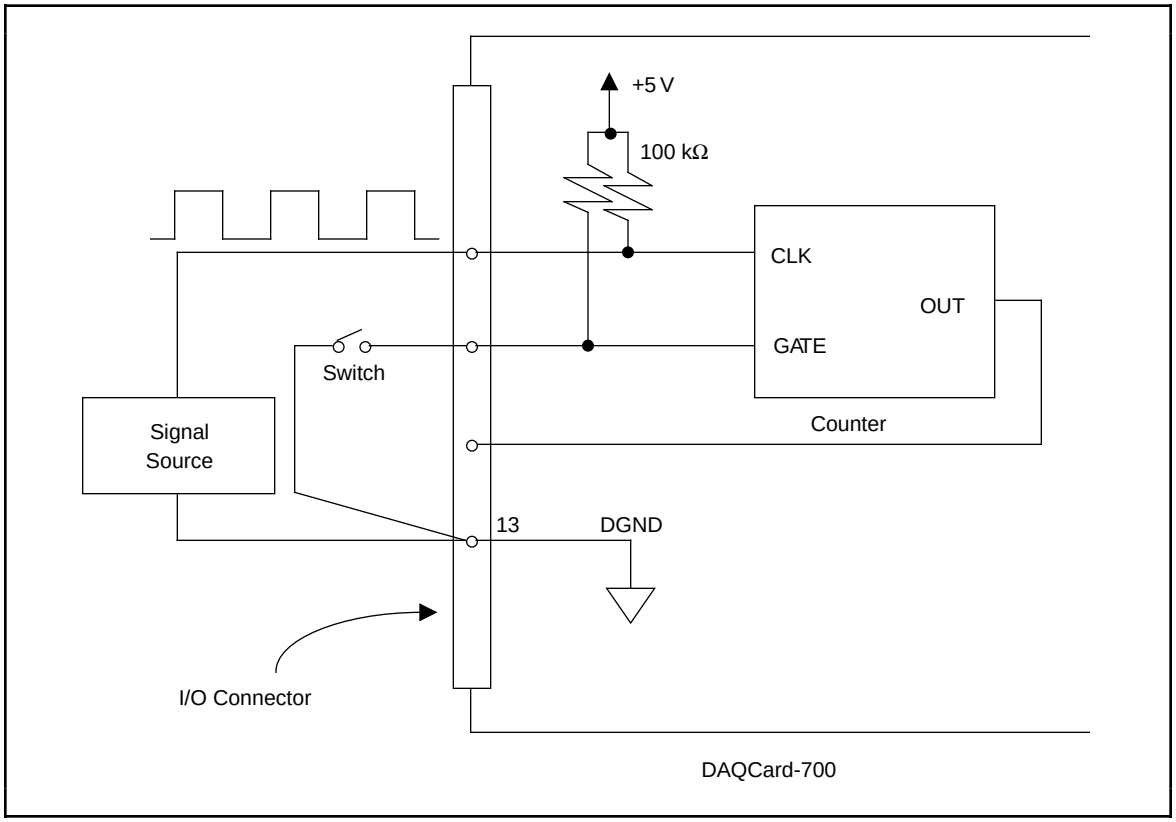


Figure 3-8. Event-Counting Application with External Switch Gating

Use level gating to measure pulse width. Apply the pulse to be measured to the counter GATE input. Load the counter with the known count and program the counter to count down while the signal at the GATE input is high. The pulse width equals the counter difference (loaded value minus read value) multiplied by the CLK period.

To measure time lapse, program a counter to be edge gated. Apply an edge to the counter GATE input to start the counter. Program the counter 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 CLK period.

To measure frequency, program a counter to be level gated and count the number of falling edges in a signal applied to a CLK input. The gate signal you applied to the counter GATE input is of a known duration. In this case, program the counter to count falling edges at the CLK 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 a second counter to generate the gate signal in this application.

