SC-2042-RTD
User Manual

Eight-Channel RTD Signal Conditioning Accessory

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About This Manual

This manual describes the electrical and mechanical aspects of the SC-2042-RTD and contains information concerning its configuration and operation. The SC-2042-RTD is an eight-channel resistance temperature device (RTD) signal conditioning accessory for National Instruments DAQ boards. The SC-2042-RTD provides eight channels of current excitation, RTD input signal interfacing to National Instruments DAQ boards via a 50-pin I/O connector, and breakout screw terminals for all pins on the DAQ board I/O connector.

Organization of This Manual

The *SC-2042-RTD User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the SC-2042-RTD, lists what you need to get started with your SC-2042-RTD, describes the optional software and optional equipment, and explains how to unpack your SC-2042-RTD.
- Chapter 2, *Configuration and Installation*, describes the installation and configuration of your SC-2042-RTD. This chapter also explains how to connect the SC-2042-RTD to the DAQ board and configure the DAQ board for use with the SC-2042-RTD.
- Chapter 3, *Signal Connections*, describes the signal connections to the SC-2042-RTD board.
- Chapter 4, *Theory of Operation*, contains a functional overview of the SC-2042-RTD board and explains the operation of each functional unit making up the SC-2042-RTD.
- Chapter 5, *Calibration Procedures*, discusses the calibration procedures for the SC-2042-RTD board.
- Appendix A, *Specifications*, lists the specifications for the SC-2042-RTD.
- Appendix B, *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 abbreviations, acronyms, metric prefixes, mnemonics, and symbols.
- The *Index* contains an alphabetical list of key terms and topics used in this manual, including the page where you can find each one.

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.
Lab/1200	Lab/1200 refers to the National Instruments Lab-PC+, DAQPad-1200, and DAQCard-1200 products unless otherwise noted.
MIO	MIO refers to the National Instruments AT-MIO-16/64 and NB-MIO-16/64 (except the -16H and -DH) DAQ boards unless otherwise noted.
MIO E	MIO E refers to the National Instruments MIO E Series of DAQ boards unless otherwise noted.
`monospace`	Text in this font denotes text or characters that are to be literally input from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, variables, filenames, and extensions, and for statements and comments taken from program code.

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

National Instruments Documentation

The *SC-2042-RTD User Manual* is one piece of the documentation set for your 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 manuals—Examples of software manuals you might have are the LabVIEW and LabWindows® /CVI manual sets and the NI-DAQ manuals. After you set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) manuals or the NI-DAQ manuals to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software manuals before you configure your hardware.
- Accessory manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory board user manuals. They explain how to physically connect the relevant pieces of the system together. Consult these guides when you are making your connections.

Related Documentation

The following document contains information that you may find helpful as you read this manual:

- Your DAQ hardware 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 B, *Customer Communication*, at the end of this manual.

Chapter 1
Introduction

This chapter describes the SC-2042-RTD, lists what you need to get started with your SC-2042-RTD, describes the optional software and optional equipment, and explains how to unpack your SC-2042-RTD.

About the SC-2042-RTD

The SC-2042-RTD is an eight-channel signal conditioning board that interfaces RTD signal inputs directly to National Instruments DAQ plug-in boards. Each channel consists of an independent 1 mA current excitation source and screw terminal connections to accommodate four-wire RTD measurements. Output current excitation leads and input signal leads are attached at the screw terminals. Each current excitation source can drive loads up to 8.5 kΩ, which covers the full temperature range of common RTDs, including 10 Ω, 100 Ω, and 2 kΩ devices. The RTD signal inputs are routed to the eight differential inputs of the MIO board or the four differential inputs of the Lab-PC+, DAQPad-1200, or DAQCard-1200 boards.

Note: ***The NB-MIO-16H and AT-MIO-16H series boards have a maximum gain of 8 and are not intended for interfacing to low-level signals. Therefore, you should not use these boards with the SC-2042-RTD.***

The SC-2042-RTD has additional screw terminals for convenient signal termination of every I/O line on the DAQ board interfacing connector.

