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DAQMeter™ DAQCard™-4050 User Manual

Digital Multimeter Card for PCMCIA

February 1997 Edition
Part Number 321427A-01

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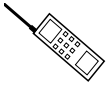
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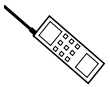
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About This Manual

This manual describes the electrical and mechanical aspects of the DAQMeter DAQCard-4050 and contains information concerning its operation and programming.

The DAQMeter DAQCard-4050 is a digital multimeter card for computers with Type II PCMCIA slots compliant with revision 2.1 of the PCMCIA specifications.

Organization of This Manual

The *DAQMeter DAQCard-4050 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the DAQMeter DAQCard-4050, lists what you need to get started, describes the optional software and optional equipment, and explains how to unpack your card.
- Chapter 2, *Installation and Configuration*, explains safety instructions and describes how to install and configure a DAQMeter DAQCard-4050.
- Chapter 3, *DMM Operation*, describes how to use your DAQMeter DAQCard-4050 and includes operation tips on taking voltage, resistance, diode, and current readings.
- Appendix A, *Specifications*, lists the specifications for the DAQMeter DAQCard-4050.
- Appendix B, *PC Card Questions and Answers*, contains a list of common questions and answers relating to PC Card (PCMCIA) operation.
- Appendix C, *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 where you can find the topic.

Conventions Used in This Manual

The following conventions are used in this manual:

bold — Bold text denotes the names of menus, menu items, parameters, dialog boxes, dialog box buttons or options, icons, windows, Windows 95 tabs, or LEDs.

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. This font also denotes text from which you supply the appropriate word or value, as in Windows 3.*x*.

`monospace` — Text in this font denotes text or characters that should literally enter 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, operations, variables, filenames and extensions, and for statements and comments taken from programs.

The *Glossary* lists abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms.

National Instruments Documentation

The *DAQMeter DAQCard-4050 User Manual* is one piece of the documentation set for your 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:

- 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—You might have several sets of software documentation, including LabVIEW, LabWindows®/CVI, VirtualBench, and NI-DAQ. After you have set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) 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 installation guides or 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.

Related Documentation

The following document contains information that you may find helpful:

- Your computer user manual

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 C, *Customer Communication*, at the end of this manual.

Introduction

Chapter 1

This chapter describes the DAQMeter DAQCard-4050, lists what you need to get started, describes the optional software and optional equipment, and explains how to unpack your card.

About the DAQMeter DAQCard-4050

Thank you for buying a National Instruments DAQMeter DAQCard-4050. The DAQCard-4050 is a digital multimeter card for computers equipped with Type II PCMCIA slots.

The DAQCard-4050 features accurate 5 1/2-digit DC voltage, true root mean square (RMS) AC voltage, ohm, and diode measurements in a PC Card format. You can use the card to make the same measurements you would with a standard benchtop digital multimeter. The DAQCard-4050 contains a 24-bit analog-to-digital converter (ADC) with digital filtering, which gives the card excellent resolution, accuracy, and noise rejection. Coupled with a CSM series current shunt module available from National Instruments, the DAQCard-4050 also effectively measures AC and DC current.

The DAQCard-4050's small size, weight, and low power consumption make this device ideal for use in portable computers, which makes remote measurements and data-logging practical. The DAQCard-4050 requires very little power when in operation, thus extending the life of your computer batteries.

A system based on the DAQCard-4050 offers the flexibility, performance, and size that makes it ideal for service, repair, and manufacturing as well as for use in industrial and laboratory environments. The DAQCard-4050, used in conjunction with your computer, is a versatile, cost-effective platform for high-resolution measurements.

Detailed specifications for the DAQCard-4050 are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your DAQCard-4050, you will need the following:

- ❑ DAQMeter DAQCard-4050
- ❑ *DAQMeter DAQCard-4050 User Manual*
- ❑ One of the following software packages and documentation:
  - NI-DAQ for PC compatibles
  - LabVIEW for PC compatibles
  - LabWindows/CVI
  - VirtualBench
  - DAQMeter DAQCard-4050 Instrument Driver
- ❑ DAQMeter DAQCard-4050 accessory cable
- ❑ One pair of test probes (red and black)
- ❑ Your computer

Software Programming Choices

There are several options to choose from to program and use your National Instruments DAQ hardware. You can use LabVIEW, LabWindows/CVI, VirtualBench, or the DAQMeter DAQCard-4050 Instrument Driver.

National Instruments 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. However, the DAQCard-4050 works only with the Easy I/O functions. For full functionality, you can use the DAQMeter DAQCard-4050 Instrument Driver with LabWindows/CVI.

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

VirtualBench

VirtualBench is a suite of VIs that allow you to use your data acquisition products just as you use stand-alone instruments, but you benefit from the processing, display, and storage capabilities of PCs. VirtualBench instruments load and save waveform data to disk in the same forms that can be used in popular spreadsheet programs and word processors. A report generation capability complements the raw data storage by adding timestamps, measurements, user name, and comments.

The complete VirtualBench suite contains VirtualBench-Scope, VirtualBench-DSA, VirtualBench-Function Generator, VirtualBench-FG, VirtualBench-Arb, VirtualBench-AODC, VirtualBench-DIO, VirtualBench-Board Calibrator, VirtualBench-DMM, and VirtualBench-Logger. Your DAQCard-4050 kits contains a copy of VirtualBench-DMM. VirtualBench-DMM is a turn-key application that allows you to make measurements as you would with a standard benchtop multimeter.

DAQMeter DAQCard-4050 Instrument Driver and NI-DAQ

The DAQMeter DAQCard-4050 Instrument Driver provides flexibility and programmability in a standard instrument driver format.

The instrument driver application programming interface (API) is designed after a classical, full-featured digital multimeter instrument driver. The instrument driver lets you avoid making low-level software calls. The DAQMeter DAQCard-4050 Instrument Driver works with

LabVIEW, LabWindows/CVI, or conventional programming languages such as C and Visual Basic.

While you can do most programming at the instrument driver level, you can use NI-DAQ for complete control over the card's functionality as well as for integrating your system into larger National Instruments data acquisition systems.