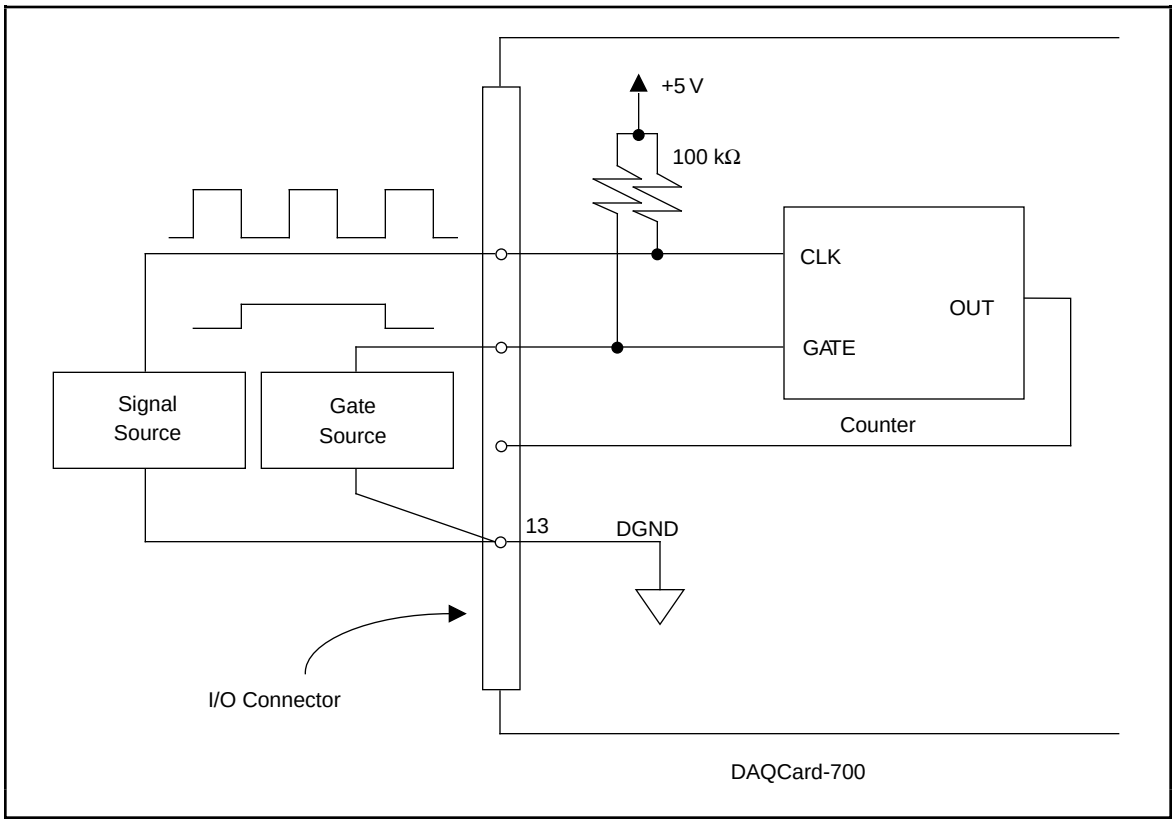
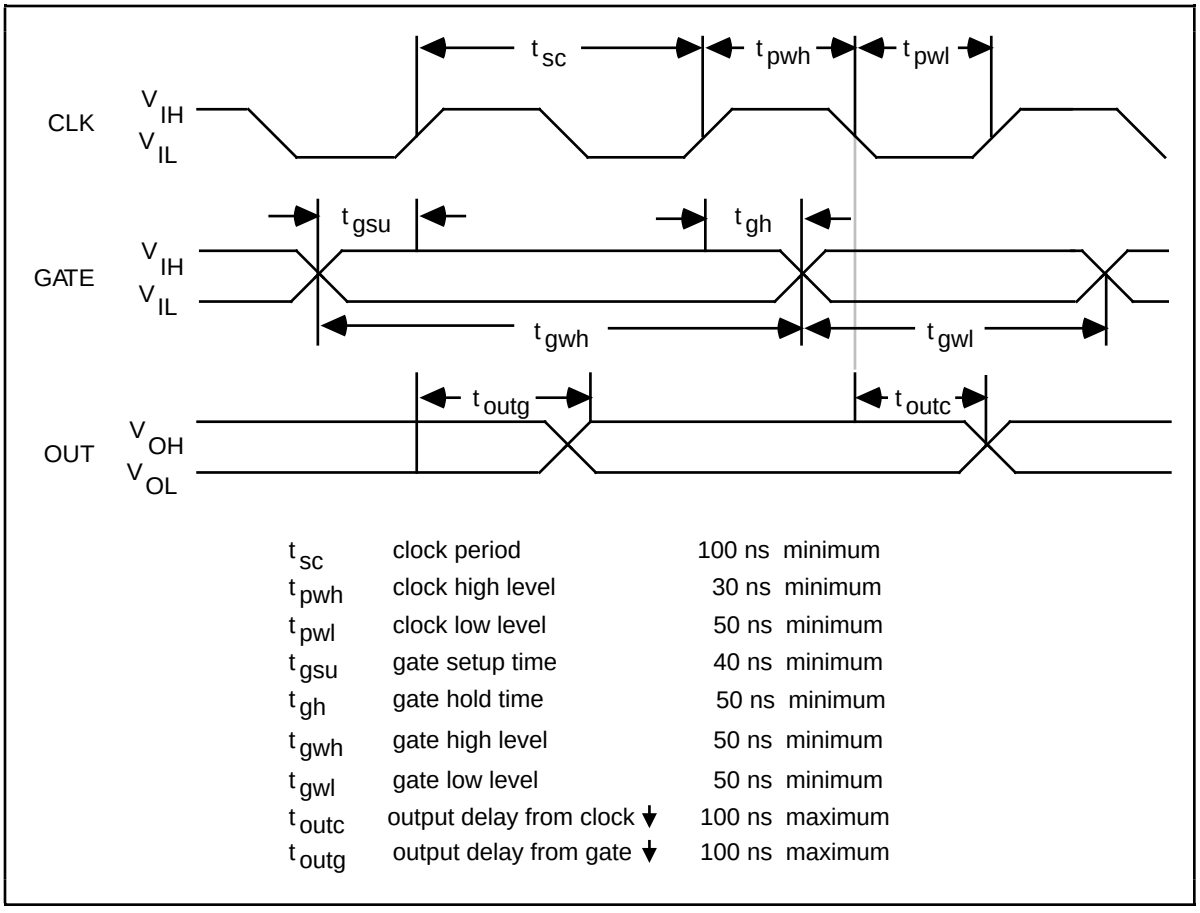


Figure 3-9. Frequency Measurement Application

The GATE, CLK, and OUT signals for counters 1 and 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 -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.