The SC-2042-RTD is a circuitboard assembly that is placed on a workbench or mounted in a 19-in. rack. The SC-2042-RTD draws power from the DAQ board via the 50-pin interfacing connector. A green LED indicates when the board is powered on.

What You Need to Get Started

To set up and use your SC-2042-RTD, you will need the following components:

- ❑ SC-2042-RTD board
- ❑ *SC-2042-RTD User Manual*
- ❑ SC-2042-RTD screw terminal sticker labels
- ❑ One of the following software packages and documentation:
  - LabVIEW for Macintosh
  - LabVIEW for Windows
  - LabWindows/CVI for Windows
  - NI-DAQ for Macintosh
  - NI-DAQ for PC compatibles

❑ One of the following:
- 1.0, 2.0, 5.0, or 10.0 m SH6850 cable or 1 m R6850 cable assembly kit (MIO E Series DAQ board)
- 0.2, 0.5, 1.0, or 2.0 m NB-1 cable (MIO Series, Lab-PC+, or DAQPad-1200 board)
- 0.5, 1.0, or 2.0 m PR50-50F cable (DAQCard-1200)

Detailed specifications of the SC-2042-RTD are in Appendix A, *Specifications*.

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 LabWindows/CVI. 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.

NI-DAQ also internally addresses many of the complex issues between the computer and the DAQ hardware such as programming the PC interrupt 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.

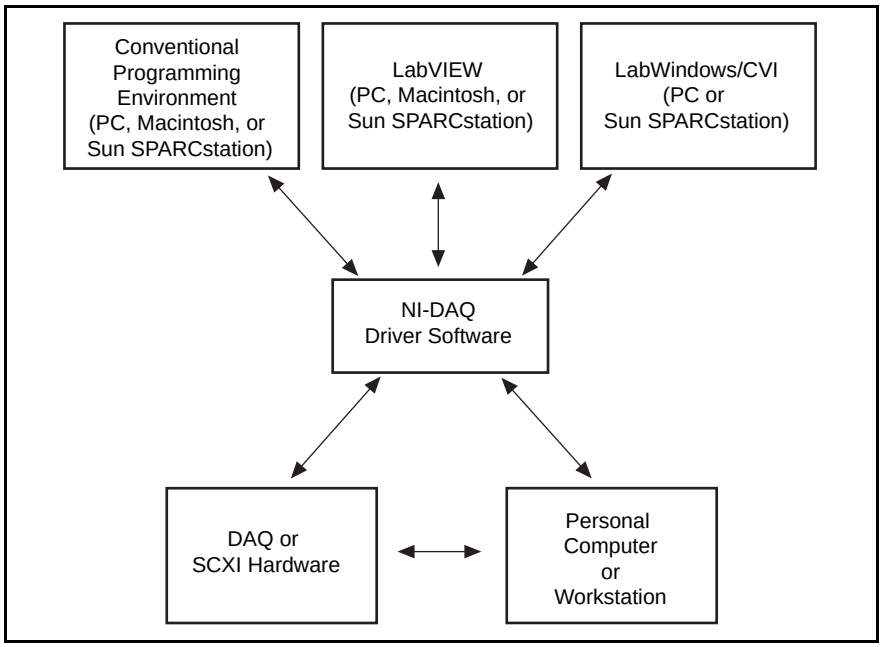


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

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 easier than and as flexible as register-level programming and can save you weeks of development time.

Optional Equipment

You can use the following National Instruments products with your SC-2042-RTD:

- Single or double height rack-mount kit with acrylic plastic cover
- Single or double height rack-mount kit with metal wraparound cover

For more information about optional equipment available from National Instruments, refer to your National Instruments catalog or call the office nearest you.

Unpacking

Your SC-2042-RTD board is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, take the following precautions:

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

Chapter 2
Installation and Configuration

This chapter describes the installation and configuration of your SC-2042-RTD. This chapter also explains how to connect the SC-2042-RTD to the DAQ board and configure the DAQ board for use with the SC-2042-RTD.