Whether you are using the DAQMeter DAQCard-4050 Instrument Driver, LabVIEW, or LabWindows/CVI, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

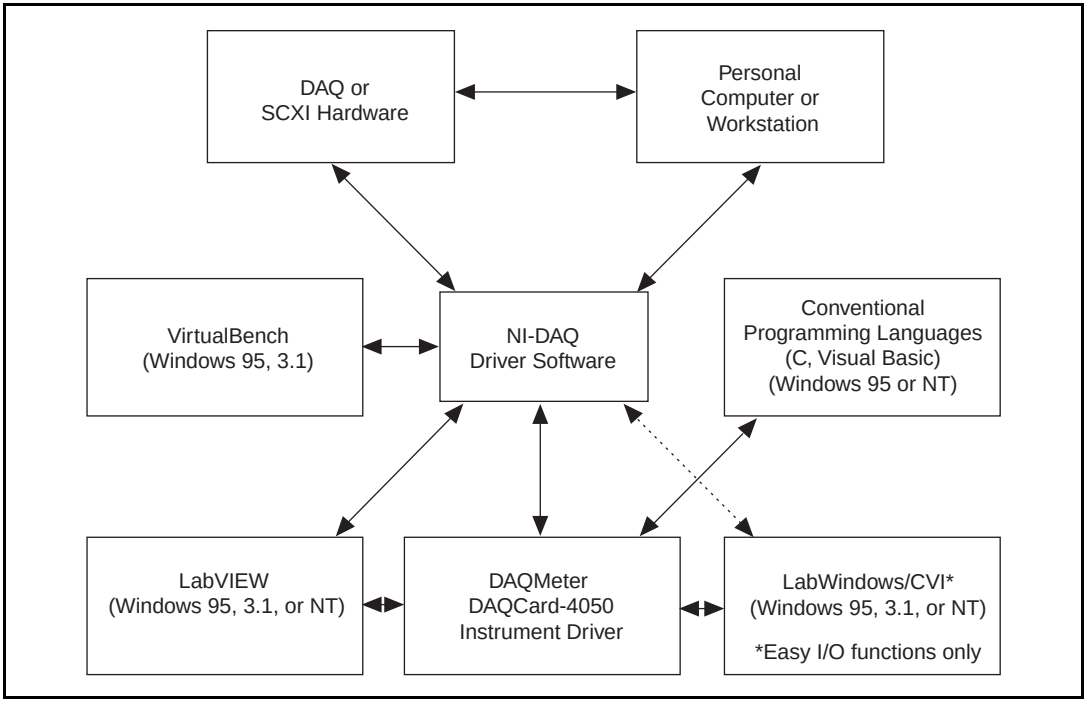


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

Optional Equipment

National Instruments offers a variety of products to use with your DAQCard-4050, including cables, connector blocks, and other accessories, as follows:

- Current shunt modules for making current measurements
- Additional test probes and accessories to simplify making measurements

For more specific information about these products, refer to your National Instruments catalogue or website, or call the office nearest you.

Unpacking

Your DAQCard-4050 is shipped in an antistatic vinyl box. When you are not using your DAQCard-4050, store it in this box. Because your DAQCard-4050 is enclosed in a fully shielded case, no additional electrostatic precautions are necessary. However, for your own safety and to protect your DAQCard-4050, never attempt to touch the connector pins.

Installation and Configuration

Chapter 2

This chapter explains safety instructions and describes how to install and configure a DAQMeter DAQCard-4050.

Safety Instructions

⚠ **Caution:** ***DO NOT OPERATE THIS DEVICE IN AN EXPLOSIVE ATMOSPHERE OR WHERE THERE MAY BE FLAMMABLE GASES OR FUMES.***

Equipment described in this document must be used in an Installation Category II environment per IEC 664. This category requires local level supply mains-connected installation.

To prevent safety hazards, the maximum voltage between either of the inputs and the ground of the computer should never exceed ±250 VDC or 250 V_{rms}.

DO NOT OPERATE DAMAGED EQUIPMENT. The safety protection features built into this device can become impaired if the device becomes damaged in any way. If the device is damaged, do not use until service-trained personnel can check its safety. If necessary, return the device to National Instruments for service and repair to ensure that its safety is not compromised.

Do not operate this equipment in a manner that contradicts the information specified in this document. Misuse of this equipment could result in a shock hazard.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the device. Return the device to National Instruments for service and repair to ensure that its safety is not compromised.

Connections that exceed any of the maximum signal ratings on the DAQCard-4050 can create a shock or fire hazard or can damage any or all of the devices connected to the DAQCard-4050. National Instruments is NOT LIABLE FOR ANY DAMAGES OR INJURIES resulting from incorrect signal connections.

Clean devices and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

Installation

☞ **Note:** ***You should install your driver software before installing your hardware. Refer to the DAQMeter DAQCard-4050*** *Read Me First* ***document for software installation instructions.***

There are two basic steps to installing a DAQCard-4050:

1. If you have Windows 3.1, you must have Card & Socket Services 2.0 (or a later version) software installed on your computer. If you have Windows 95, you do not need Card & Socket Services. These services are built into the Windows 95 operating system.
2. Insert the DAQCard-4050 and attach the DAQCard-4050 accessory cable.

   The DAQCard-4050 has two connectors—a 68-pin PCMCIA bus connector on one end and a 4-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 DAQCard-4050 and the DAQCard-4050 accessory cable are both keyed so that the cable can be inserted only one way.

   Be careful not to put strain on the DAQCard-4050 accessory cable when inserting it into and removing it from the DAQCard-4050. Always grasp the cable by the connector you are plugging or unplugging. *Never* pull directly on the DAQCard-4050 accessory cable to unplug it from the DAQCard-4050.

The DAQCard-4050 is now installed.

Cable and Probes

The DAQCard-4050 kit contains the DAQCard-4050 accessory cable, which connects the DAQCard-4050 to a pair of test probes with shrouded banana plugs. These probes are also included in the kit. Both the DAQCard-4050 accessory cable and the test probes meet international safety requirements including UL 3111 and IEC 1010-1 for the full ranges of applications supported by the DAQCard-4050. Before using any probes or accessories not supplied by National Instruments, ensure that they meet applicable safety requirements for the signal levels you may encounter.