Cabling

National Instruments currently offers two different cables for use with the DAQCard-700, the PR-50-50F and the PR-50-50M. National Instruments also offers a cable termination accessory, the CB-50, for use with the DAQCard-700. This kit includes a terminated, 50-conductor, flat ribbon cable and a connector block. You can attach signal input and output wires to screw terminals on the connector block and therefore, to the DAQCard-700 I/O connector.

The CB-50 is useful for the initial prototyping of an application or in situations in which the DAQCard-700 interconnections are frequently changed. After you develop a final field wiring scheme, however, you may want to develop your own cable. This section contains information and guidelines for the design of custom cables.

The PR-50-50M is terminated in a 50-pin, male ribbon cable header connector. The mating connector for this cable is a 50-position, polarized, ribbon socket connector with strain relief. National Instruments uses a polarized (keyed) connector to prevent inadvertent upside-down connections to the DAQCard-700. Recommended manufacturer part numbers for this mating connector are as follows:

- Electronic Products Division/3M (part number 3425-7650)
- T&B/Ansley Corporation (part number 609-5041CE)

The PR-50-50F is terminated in a 50-pin, female ribbon cable socket connector. The mating connector for this cable is a 50-position, polarized, ribbon socket header. National Instruments uses a polarized (keyed) connector to prevent inadvertent upside-down connection to the DAQCard-700. Recommended manufacturer part numbers for this mating connector are as follows:

- Electronic Products Division/3M (part number 3433-6302)
- DuPont (part number 71912-150)

The following are the standard ribbon cables (50-conductor, 28 AWG, stranded) that work with these connectors:

- Electronic Products Division/3M (part number 3365/50)
- T&B/Ansley Corporation (part number 171-50)

The PCMCIA I/O cable connector, like the card connector attached to the card itself, is a unique custom-designed part. It is only available as part of the PR-50-50 cable assembly.

Chapter 4
Theory of Operation

This chapter includes an overview of the DAQCard-700 and explains the operation of each functional unit making up the DAQCard-700.

Functional Overview

The block diagram in Figure 4-1 shows a functional overview of the DAQCard-700.

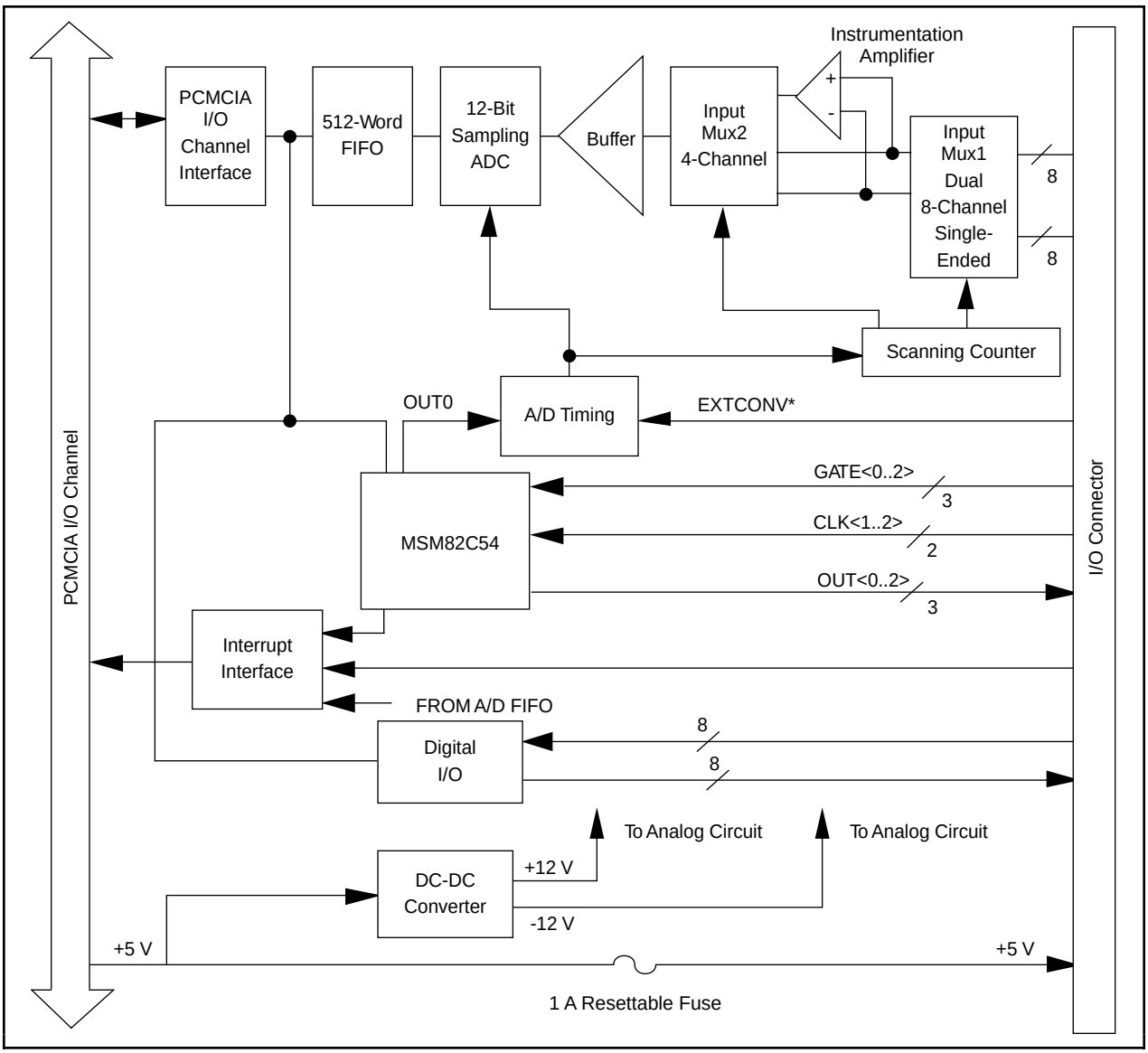


Figure 4-1. DAQCard-700 Block Diagram

The following are the major components making up the DAQCard-700:

- PCMCIA I/O channel interface circuitry
- Analog input circuitry
- Digital I/O circuitry
- Timing I/O circuitry

Data acquisition functions can be executed 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.

PCMCIA I/O Channel Interface Circuitry

The PCMCIA I/O channel interface circuitry consists of an address bus, a data bus, interrupt lines, and several control and support signals. The components making up the DAQCard-700 PCMCIA I/O channel interface circuitry are shown in Figure 4-2.

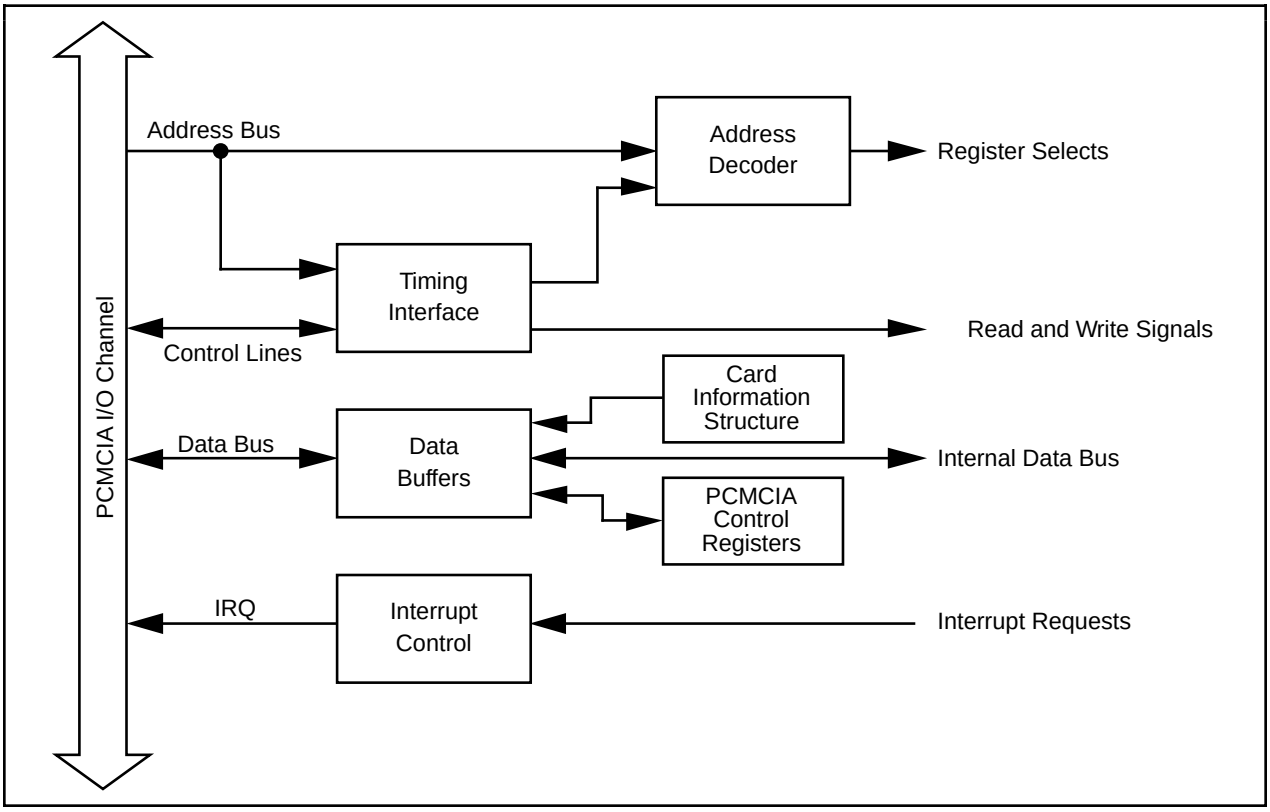


Figure 4-2. PCMCIA I/O Interface Circuitry Block Diagram

When you first insert the card, the system examines information stored in the DAQCard-700 Card Information Structure. This data is used to configure the card appropriately for the system in which it is used. When the system has assigned the card to a section of memory, it updates the PCMCIA control registers and initializes the card.

The rest of the circuitry consists of address decoders, data buffers, I/O channel interface timing control circuitry, and interrupt control circuitry. The circuitry monitor uses CE1* (controlled by the PCMCIA Card and Socket Services Software) as the card enable signal, and uses lines A0 through A4 plus timing signals to generate the onboard register select signals and read/write signals. The data buffers control the direction of data transfer on the bi-directional data lines based on whether the transfer is a read or write. The interrupt control circuitry routes any enabled interrupts to the IREQ* line, which is routed to an available interrupt request line by the system motherboard. The DAQCard-700 generates interrupts in three different situations:

- When a prescribed number of A/D conversions can be read from FIFO
- When an active low-level signal is detected on the EXTINT* line
- When a rising-edge signal is detected on counter 2 output

Each one of these interrupts is individually enabled and cleared. If you want more detailed information on externally generating interrupts, refer to the optional *DAQCard-700 Register-Level Programmer Manual*.