Installation

Note: ***You must power off your computer before installing or making any connection to the SC-2042-RTD.***

The SC-2042-RTD includes two 50-pin cable connectors for signal connection to a DAQ board. Table 2-1 lists the required cables and connectors to use with each DAQ board options.

Table 2-1. Installation and Cabling Options for the SC-2042-RTD

DAQ Board	Required Cabling	SC-2042-RTD 50-Pin Connector
68-pin MIO E Series boards[1]	R6850 or SH6850	MIO (J10)
50-pin MIO boards[2]	NB1	MIO (J10)
100-pin MIO boards[3]	R1005050	MIO (J10)
Lab-PC+, DAQPad-1200	NB1	Lab/1200 (J9)
DAQCard-1200	PR50-50F	Lab/1200 (J9)

[1] To install the SC-2042-RTD with any of these boards, refer to the installation guide of the cable kit for instructions.

[2] The NB-MIO-16H and AT-MIO-16H boards have a maximum gain of 8 and are not intended for interfacing to low-level signals. Therefore, you should not use these boards with the SC-2042-RTD.

[3] The SC-2042-RTD connects only to pins 1–50 (ACH<0..15>) of the 100-pin MIO boards.

You can also mount the SC-2042-RTD in a rack-mount chassis using the mounting holes (indicated by arrows on the board) in the four corners of the SC-2042-RTD board.

The SC-2042-RTD is installed. You are now ready to install and configure your software. If you are using NI-DAQ, LabVIEW, or LabWindows/CVI, refer to the installation instructions to install and configure your software.

Board Configuration

You do not need to configure the SC-2042-RTD. However, you must configure the DAQ board analog channels for differential inputs.

Chapter 3
Signal Connections

This chapter describes the signal connections to the SC-2042-RTD board.