To use the DAQCard-4050 accessory cable and probes with the DAQCard-4050, first connect the cable to the card as shown in Figure 2-1. The accessory cable connector is polarized so that it cannot be plugged in incorrectly.

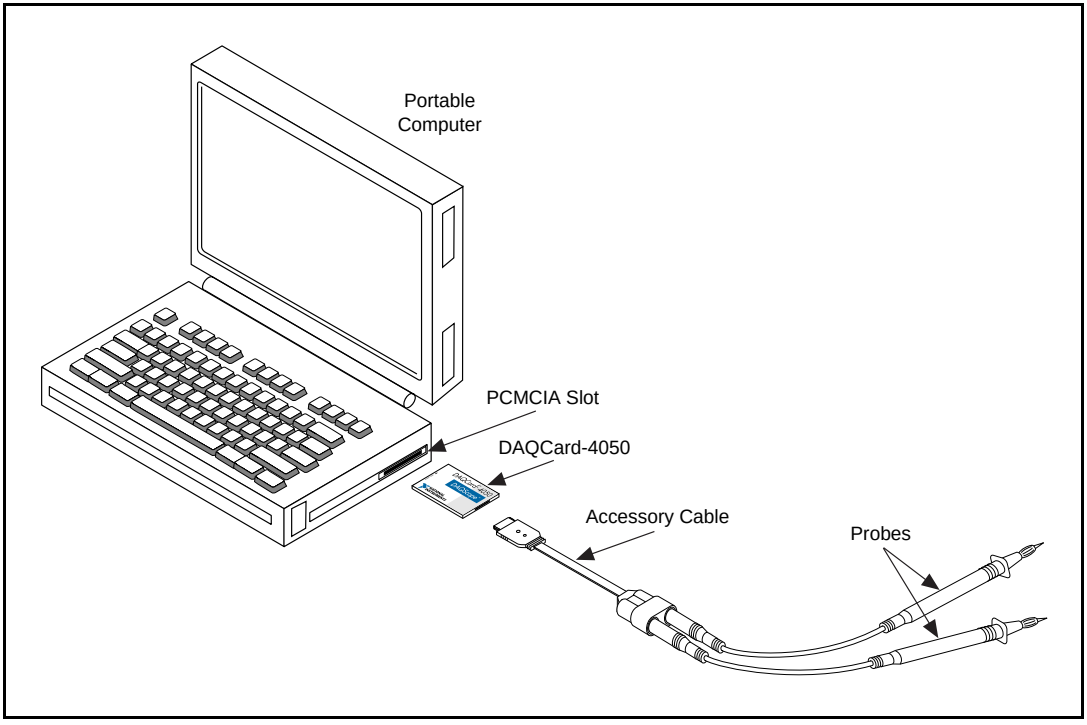


Figure 2-1. Installing the DAQCard-4050 and Cables

The test probes connect to the DAQCard-4050 accessory cable via shrouded banana jacks. The shrouds around the banana jacks prevent you from contacting potentially hazardous voltages connected to the test probes. You can also connect the cable to standard (unshrouded) banana jack probes or accessories; however, use unshrouded probes or accessories only when the voltages are less than 30 V_{rms} or 42 $V_{pk\text{-}to\text{-}pk}$.

You can use the measurement ends of the test probes in either of two ways, as shown in Figure 2-2. With the plastic covers over the ends, you can use the probes to directly probe the circuit or device to be tested. With the plastic tip covers removed, the test probes can accept standard banana jack accessories (such as spade lugs, alligator clips, or spring clips), which are available from National Instruments.

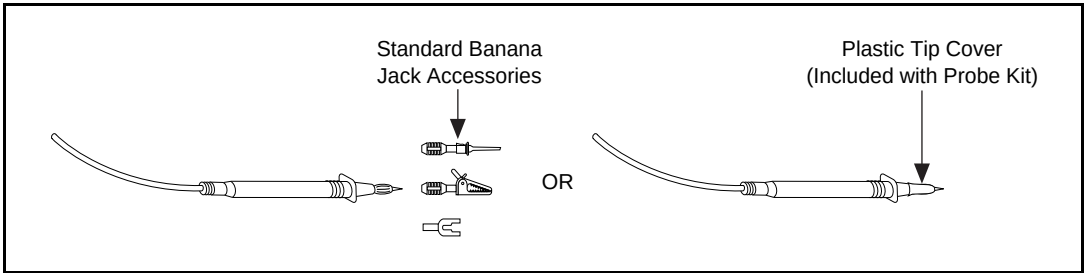


Figure 2-2. Probe Types

Hardware Configuration

The DAQCard-4050 is a fully software-configurable, Plug and Play device. Configuration information is stored in nonvolatile memory. The Plug and Play services query the device, read the information, and arbitrate resource allocation for items such as base address and interrupt level. After assigning these resources, the operating system enables the device for operation.

Chapter 3

DMM Operation

This chapter describes how to use your DAQMeter DAQCard-4050 and includes operation tips on taking voltage, resistance, diode, and current readings.

Warm-up

Measurements taken with the DAQCard-4050 change with temperature. These changes are called *thermal drifts* or *temperature coefficients*. The DAQCard-4050 temperature coefficient specifications are listed in the *Accuracy* sections in Appendix A, *Specifications*. PCMCIA slots, especially those in many notebook computers, can warm up a card significantly above the ambient temperature. Therefore, measurements made immediately after inserting the DAQCard-4050 or powering up the computer can differ significantly from measurements made after the DAQCard-4050 has fully warmed up.

To minimize the effects of thermal drift and ensure the specified accuracies, let the DAQCard-4050 warm up for at least 30 seconds after power-up before taking measurements. To maximize the relative accuracy of measurements, take all measurements after the DAQCard-4050 has had a chance to fully warm up in the computer, about 15 minutes.