Analog Input and Data Acquisition Circuitry

The DAQCard-700 has 16 channels of analog input with 12-bit A/D conversion. Using the timing circuitry, the DAQCard-700 can also automatically time multiple A/D conversions. Figure 4-3 shows a block diagram of the analog input and data acquisition circuitry.

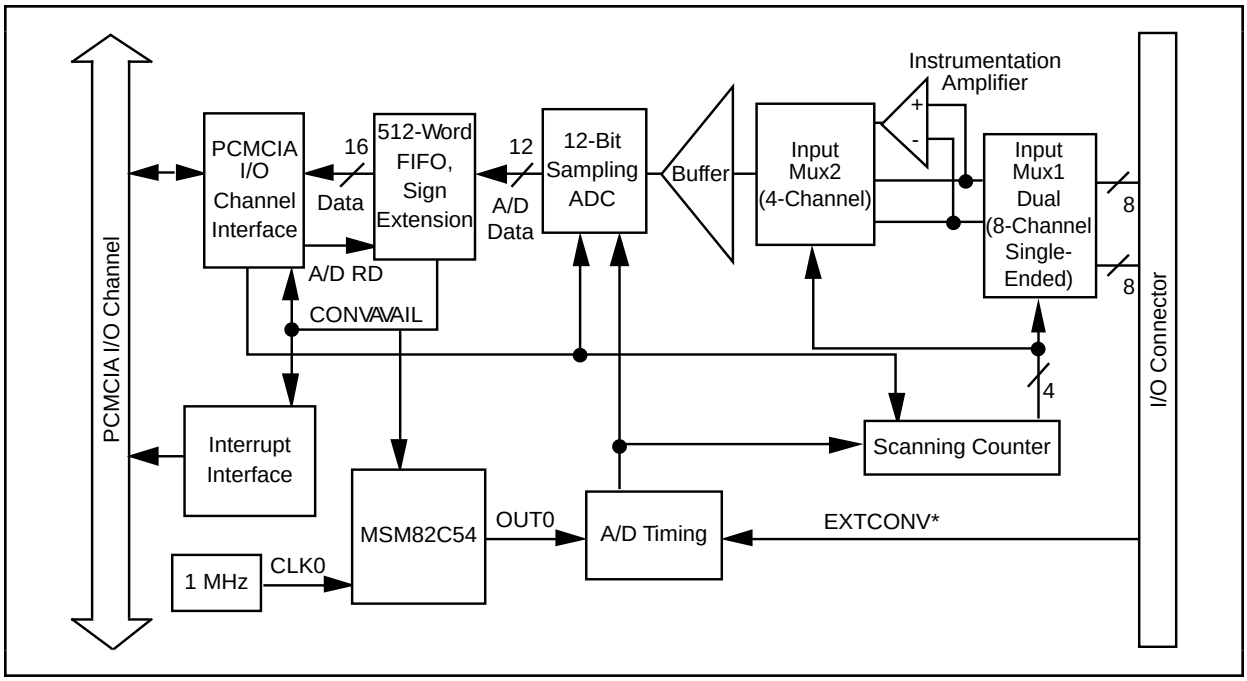


Figure 4-3. Analog Input and Data Acquisition Circuitry Block Diagram

Analog Input Circuitry

The analog input circuitry consists of an input multiplexer, a software-selectable gain stage, and a 12-bit sampling ADC. The 12-bit output is sign-extended to 16 bits, then stored in a 512-word-deep FIFO memory.

The input multiplexer stage is made up of two CMOS analog input multiplexers. In single-ended mode, the input multiplexers switch between 16 analog input channels (channels 0 through 15). In differential mode, one of the input multiplexers switches between eight differential pairs (channels 0 and 8, 1 and 9, and so on). With the input multiplexer stage, input overvoltage protection of ± 30 V is available, powered on or off.

The DAQCard-700 uses a 12-bit successive-approximation ADC. Software-selectable gains of 1, 0.5, and 0.25 for the input signal combined with the ADC fixed input range of ± 10 V yield three useful analog input signal ranges. These ranges are ±10 V, ± 5 V, and ± 2.5 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 -2,048 to 2,047. The output from the 12-bit ADC is always sign-extended to 16 bits by the card circuitry so that data values read from the FIFO are 16 bits wide.

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 DAQCard-700 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. Sources for these signals are supplied mainly by timers on the DAQCard-700 card. 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 DAQCard-700, 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 the counter is reprogrammed.

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

Multichannel (Scanned) Data Acquisition

Multichannel data acquisition is performed by enabling scanning during data acquisition. Multichannel scanning is controlled by a scan counter.

For scanning operations, the scan counter decrements from the highest numbered channel (selected by the user) through channel 0 and then repeats the sequence. For single-ended mode, therefore, any number of channels from 2 to 16 can be scanned. For differential mode, any number of channels from 2 to 8 can be scanned. Notice that the same analog input range is used for all channels in the scan sequence.