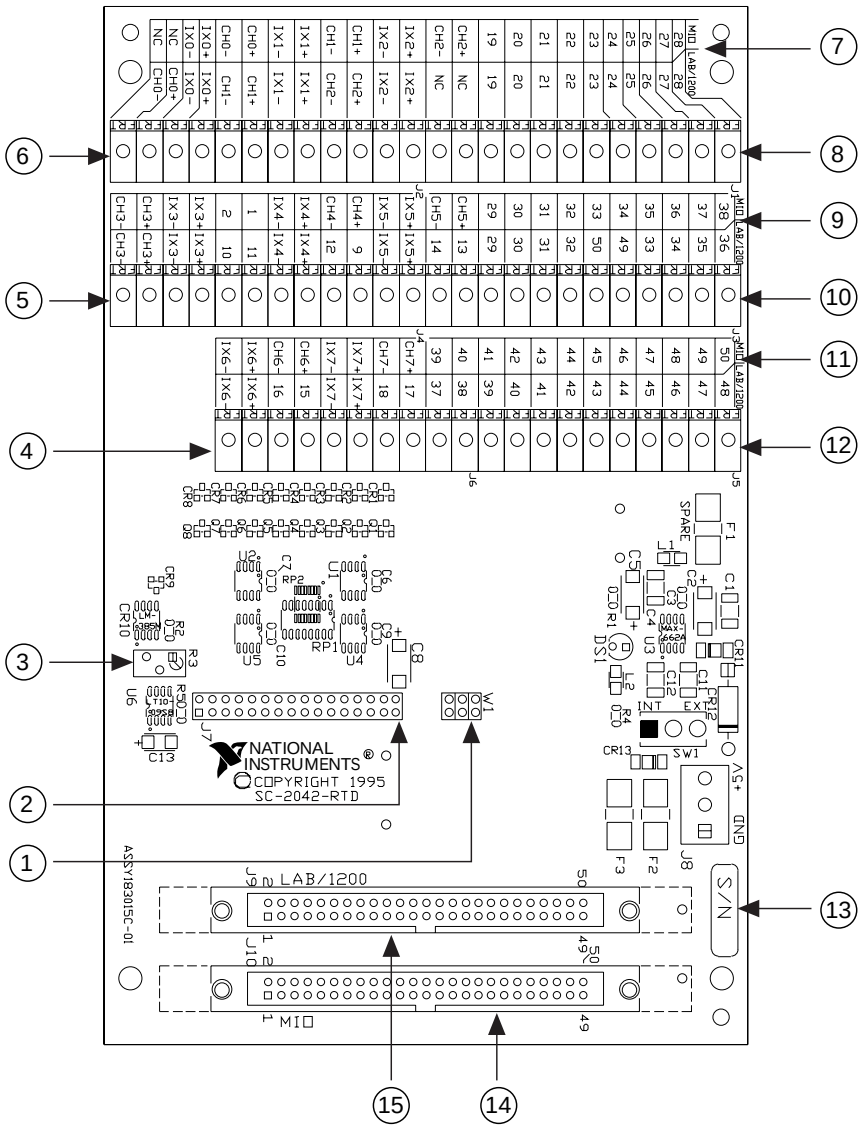
I/O Connectors Description

Warning: ***Connections, including any power signals connected to ground and vice versa, that exceed any of the maximum ratings of input or output signals on the DAQ board can damage the DAQ board and the computer. National Instruments is NOT liable for any damages resulting from any such signal connections.***

The SC-2042-RTD has two male 50-pin I/O connectors through which you can interface it to a DAQ board. These connectors, J9 and J10, are labeled *Lab/1200* and *MIO*, respectively. The Lab/1200 connector (J9) carries the signals between the SC-2042-RTD and a Lab/1200 board. The MIO connector (J10) carries the signals between the SC-2042-RTD and an MIO or MIO E board. You can use only one of these connectors to interface to a DAQ board at any time. Figure 3-1 shows the position of these connectors on the SC-2042-RTD board.

Notes: ***If you are connecting to an MIO or MIO E board, you must use the MIO connector. If you are connecting to a Lab/1200 board you must use the Lab/1200 connector. These connectors are NOT pin-for-pin compatible and, therefore, you must be careful NOT to use the wrong connector.***

Connectors J7 and W1 are reserved for National Instruments internal use only.



1	W1-Internal Use Only	9	Silkscreened Screw Terminal Label
2	J7-Internal Use Only	10	J3
3	R3	11	Silkscreened Screw Terminal Label
4	J6	12	J5
5	J4	13	Serial Number
6	J2	14	J10
7	Silkscreened Screw Terminal Label	15	J9
8	J1		

Figure 3-1. SC-2042-RTD Parts Locator Diagram

Signal Connector Descriptions

Screw terminals J1 through J6, shown in Figure 3-1, provide current excitation output and terminate all signals on the MIO and Lab/1200 I/O connectors. Two sets of labels are silkscreened onto the SC-2042-RTD board for these screw terminals—one set for the MIO connector and the other for the Lab/1200 connector. Notice that only the current excitation output screw terminals IX*n*+, IX*n*- (*n* is the channel number), and the analog signal input screw terminals CH*n*+ and CH*n*- have signal names. All other screw terminals are labeled with the pin numbers of the MIO and Lab/1200 I/O connector pins to which they are mapped.

Additionally, a sheet of sticker labels printed with signal names for every screw terminal is included with your SC-2042-RTD. This sheet consists of three sets of sticker labels, one set printed with MIO Series signal names, one set with Lab/1200 Series signal names, and one set with MIO E Series signal names. You can peel the appropriate set of sticker labels and apply them on the SC-2042-RTD board over the silkscreened labels by following these steps:

1. Select the set of sticker labels (MIO, Lab/1200 or MIO E Series) that corresponds to the type of DAQ board to which you are connecting the SC-2042-RTD.

2. Peel off each of the three labels and mount them on the SC-2042-RTD over the silkscreened labels. For the Lab/1200 boards, make sure you match the sticker label signal numbers to the Lab/1200 silkscreened signal numbers on the board.

Table 3-1 shows the screw terminal mapping to connector pins on the MIO connector. This table lists the pin numbers of the I/O connector, the signal name silkscreened on the board of the screw terminal to which each pin is mapped, and the corresponding screw terminal signal name on the sticker label. Tables 3-2 and 3-3 list the screw terminal signal summaries for the MIO board and the connector, respectively. Tables 3-4, 3-5, and 3-6 show the screw terminal and connector information for the Lab/1200 boards.