Choosing a Reading Rate

In all measurement ranges and modes of the DAQCard-4050, there are three possible *reading rates* available for use—10, 50, and 60 readings/s. The reading rate is the rate at which a new measurement is taken. In addition to the measurement speed, the selection of the reading rate affects the filtering, and thus the noise level, of measurements.

In NI-DAQ, you set the reading rate directly. To optimize the measurement accuracy and minimize the noise level, you should choose a reading rate of 10 readings/s. If you are using the DAQCard-4050 Instrument Driver, select the resolution or the *aperture time*. Also called the number of *powerline cycles*, aperture time is the period of time over which a measurement is averaged. The setting of resolution and aperture time for the DAQCard-4050 Instrument Driver are discussed in the `ni_dmm.hlp` file on the instrument driver installation diskette.

In practice, much of the noise encountered in measurements occurs at harmonics (multiples) of the local power line frequency. The DAQCard-4050 filters out noise at harmonics of its reading rate. A reading rate of 50 readings/s filters noise at harmonics of 50 Hz, while a reading rate of 60 readings/s filters noise at harmonics of 60 Hz. Since both 50 Hz and 60 Hz are multiples of 10 Hz, choosing a sample rate of 10 reading per second will let the DAQCard-4050 filter out harmonics of both 50 Hz *and* 60 Hz.

Measuring Voltages

Connect the test probes to voltage signals as shown in Figure 3-1. For DC voltages, the HI (red) terminal is the positive terminal, and the LO (black) terminal is negative. For AC voltages, positive and negative terms are irrelevant.

The DAQCard-4050 is protected against damage from voltages within ±250 VDC or 250 V_{rms} in all ranges. You should never apply voltages above these levels to the inputs.

Caution: ***To prevent possible safety hazards, the maximum voltage between either of the inputs and the ground of the computer should never exceed ±250 VDC or 250 V_{rms}.***

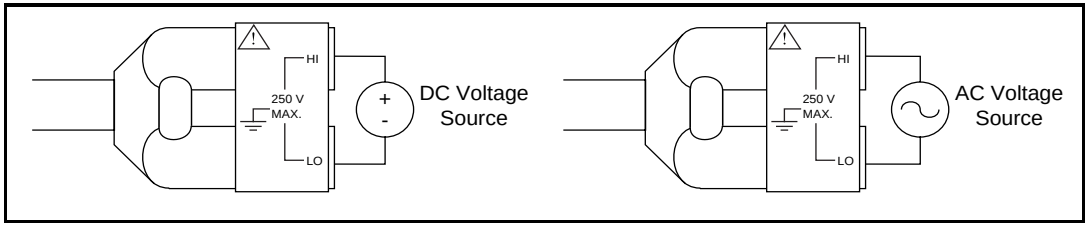


Figure 3-1. Connecting Probes for Voltage Measurement

DC Voltages

Input Ranges

The DAQCard-4050 has five input ranges available for measuring DC voltages. These ranges are ±20 mV, ±200 mV, ±2.0 V, ±25 V, and ±250 V. The DAQCard-4050 can measure DC voltages to its specified accuracy as long as the voltage is within the selected input range. The DAQCard-4050 can measure voltages outside of the input range (the *overrange)* with reduced accuracy. Table 3-1 shows the accuracy, typical overrange, and input impedance of each of the input ranges.

Table 3-1. DC Input Range Accuracy

Input Range	Percent of Reading Error	Percent of Range Error	Overrange	Input Impedance
±20 mV	0.005%	0.1%	±22 mV	> 1 GΩ
±200 mV	0.005%	0.025%	±220 mV	> 1 GΩ
±2.0 V	0.004%	0.01%	±2.2 V	> 1 GΩ
±25 V	0.006%	0.035%	±27 V	1 MΩ
±250 V	0.006%	0.007%	±250 V	1 MΩ

Accuracy Considerations

If you are making sensitive measurements (measurements that need a high degree of accuracy), you should consider problems associated with input impedance, AC noise effects, and thermal electromotive forces (thermal EMFs).

Input Impedance

The input impedance of the DAQCard-4050 can cause additional span errors by creating an attenuator with the impedance of the circuit under test. Although the high (>1 GΩ) impedance in the lower three input ranges is not likely to cause any significant errors, the lower impedance of the ±25 V and ±250 V ranges can *attenuate* (make smaller) the signal being measured.

Figure 3-2 illustrates the input impedance of the DAQCard-4050 and its effect on the measurement of a circuit under test. If the source impedance of the circuit being tested is known, you can correct for the attenuation caused by the DAQCard-4050 in software.

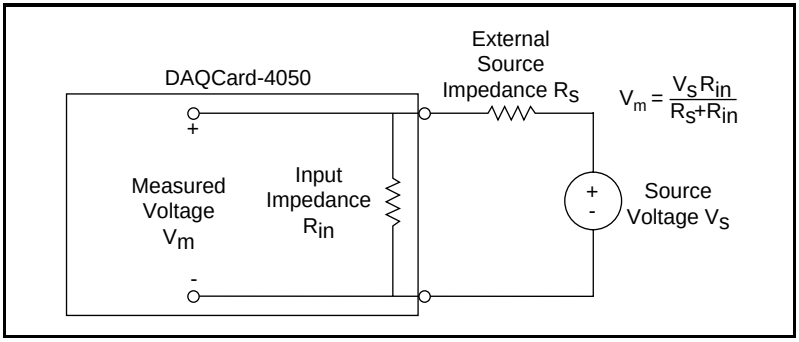


Figure 3-2. The Effect of Input Impedance on Signal Measurement

AC Noise Effects

The DAQCard-4050 filters out AC voltages while in the DC voltage measurement ranges. However, if the amplitudes of the AC voltages are large compared to the DC voltages, or if the peak value (AC+DC) of the measured voltage is outside the overrange limits, the DAQCard-4050 may exhibit additional errors. To minimize these errors, keep the circuit under test and the DAQCard-4050 away from strong AC magnetic sources and minimize the area of the loop formed by the test leads. Choosing the 10 readings/s reading rate will also help minimize noise from AC sources. If the peak value of the measured voltage is likely to exceed the selected input range, select the next high input range.