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 multiplexers and operational amplifier. After the input multiplexers are switched, the amplifier must be able to settle to the new input signal value to within 12-bit accuracy before an A/D conversion is performed, or 12-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 12-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 at various input ranges 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

The DAQCard-700 has 16 digital I/O lines that are TTL-compatible. Pins DIN<0..7> of the I/O connector are digital input lines, and pins DOUT<0..7> 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..7> lines. Writing the Digital Output Register drives the new value onto DOUT<0..7> lines. The external device may drive the EXTINT* signal to signal the readiness of data transfer. Figure 4-4 shows a diagram of this circuitry.

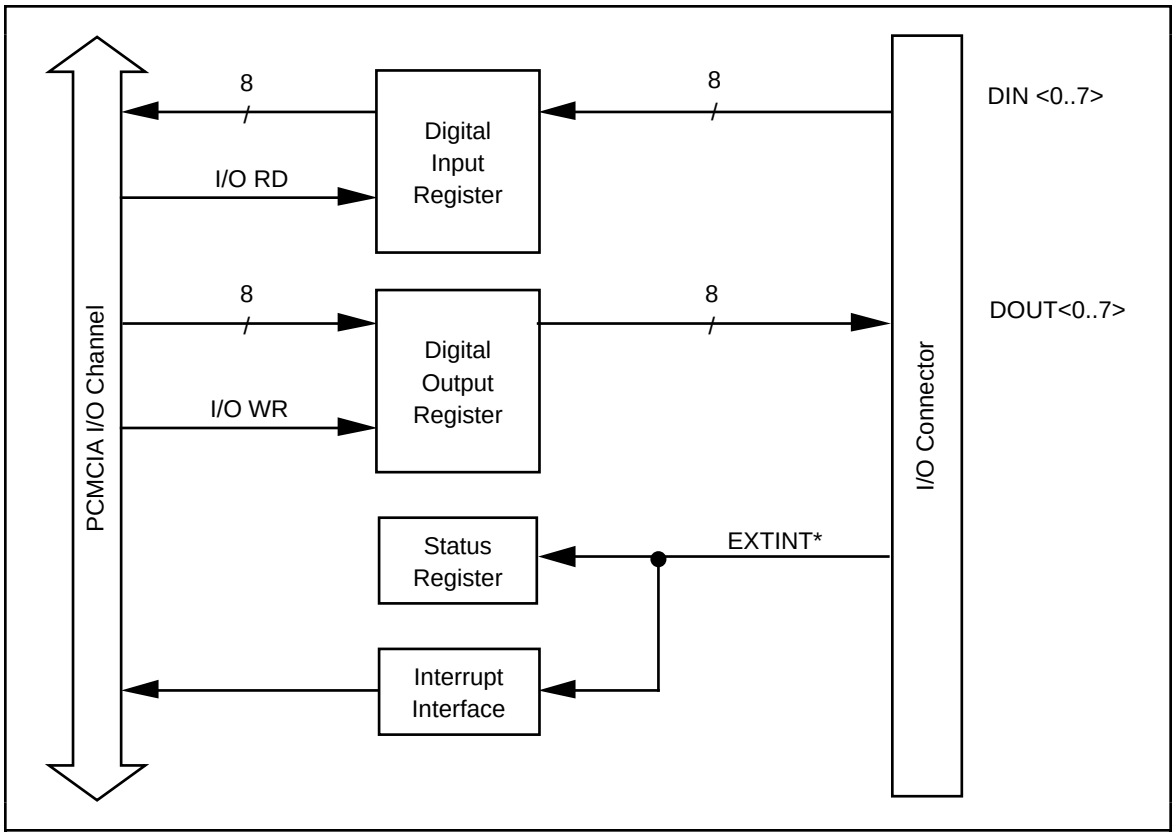


Figure 4-4. Digital I/O Circuitry Block Diagram

Timing I/O Circuitry

The DAQCard-700 uses an MSM82C54 counter/timer integrated circuit for data acquisition timing and for general-purpose timing I/O functions. Three counters of the MSM82C54 are available for general use, but one of them can be used internally for data acquisition timing. Figure 4-5 shows a block diagram of both groups of timing I/O circuitry.