Table 3-1. Screw Terminal to MIO Connector Pin Map

MIO Connector	Screw Terminals		
Pin Numbers	**Silkscreened Signal Names**	**MIO Sticker Label Signal Names**	**MIO E Series Sticker Label Signal Names**
1	1	AIGND	AIGND
2	2	AIGND	AIGND
NC	IX0+	IX0+	IX0+
NC	IX0-	IX0-	IX0-
3	CH0+	CH0+	CH0+
4	CH0-	CH0-	CH0-
NC	IX1+	IX1+	IX1+
NC	IX1-	IX1-	IX1-
5	CH1+	CH1+	CH1+
6	CH1-	CH1-	CH1-
NC	IX2+	IX2+	IX2+
NC	IX2-	IX2-	IX2-
7	CH2+	CH2+	CH2+
8	CH2-	CH2-	CH2-
NC	IX3+	IX3+	IX3+
NC	IX3-	IX3-	IX3-
9	CH3+	CH3+	CH3+
10	CH3-	CH3-	CH3-
NC	IX4+	IX4+	IX4+
NC	IX4-	IX4-	IX4-
11	CH4+	CH4+	CH4+
12	CH4-	CH4-	CH4-
NC	IX5+	IX5+	IX5+
NC	IX5-	IX5-	IX5-
13	CH5+	CH5+	CH5+
14	CH5-	CH5-	CH5-
NC	IX6+	IX6+	IX6+
NC	IX6-	IX6-	IX6-
15	CH6+	CH6+	CH6+
16	CH6-	CH6-	CH6-
NC	IX7+	IX7+	IX7+
NC	IX7-	IX7-	IX7-
17	CH7+	CH7+	CH7+
18	CH7-	CH7-	CH7-

Table 3-1. Screw Terminal to MIO Connector Pin Map (Continued)

MIO Connector	**Screw Terminals**		
Pin Numbers	**Silkscreened Signal Names**	**MIO Sticker Label Signal Names**	**MIO E Series Sticker Label Signal Names**
19	19	AISENSE	AISENSE
20	20	DAC0OUT	DAC0OUT
21	21	DAC1OUT	DAC1OUT
22	22	EXTREF	EXTREF
23	23	AOGND	AOGND
24	24	DGND	DGND
25	25	ADIO0	DIO0
26	26	BDIO0	DIO4
27	27	ADIO1	DIO1
28	28	BDIO1	DIO5
29	29	ADIO2	DIO2
30	30	BDIO2	DIO6
31	31	ADIO3	DIO3
32	32	BDIO3	DIO7
33	33	DGND	DGND
34	34	5 V	5 V
35	35	5 V	5 V
36	36	SCANCLK	SCANCLK
37	37	†	EXTSTRB*
38	38	†	TRIG1
39	39	†	TRIG2
40	40	EXTCONV*	CONV*
41	41	SOURCE1	GPCTR1_S
42	42	GATE1	GPCTR1_G
43	43	OUT1	GPCTR1_O
44	44	†	UPDATE*
45	45	GATE2	WFTRIG
46	46	OUT2	STARTSCAN
47	47	SOURCE5	GPCTR0_S
48	48	GATE5	GPCTR0_G
49	49	OUT5	GPCTR0_O
50	50	FOUT	FREQ_O

† The function of this connector pin will vary depending on your version of MIO Series board. Refer to your MIO user manual and fill in the appropriate pin name.

Table 3-2. Screw Terminal Signal Summary for MIO or MIO E Series Board

Signal Name	Description
CH<0..7>±	Input Channels—These inputs are the signal inputs for analog channels 0 through 7.
IX<0..7>±	Current Excitation Output Channels 0 through 7—These outputs provide a precise 1 mA current to the sensors connected to these channels.
Others	All other screw terminals provide signal termination for all the remaining I/O lines of the DAQ board. If you are not using the sticker labels, the silkscreened numbers are the pin numbers of the MIO I/O connector pins to which they are mapped.
NC	No Connect—These screw terminals are not connected to the MIO connector.