Thermal EMF

Thermal EMFs, or *thermoelectric potentials*, are voltages generated at the junctions of dissimilar metals and are functions of temperature. Thermal EMFs in a circuit under test can cause higher than expected offsets that change with variances in temperature. Occasionally these voltages are desirable, such as when the thermal EMF of a thermocouple is used to measure temperature changes. Other times these voltages are sources of error.

To minimize thermal EMFs, use copper leads to connect the signal to the DAQCard-4050. Also, try to maintain a constant temperature in the circuits under test, perhaps by using an enclosure to minimize air currents.

AC Voltages

True RMS Method

In the AC voltage ranges, the DAQCard-4050 measures the AC-coupled root mean square (RMS) value of a signal. The RMS value of a signal is a fundamental measurement of the magnitude of an AC signal. The RMS value of an AC signal can be defined mathematically as the square root of the average of the square of a signal. In practical terms, the RMS value of an AC signal is the DC value required to produce an equivalent amount of heat in the same load.

The DAQCard-4050 first AC-couples the measured signal to remove any DC components and then measures the RMS value of the AC component. This method lets you measure a small AC signal in the presence of a large DC offset.

Input Ranges

The DAQCard-4050 has five input ranges available for measuring AC voltages. These ranges are 20 mV_{rms}, 200 mV_{rms}, 2.0 V_{rms}, 25 V_{rms}, and 250 V_{rms}. The DAQCard-4050 can measure AC voltages to its specified accuracy as long as the voltage is at least 10% and no more than 100% of the selected input range. The DAQCard-4050 can measure voltages outside of the input range (the *overrange)* with reduced accuracy. Table 3-2 shows the accuracy and typical overrange of each of the input ranges. The accuracy is based on a 1 kHz sine wave of full-scale input range.

Table 3-2. AC Input Range Accuracy

Input Range	Percent of Reading Error	Percent of Range Error	Overrange
20 mV_{rms}	0.3%	0.1%	22 mV_{rms}
200 mV_{rms}	0.3%	0.1%	220 mV_{rms}
2.0 V_{rms}	0.4%	0.2%	2.2 V_{rms}
25 V_{rms}	0.4%	0.2%	27 V_{rms}
250 V_{rms}	0.3%	0.1%	250 V_{rms}

The impedance in each of these ranges is 1 MΩ. The DC component in any of these ranges can be as high as 250 VDC.

Accuracy Considerations

The AC voltage measurement accuracy is dependent on many factors, including the signal amplitude, frequency, and waveform shape (or *crest factor*). Each of these factors, and their effects on your measurements, are discussed below. In addition to these factors, consider the effects of the source impedance of your circuit. These effects are described in the *Input Impedance* section earlier in this chapter.

Frequency Response

The accuracy of the DAQCard-4050's AC voltage measurements is a function of the input signal's frequency. Table 3-3 shows the additional measurement errors associated with different frequency ranges. These errors are for full-scale, sine wave inputs.

Table 3-3. Input Frequency Error Rate

Input Frequency	Additional Error (Percent of Full Scale)
20–50 Hz	2%
50–100 Hz	1%
100 Hz–5 kHz	0%
5–10 kHz	1%
10–25 kHz	2%

Crest Factor

The DAQCard-4050 is calibrated to optimize the accuracy of measuring sine wave inputs. Because the DAQCard-4050 uses the RMS method of the AC measurements, it can also accurately measure inputs other than sine waves. The accuracy of these measurements depends on the *crest factor* of the input signal. The crest factor of a signal is the ratio of the peak value of the signal to the RMS value of the signal. For example, a symmetrical square wave has a crest factor of 1 and an undistorted sine wave has a crest factor of 1.4. The DAQCard-4050 can measure signals with crest factors of up to 10.

Table 3-4 shows the additional errors associated with different crest factors.

Table 3-4. Crest Factor Error Rate

Crest Factor	Additional Error (Percent of Full Scale)
1–2	no error
2–5	1%
5–10	2%

AC Voltage Offset

The AC measurements of the DAQCard-4050 are specified over the range of 10% to 100% of the full scale input range. Below 10% of the input range, errors due to the AC voltage offset become significant. This offset, unlike DC voltage offsets, cannot simply be subtracted from the readings or zeroed out because the offset gets converted in the RMS conversion. The relationship between the input voltage, AC offset voltage, and the measured voltage is as follows:

$$Vmeasured = \sqrt{(Vin)^2 + (Voffset)^2}$$

For example:

Range = 200 mV_{rms}
Input voltage = 100 mV_{rms}
AC offset voltage = 0.5 mV_{rms}

The measured voltage in this example would be $V_{measured}$ = 100.001 mV_{rms}; the 0.5 mV_{rms} offset contributes only 0.001 mV_{rms} of error and is, therefore, negligible. However, if the input voltage were only 10 mV_{rms}, the measured voltage would be 10.012 mV_{rms}. To minimize the errors due to the AC offset voltage, choose an input range that keeps the measured voltage between 10% and 100% of full scale.

Measuring Resistance

Signal Connections

Connect the test probes to resistors as shown in Figure 3-3. To accurately measure the value of a resistor, make sure the resistor is not connected to any other circuits. Erroneous or misleading readings may result if the resistor you are measuring is connected to external circuits that supply voltages or currents or to external circuits that change the effective resistance of that resistor.

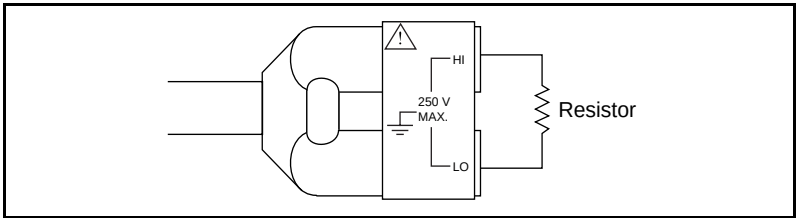


Figure 3-3. Connections for Resistance Measurement

The DAQCard-4050 is protected against damage from voltages within ±250 VDC or 250 V_{rms} in all ranges. However, voltages above these levels should never be applied to the inputs.