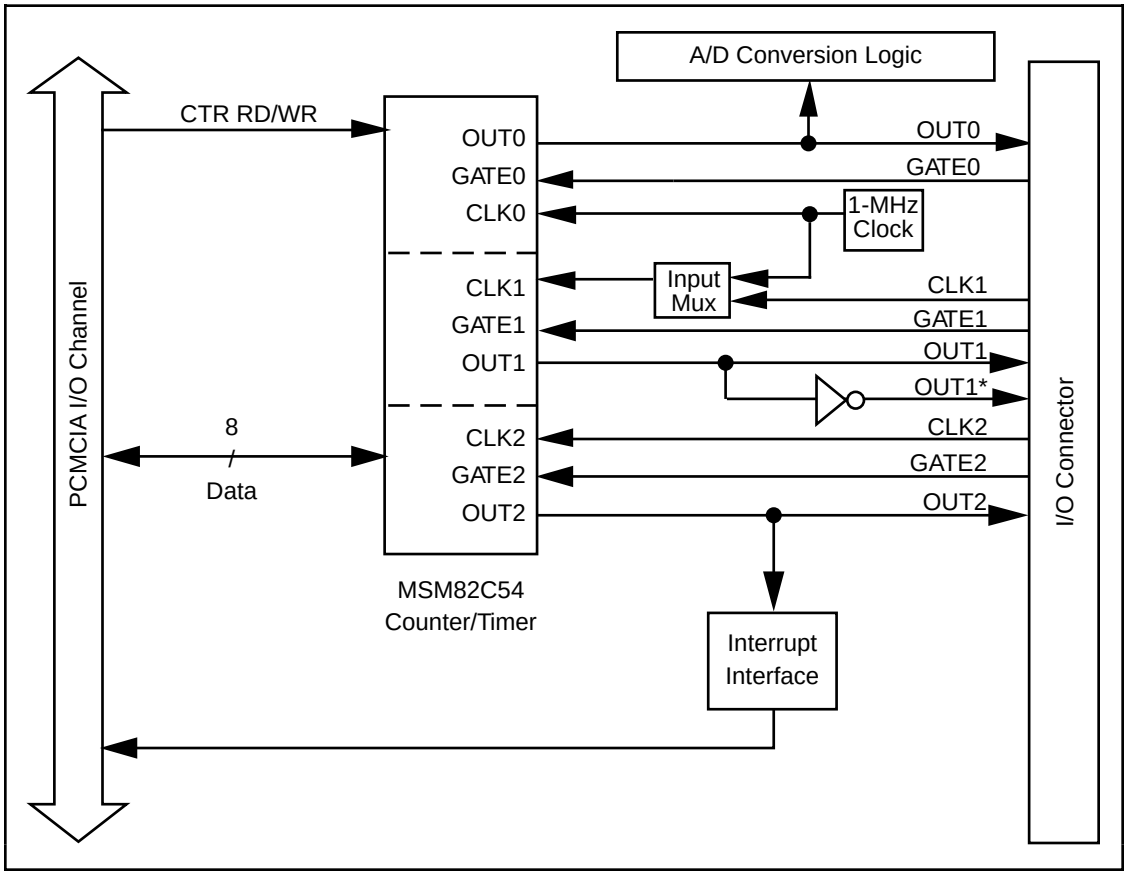


Figure 4-5. Timing I/O Circuitry Block Diagram

The MSM82C54 contains three independent 16-bit counter/timers and one 8-bit Mode Register. As shown in Figure 4-5, counter 0 can be 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-700 Register-Level Programmer Manual*.

The MSM82C54 for counter 0 uses a 1 MHz clock generated from the onboard oscillator. The timebases for counters 1 and 2 can be supplied externally through the 50-pin I/O connector. In addition, counter 1 can optionally use the same onboard 1 MHz clock that is used for data acquisition timing, which facilitates synchronous operations. The 16-bit counters in the MSM82C54 can be diagrammed as shown in Figure 4-6.

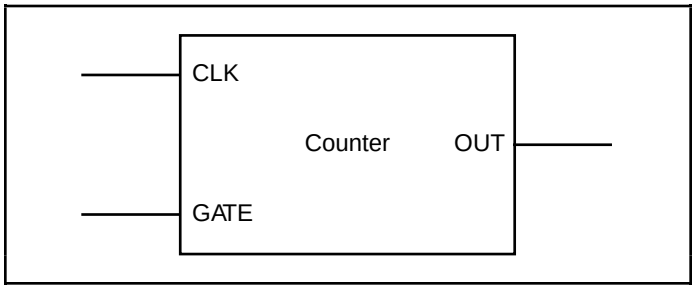


Figure 4-6. Counter Block Diagram

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 DAQCard-700. These specifications are typical at 25° C unless otherwise noted. The operating temperature range is 0° to 70° C.

Analog Input

Input Characteristics

Number of channels	16 single-ended or 8 differential software selectable
Type of ADC	Successive approximation
Resolution	12 bits, worst-case code range -2024 to +2023 (due to software calibration)
Max sampling rate	100 kS/s[1]
Input signal ranges	±10 V, ±5 V, ±2.5 V software selectable
Input coupling	DC
Max working voltage	
(signal + common mode)	Each input should remain within ±9.5 V of AIGND (in Diff mode)
Overvoltage protection	±30 V powered on, ± 30 V powered off
Inputs protected	ACH<0..15>
FIFO buffer size	512 samples
Data transfers	Interrupts, programmed I/O

Transfer Characteristics

Relative accuracy	±1 LSB typ, ±1.5 LSB max
DNL	±0.5 LSB typ, ±1 LSB max
No missing codes	12 bits, guaranteed
Offset error	
After software calibration	±1 LSB
Before software calibration	±2 LSB typ, ±9 LSB max
Gain error (relative to calibration reference)	
After software calibration	±0.036% max
Before software calibration	±0.07% of reading typ, ±0.4% max

Amplifier Characteristics

Input impedance	1 GΩ in parallel with 40 pF
CMRR (all input ranges)	-72 dB, DC to 60 Hz

[1] Please refer to the *Dynamic Characteristics* section for maximum *scan* rates with stated accuracy.