Table 3-3. MIO (J10) I/O Connector Signal Summary

Signal Name	Pin Number	Description
AIGND	1	Analog Input Ground—This pin establishes the return path for the excitation current produced by the current excitation sources.
CH<0..7>±	3–18	Analog Input Channels—These pins map to ACH<0..15> on your MIO or MIO E board. They are the signal inputs for analog differential input channels 0 through 7.
DGND	33	Digital Ground—This pin is the reference for the +5 VDC power supply, as well as the digital signals at the screw terminals.
+5 V	34	+5 VDC Source—This pin provides DC power for the SC-2042-RTD from the MIO or MIO E board. It is also routed to a screw terminal to provide power to external circuits. The maximum current that can be drawn from the +5 V line for external use is the current available from your MIO or MIO E Series board minus the current used by the SC-2042-RTD (60 mA).
Others	Others	The remaining pins are routed to screw terminals to provide easy access to the power and ground lines and the analog output, digital, or counter/timer I/O signals of the DAQ board. Refer to the *Signal Connections* chapter in your DAQ board user manual for pin descriptions.
NC	—	No Connect—These signals are not connected to the MIO connector.

Table 3-4. Screw Terminal to Lab/1200 Connector Pin Map

Lab/1200 Connector	**Screw Terminals**	
Pin Numbers	**Silkscreened Signal Names**	**Lab/1200 Sticker Label Signal Names**
1	CH0+	CH0+
2	CH0-	CH0-
NC	IX0+	IX0+
NC	IX0-	IX0-
3	CH1+	CH1+
4	CH1-	CH1-
NC	IX1+	IX1+
NC	IX1-	IX1-
5	CH2+	CH2+
6	CH2-	CH2-
NC	IX2+	IX2+
NC	IX2-	IX2-
7	CH3+	CH3+
8	CH3-	CH3-
NC	IX3+	IX3+
NC	IX3-	IX3-
NC	IX4+	IX4+
NC	IX4-	IX4-
NC	IX5+	IX5+
NC	IX5-	IX5-
NC	IX6+	IX6+
NC	IX6-	IX6-
NC	IX7+	IX7+
NC	IX7-	IX7-
9	9	AISENSE
10	10	DAC0OUT
11	11	AGND
12	12	DAC1OUT
13	13	DGND
14	14	PA0
15	15	PA1
16	16	PA2
17	17	PA3
18	18	PA4
19	19	PA5

Table 3-4. Screw Terminal to Lab/1200 Connector Pin Map (Continued)

Lab/1200 Connector	**Screw Terminals**	
Pin Numbers	**Silkscreened Signal Names**	**Lab/1200 Sticker Label Signal Names**
20	20	PA6
21	21	PA7
22	22	PB0
23	23	PB1
24	24	PB2
25	25	PB3
26	26	PB4
27	27	PB5
28	28	PB6
29	29	PB7
30	30	PC0
31	31	PC1
32	32	PC2
33	33	PC3
34	34	PC4
35	35	PC5
36	36	PC6
37	37	PC7
38	38	EXTTRIG
39	39	EXTDACUP*
40	40	EXTCONV*
41	41	OUTB0
42	42	GATB0
43	43	OUTB1
44	44	GATB1
45	45	CLKB1
46	46	OUTB2
47	47	GATB2
48	48	CLKB2
49	49	5V
50	50	DGND

Table 3-5. Screw Terminal Signal Summary for Lab/1200 Series Board

Signal Name	Description
CH<0..3>±	Input Channels—These inputs are the signal inputs for analog channels 0 through 3[1].
IX<0..3>±	Current Excitation Output Channels 0 through 3—These outputs provide a precise 1 mA current to the sensors connected to these channels.
Others	All other screw terminals provide signal termination for all the remaining I/O lines of the DAQ board. If you are not using the sticker labels, the silkscreened numbers are the pin numbers of the Lab/1200 I/O connector pins to which they are mapped.
NC	No Connect—These screw terminals are not connected to the Lab/1200 connector.