Caution: ***To prevent possible safety hazards, the maximum voltage between either of the inputs and the ground of the computer should never exceed ±250 VDC or 250 V_{rms}.***

Input Ranges

The DAQCard-4050 has five basic input ranges for resistance as well as an extended range. The basic ranges are 200 Ω, 2.0 kΩ, 20 kΩ, 200 kΩ, and 2 MΩ. With the extended range, measurements up to at least 20 MΩ are possible.

The DAQCard-4050 measures resistance by sending a current through the test resistor and measuring the voltage this current develops across the resistor. In the Extended Ohms range, the DAQCard-4050 adds a 1 MΩ resistor in parallel with the test resistor, and then calculates the value of the resistor being tested. Table 3-5 shows the accuracy of the readings in the different ranges.

Table 3-5. Resistance Input Range Accuracy

Input Range	Excitation Current	Percent of Reading Error	Percent of Range Error
200 Ω	100 µA	0.007%	0.2%
2.0 kΩ	100 µA	0.007%	0.03%
20 kΩ	100 µA	0.007%	0.02%
200 kΩ	1 µA	0.01%	0.03%
2 MΩ	1 µA	0.01%	0.06%
Extended Ohms	1 µA	See note below.	

Note: The accuracy of measurements made in the Extended Ohms range varies with the value being measured. For resistances up to 1 MΩ, the accuracy is 0.05%. For resistances between 1 MΩ and 20 MΩ, the accuracy is 0.1%. For larger resistances, the error is 0.4%.

Continuity Measurements

Many traditional multimeters can make continuity measurements, which test for the presence or absence of continuity between the two test probes. These measurements are simply resistance measurements, where the resistance between the two probes is measured and compared to a set value. You can perform continuity measurements on a circuit by setting the DAQCard-4050 to the 200 Ω range and comparing the measured value to some low resistance value (10 Ω is typical). If the measured value is less than 10 Ω, there is continuity between the test probes.

Testing Diodes

You can also use the DAQCard-4050 to measure the forward drop across a diode. You can measure voltage drops of up to 2 V.

Signal Connections

Connect the test probes to a diode as shown in Figure 3-4. To accurately measure the forward voltage of a diode, make sure that the diode is not connected to any other circuits. The DAQCard-4050 biases the diode with a current of 100 µA and measures the resulting voltage drop. Diode measurements are made with a fixed range of 2.0 V and an accuracy of 0.01%.

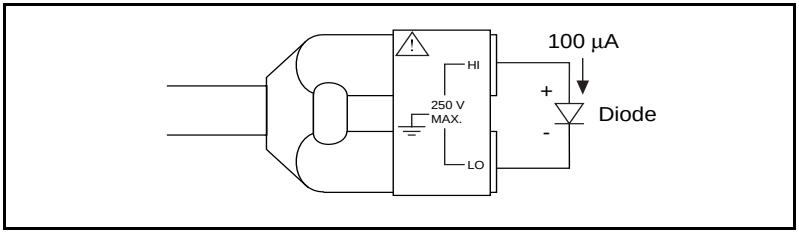


Figure 3-4. Connections for Diode Measurement

Measuring Current

You can use the DAQCard-4050 to measure current with an optional National Instruments CSM series current shunt module. These accessories are connected between the DAQCard-4050 cable and the test probes as shown in Figure 3-5.

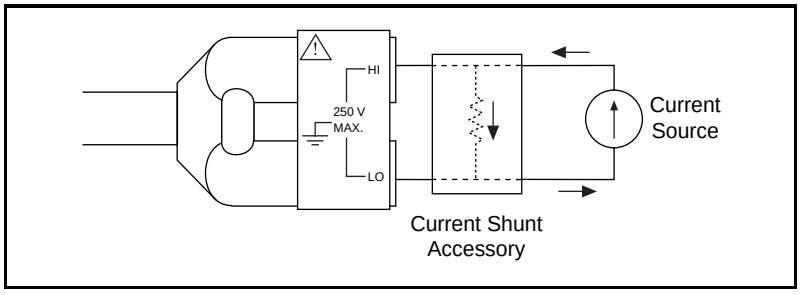


Figure 3-5. Connections for Current Measurement

Current shunt accessories contain a precision resistor that converts the current through the shunt into a voltage that the DAQCard-4050 can measure in voltage mode. You can calculate the value of the current flowing through the shunt by dividing the voltage reading by the value of the precision resistor.

Specifications

Appendix
A

This appendix lists the specifications of the DAQMeter DAQCard-4050. These specifications are typical at 25° C unless otherwise specified. The operating temperature range is 0° to 55° C.

DC Voltage

Accuracy

Range	Accuracy* ±(% of reading + % of range)	Temperature Coefficient ±(ppm of reading + ppm of range)/°C	Overrange
250.000 V	0.006% + 0.007%	9 ppm + 5 ppm	250.000 V
25.0000 V	0.006% + 0.035%	9 ppm + 30 ppm	27.0000 V
2.00000 V	0.004% + 0.01%	5 ppm + 5 ppm	2.20000 V
200.000 mV	0.005% + 0.025%	5 ppm + 20 ppm	220.000 mV
20.000 mV	0.005% + 0.1%	5 ppm + 175 ppm	22.0000 mV
* Percent of range includes the effects of nonlinearity, noise, and offset errors.			