Dynamic Characteristics

Settling time ±0.024% accuracy
(±1 LSB) for full-scale step ..... 25 µs max at ±10 V, ±5 V
10 µs at ±2.5 V (RSE)
System noise ..... 0.5 LSB rms at ±5 V range

Stability

Recommended warm-up time ..... 15 min
Onboard calibration reference
Level ..... 3.0 V (±0.2 mV)
Temperature coefficient ..... 60 ppm/°C max

Digital I/O

Number of channels ..... 8 input and 8 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)	–	0.4 V
Output high voltage (I_{out} = 4 mA)	3.7 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
Base clocks available ..... 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

+5 VDC (±5%) ..... 100 mA in operational mode
70 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 Card type ..... Type II
I/O connector..... 50-pin male

Environment

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

Appendix B
Differences between the PC-LPM-16 and the DAQCard-700

This appendix contains a summary of differences between the PC-LPM-16 and the DAQCard-700 that may be relevant to you if you are a current PC-LPM-16 user. For a summary of programming differences, refer to the *DAQCard-700 Register-Level Programmer Manual*.

The DAQCard-700 is compatible with the PC-LPM-16. Software developed for the PC-LPM-16 using NI-DAQ or LabWindows routines, as well as LabVIEW virtual instruments (VIs) for the PC-LPM-16, typically work with the DAQCard-700 without modification. The following table summarizes the significant differences.

Functionality	PC-LPM-16	DAQCard-700
FIFO read	Two, 8-bit words	One, 16-bit word
FIFO buffer size	16 samples	512 samples
Maximum sample rate	50 kS/s	100 kS/s
Supply voltages at I/O connector	+5 V, +12 V, -12 V	+5 V
Maximum input voltage rating	± 45 V	± 30 V
ADC calibration	hardware calibration	software calibration
Timer chip	MSM82C53	MSM82C54*****
Maximum timer source frequency	8 MHz	10 MHz
Input modes	single ended	single ended, differential
Input ranges	±5 V, ±2.5 V, 0-10 V, 0-5 V, jumper selectable	±10 V, ±5 V, ±2.5 V, software selectable

***** The MSM82C54 timer used in the DAQCard-700 is compatible with the MSM82C53.

Appendix C
PC Card Questions and Answers

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.

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 utilities are `WDAQCONF` for Windows users or `DAQCONF` for DOS 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 DOS utility called DAQPOWER_EXE will switch all National Instruments PC Cards between normal mode and power-down mode. Power-up and power-down icons are also installed for Windows users to access either of these two power-management modes.

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's 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 either `DAQCONF.EXE` in DOS or `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-700.

- Normal Mode—This is the normal operating mode of the DAQCard-700 in which all the circuits are fully functional. This mode draws about 100 mA from the 5 V supply (about 500 mW).
- Power-Down Mode—In this mode, the digital circuitry is powered on and is functional. The analog input circuits are 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-700. This utility is also 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 70 mA from the 5 V supply (about 350 mW).

Table D-1 shows the effects of different power-management modes on the DAQCard-700 circuits.

Table D-1. DAQCard-700 Power-Management Modes

	Normal Mode	**Power-Down Mode**
Analog Input	Functional. Defaults to bipolar (±10 V) RSE. Protected to ±30 V. Impedance > 1 GΩ.	Nonfunctional. Draws negligible power. Protected to ±30 V. Impedance = 4.7 kΩ, which is the input protection resistance.
Calibration Circuitry	Functional. Offset and Gain values can be read from the card information structure.	Functional. Offset and Gain values can be read from the card information structure.
Digital I/O	Functional. Digital Output defaults to 0. Protected from -0.5 to 5.5 V.	Functional. Digital Output defaults to 0. 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.

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Appendix E
Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve technical problems you might have as well as a form you can use to comment on the product documentation. Filling out a copy of the *Technical Support Form* before contacting National Instruments helps us help you better and faster.

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Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 71 11
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 48301892	02 48301915
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
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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.

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Computer brand _____ Model _____ Processor _____

Operating system _____

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 will reproduce the problem _____

_____

_____

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DAQCard-700 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.

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- PCMCIA Software Version _____

Other Products

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- Microprocessor _____
- Clock Frequency _____
- Type of Video Board Installed _____
- Operating System _____
- Operating System Version _____
- 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 _____

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Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{12}

°	degrees
Ω	ohms
%	percent
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
BCD	binary-coded decimal
C	Celsius
CE	card enable signal
CLK	clock input signal
CMOS	complementary metallic oxide semiconductor
CMRR	common-mode rejection ratio
D/A	digital-to-analog
DAQ	data acquisition
DC	direct current
DGND	digital ground signal
DIFF	differential configuration
DIN	digital input signal
DMA	direct memory access
DNL	differential nonlinearity
DOUT	digital output signal
EISA	Extended Industry Standard Architecture
ESP	Engineering Software Package
EXTCONV	external control signal to trigger A/D conversions
EXTINT	external interrupt signal
F	farads
FIFO	first-in-first-out
GATE	gate input signal

hex	hexadecimal
Hz	hertz
in.	inches
I/O	input/output
ISA	Industry Standard Architecture
LED	light-emitting diode
LSB	least significant bit
MB	megabytes of memory
MSB	most significant bit
NC	not connected (signal)
NRSE	nonreferenced single ended
OUT	output signal
PCMCIA	Personal Computer Memory Card International Association
RAM	random-access memory
RMA	Return Material Authorization
rms	root mean square
S	samples
s	seconds
SCXI	Signal Conditioning eXtensions for Instrumentation
TTL	transistor-transistor logic
V	volts
VCC	positive supply voltage from the PCMCIA bus (usually +5V)
VDC	volts, direct current
VI	virtual instrument
V_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
V_{OH}	volts, output high
V_{OL}	volts, output low

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