[1] The Lab/1200 boards (Lab-PC+, DAQPad-1200 and DAQCard-1200) have four differential analog inputs.

Table 3-6. Lab/1200 (J9) I/O Connector Signal Summary

Signal Name	Pin Number	Description
AGND	11	Analog Ground—This pin establishes the return path for the excitation current produced by the current excitation sources.
CH<0..3>±	1–8	Analog Input Channels—These pins map to ACH<0..7> on your Lab/1200 DAQ board. They are the signal inputs for analog differential input channels 0 through 3[1].
DGND	50	Digital Ground—This pin is the reference for the +5 VDC power supply, as well as the digital signals at the screw terminals.
+5 V	49	+5 VDC Source—This pin provides DC power for the SC-2042-RTD from the Lab/1200 board. This pin is also routed to a screw terminal to provide power to external circuits. The maximum current that can be drawn from the +5 V line for external use is the current available from your Lab/1200 board minus the current used by the SC-2042-RTD (60 mA).
Others	Others	The remaining pins are routed to screw terminals to provide easy access to the power and ground lines and the analog output, digital, or counter/timer I/O signals of the DAQ board. Refer to the *Signal Connections* chapter in your DAQ board user manual for pin descriptions.
NC	—	No Connect—These signals are not connected to the Lab/1200 connector.

[1] The Lab/1200 boards (Lab-PC+, DAQPad-1200 and DAQCard-1200) have four differential analog inputs.

Sensor Connection to the SC-2042-RTD

Sensors such as RTDs and thermistors are resistive devices through which you drive a current and measure the voltage generated. However, any resistance in the lead wires that connect the RTD to your measurement system will add errors to your measurements, including a fixed offset and variations in lead resistance with changes in ambient temperature. There are several ways in which you can connect a sensor to your measurement system, each having a different level of sensitivity to lead-wire resistance effects. You can connect RTDs and thermistors to the SC-2042-RTD in four, three and two-wire configurations, as explained in the following sections.

Four-Wire Configuration

A four-wire configuration consists of four lead wires connecting a sensor to screw terminals IX*n*+, IX*n*-, CH*n*+, and CH*n*-, as shown in Figure 3-2. In this configuration, the pair of wires connected to IX*n*+ and IX*n*- carries the current and the other pair connected to CH*n*+ and CH*n*- senses the voltage across the sensor. Because almost no current flows in the sensing lead wires, their lead resistance errors are negligible, so the voltage being monitored is the voltage directly across the sensor. This configuration is insensitive to lead wire resistance effects and is the preferred configuration for applications where the highest accuracy is desired.

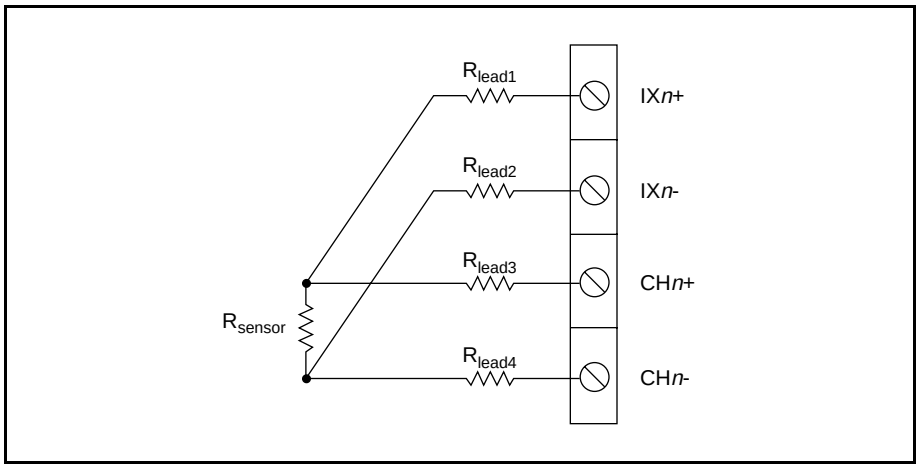


Figure 3-2. Four-Wire Sensor Connection

Three-Wire Configuration

A three-wire configuration consists of three lead wires connecting a sensor to the SC-2042-RTD in either of two ways:

- High-side sense connection—two wires connect the IX*n*+ and the CH*n*+ screw terminals to one end of the sensor and the third wire connects the IX*n*- screw terminal to the other end of the sensor. CH*n*- connects directly to IX*n*- with a jumper. Figure 3-3a shows this connection.