Noise Rejection

NMRR (10 Hz filter setting, 50/60 Hz power line frequency ±5%).....80 dB

DC CMRR .....>130 dB

AC CMRR .....90 dB, 60 Hz

Input Characteristics

Input bias current.....100 pA, 1 nA max

Input resistance ..... >1 GΩ (2 V, 200 mV, 20 mV ranges); 1 MΩ (250 V, 25 V ranges)

Linearity 0.0015%

AC Voltage

Accuracy

Range	Accuracy ±(% of reading + % of range)	Temperature Coefficient ±(ppm of reading + ppm of range)/°C	Overrange
250.000 V	0.3% + 0.1%	60 ppm + 10 ppm	250.000 V
25.0000 V	0.4% + 0.2%	60 ppm + 80 ppm	27.0000 V
2.00000 V	0.4% + 0.2%	60 ppm + 100 ppm	2.20000 V
200.000 mV	0.3% + 0.1%	60 ppm + 50 ppm	220.000 mV
20.0000 mV	0.3% + 0.1%	60 ppm + 50 ppm	22.0000 mV

Additional AC Errors

Frequency dependent errors

Input Frequency	Additional Error (% of full scale)
20–50 Hz	2%
50–100 Hz	1%
100 Hz–5 kHz	0%
5–10 kHz	1%
10–25 kHz	2%

Crest factor errors

Crest Factor	Additional Error (% of full scale)
1–2	no error
2–5	1%
5–10	2%

Noise Rejection

AC CMRR .....>90 dB, 60 Hz

Input Characteristics

Bandwidth .....20 Hz–25 kHz

Input resistance .....1 MΩ

Resistance

Accuracy

Range	Accuracy ±(% of reading + % of range)	Temperature Coefficient ±(ppm of reading + ppm of range)/°C	Overrange	Test Current
200.000 Ω	0.007% + 0.2%	13 ppm + 175 ppm	200.000 Ω	100 µA
2.00000 kΩ	0.007% + 0.03%	13 ppm + 20 ppm	2.00000 kΩ	100 µA
20.0000 kΩ	0.007% + 0.02%	13 ppm + 3 ppm	20.0000 kΩ	100 µA
200.000 kΩ	0.01% + 0.03%	17 ppm + 20 ppm	200.000 kΩ	1 µA
2.00000 MΩ	0.01% + 0.06%	17 ppm + 3 ppm	2.00000 MΩ	1 µA
Extended Ohms	0.05% + 0.006%*	500 ppm + 30 ppm	n/a	1 µA

*The accuracy of measurements made in the Extended Ohms range varies with the value being measured. For resistances up to 1 MΩ, the accuracy is 0.05%. For resistances between 1 MΩ and 20 MΩ, the accuracy is 0.1%. For larger resistances, the error is 0.4%.

Diode

Accuracy

Range	Accuracy ±(% of reading + % of range)	Temperature Coefficient ±(ppm of reading + ppm of range)	Overrange	Test Current
2 V	0.01% + 0.01%	10 ppm + 10 ppm	2.2 V	100 µA

General Specifications

Settling time ..... Determined by source impedance, user cable construction, and input signal changes

Warm-up time ..... 30 seconds before making measurements; 15 minutes for measurements accurate within typical specifications

Bus interface type ..... Slave

Safety .....Designed in accordance with IEC 1010-1 and UL 3111 for measuring and testing equipment;
Installation Category II
Pollution Degree 2
Double Insulated
Indoor use

Altitude ..... For use up to 2,000 m

Maximum working voltage between either input terminal and earth ground ..... 250 V max

Power requirement .....+5 VDC
45 mA in operational mode
15 mA in power-down mode

Physical

PCMCIA card type .....Type II

I/O connector .....4-pin male

Environment

Operating temperature .....0° to 55° C

Storage temperature .....-55° to 150° C

Relative humidity .....5% to 90% noncondensing

PC Card Questions and Answers

Appendix
B

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 1 in the*** *Configuration* ***section.***

Configuration

1. What operating system should I use with my PC Cards?

The PC Card should work with Windows 3.*x*, Windows 95, and Windows NT. We strongly recommend that you use Windows 95.

2. 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 DAQCard. The appropriate utility is the NI-DAQ Configuration Utility for Windows 3.1 users.

3. 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 Services PCMCIA driver. Our NI-DAQ software will work with any Card and Socket Service driver that is compliant to version 2.0 or higher.

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 4 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.

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 DAQCard 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 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 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–D5FFF.

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

Identify usable I/O addresses by trial and error. Of the three resources used—memory, I/O, interrupts—I/O conflicts will be low. You can use the NI-DAQ Configuration Utility in Windows to diagnose I/O space conflicts. When you have configured the NI-DAQ Configuration Utility for a particular I/O space, save the configuration. If there is a conflict, the configuration utility will attempt to 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.

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Customer Communication

Appendix C

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 Fax-on-Demand 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
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: 01 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.

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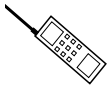
E-Mail Support (currently U.S. only)

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

`support@natinst.com`

Telephone and Fax 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
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Belgium	02 757 00 20	02 757 03 11
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 527 2321	09 502 2930
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 5734815	03 5734816
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	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
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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:_____

_____

_____

_____

_____

_____

DAQMeter DAQCard-4050 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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National Instruments Products

DAQ hardware _____

Interrupt level of hardware _____

DMA channels of hardware _____

Base I/O address of hardware _____

Programming choice _____

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

Documentation Comment Form

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Edition Date: February 1997

Part Number: 321427A-01

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

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

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Thank you for your help.

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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^{9}

Numbers/Symbols

%	percent
+	positive of, or plus
-	negative of, or minus
/	per
°	degree
±	plus or minus
Ω	ohm

A

A	amperes
AC	alternating current
AC coupled	the passing of a signal through a filter network that removes the DC component of the signal
A/D	analog-to-digital
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
ADC resolution	the resolution of the ADC, which is measured in bits. An ADC with 16 bits has a higher resolution, and thus a higher degree of accuracy, than a 12-bit ADC.
amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise
amplitude flatness	a measure of how close to constant the gain of a circuit remains over a range of frequencies
aperture time	the period of time over which a measurement is averaged; also called the number of powerline cycles
attenuate	to reduce in magnitude

B

b	bit—one binary digit, either 0 or 1
B	byte—eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data.
bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. Examples of PC buses are the PCI bus, AT bus, and EISA bus.

C

C	Celsius
CMRR	common-mode rejection ratio—a measure of an instrument's ability to reject interference from a common-mode signal, usually expressed in decibels (dB)
continuity	the measure of the ability of a material to conduct electricity
conversion device	device that transforms a signal from one form to another. For example, analog-to-digital converters (ADCs) for analog input, digital-to-analog converters (DACs) for analog output, digital input or output ports, and counter/timers are conversion devices.
conversion time	the time required, in an analog input or output system, from the moment a channel is interrogated (such as with a read instruction) to the moment that accurate data is available
coupling	the manner in which a signal is connected from one location to another
CPU	central processing unit
crest factor	the ratio of the peak value of the signal to the RMS value of the signal
CSM	current shunt module

D

DAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB=20log10 V1/V2, for signals in volts
DC	direct current

default setting	a default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*. For example, the default input for a parameter may be *do not change current setting*, and the default setting may be *no AMUX-64T boards*. If you do change the value of such a parameter, the new value becomes the new setting. You can set default settings for some parameters in the configuration utility or manually using switches located on the device.
device	a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PCMCIA cards, and devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices. SCXI modules are distinct from devices, with the exception of the SCXI-1200, which is a hybrid.
differential input	an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured
DMM	digital multimeter
DNL	differential nonlinearity—a measure in LSB of the worst-case deviation of code widths from their ideal value of 1 LSB
double insulated	a device that contains the necessary insulating structures to provide electric shock protection without the requirement of a safety ground connection
DOS	disk operating system
drivers	software that controls a specific hardware device such as a DAQ board or a GPIB interface board

E

EEPROM	electrically erasable programmable read-only memory–ROM that can be erased with an electrical signal and reprogrammed
EISA	extended industry standard architecture

F

filtering	a type of signal conditioning that allows you to filter unwanted signals from the signal you are trying to measure
ft	feet

G

gain	the factor by which a signal is amplified, sometimes expressed in decibels

H

harmonics	multiples of the fundamental frequency of a signal
half-power bandwidth	the frequency range over which a circuit maintains a level of at least -3 dB with respect to the maximum level
hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
hex	hexadecimal
Hz	hertz—per second, as in cycles per second or samples per second

I

IBM	International Business Machines
IC	integrated circuit
ID	identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
in.	inches
input bias current	the current that flows into the inputs of a circuit

input impedance	the measured resistance and capacitance between the input terminals of a circuit
Installation Category (Overvoltage Category)	classification system for expected transients on electrical supply installations
instrument driver	a set of high-level software functions that controls a specific GPIB, VXI, or RS-232 programmable instrument or a specific plug-in DAQ board. Instrument drivers are available in several forms, ranging from a function callable language to a virtual instrument (VI) in LabVIEW.
interrupt	a computer signal indicating that the CPU should suspend its current task to service a designated activity
interrupt level	the relative priority at which a device can interrupt
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
IRQ	interrupt request
ISA	industry standard architecture
isolation	a type of signal conditioning in which you isolate the transducer signals from the computer for safety purposes. This protects you and your computer from large voltage spikes and makes sure the measurements from the DAQ device are not affected by differences in ground potentials.
isolation voltage	the voltage that an isolated circuit can normally withstand, usually specified from input to input and/or from any input to the amplifier output, or to the computer bus

K

k	kilo—the standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters
K	kilo—the prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory

L

LabVIEW	laboratory virtual instrument engineering workbench

M

m	meters
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory
MB	megabytes of memory

N

NBS	National Bureau of Standards
NI-DAQ	National Instruments driver software for DAQ hardware
NMRR	normal mode rejection ratio—a measure of an instrument's ability to reject a signal applied directly to the differential inputs of the instrument
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.

O

overrange	a segment of the input range of an instrument outside of the normal measuring range. Measurements can still be made, usually with a degradation in specifications

P

PC Card	a credit-card-sized expansion card that fits in a PCMCIA slot often referred to as a PCMCIA card
PCMCIA	an expansion bus architecture that has found widespread acceptance as a de facto standard in notebook-size computers. It originated as a specification for add-on memory cards written by the Personal Computer Memory Card International Association.
peak value	the absolute maximum or minimum amplitude of a signal (AC + DC)
pk-to-pk	peak to peak value—the absolute maximum amplitude of a signal subtracted from the absolute minimum value
Plug and Play devices	devices that do not require dip switches or jumpers to configure resources on the devices—also called switchless devices
port	(1) a communications connection on a computer or a remote controller (2) a digital port, consisting of four or eight lines of digital input and/or output
ppm	parts per million

R

RAM	random-access memory
range error	an error in accuracy that is determined by the input range that is selected. The range error is independent of the value of the signal being measured.
reading error	an error in accuracy that is determined by the input range, as well as the value being measured.
reading rate	the rate at which a new measurement is taken. In addition to the measurement speed, the selection of the reading rate affects the filtering, and thus the noise level, of measurements.
resolution	the smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits or in digits. The number of bits in a system is roughly equal to 3.3 times the number of digits.

rms	root mean square—a measure of signal amplitude; the square root of the average value of the square of the instantaneous signal amplitude
ROM	read-only memory

S

s	seconds
S	samples
settling time	the amount of time required for a voltage to reach its final value within specified limits
SNR	signal-to-noise ratio–the ratio of the overall rms signal level to the rms noise level, expressed in dB
S/s	samples per second—used to express the rate at which a DAQ board samples an analog signal
system noise	a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

T

temperature coefficient	the percentage that a measurement will vary according to temperature. *See also* thermal drift.
thermal drift	measurements that changes as the temperature varies
thermoelectric potentials	*See* thermal EMFs.
thermal EMFs	thermal electromotive forces—voltages generated at the junctions of dissimilar metals that are functions of temperature. Also called thermoelectric potentials.
transfer rate	the rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations; the maximum rate at which the hardware can operate

U

UL	Underwriters Laboratory
update	the output equivalent of a scan. One or more analog or digital output samples. Typically, the number of output samples in an update is equal to the number of channels in the output group. For example, one pulse from the update clock produces one update which sends one new sample to every analog output channel in the group.
update rate	the number of output updates per second

V

V	volts
VDC	volts direct current
VI	virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
V_{rms}	volts, root mean square value

W

waveform shape	the shape the magnitude of a signal creates over time
working voltage	the highest voltage that should be applied to a product in normal use, normally well under the breakdown voltage for safety margin.

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