- Low-side sense connection—two wires connect the IX*n*- and the CH*n*- screw terminals to one end of the sensor and the third wire connects the IX***n***+ screw terminal to the other end of the sensor. CH*n*+ connects directly to IX*n*+ with a jumper. Figure 3-3b shows this connection.

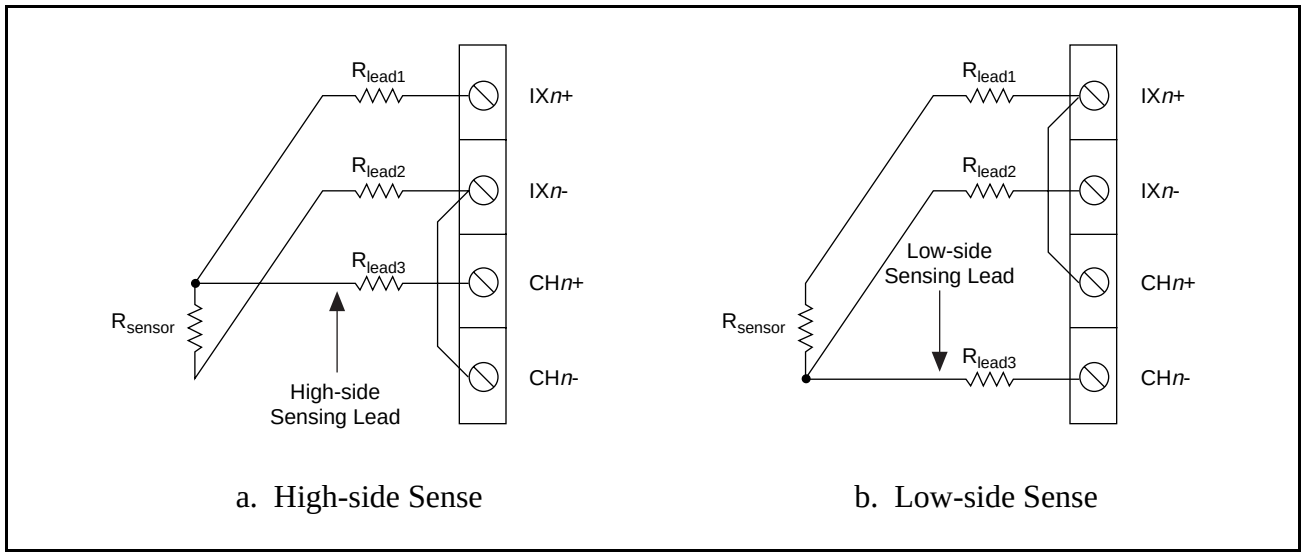


Figure 3-3. Three-Wire Sensor Connection

You can use both connections interchangeably with the SC-2042-RTD because they produce the same result. In this configuration there is only one sensing lead, so the monitored voltage is the voltage across the sensor plus the added voltage drop across one lead wire resistance. The three-wire method is less accurate than the four-wire method because the resistance effects of one lead wire contributes errors to your measurement.

Two-Wire Configuration

A two-wire configuration consists of two lead wires connecting a sensor to input channel screw terminals IX*n*+ and IX*n*-. Screw terminals CH*n*+ and CH*n*- are connected directly to IX*n*+ and IX*n*- with jumpers. The signal is sensed at the screw terminals, so the monitored voltage is the voltage across the sensor plus the added voltage drops across both lead wire resistances. This is the least accurate of the three configurations because of the added effects of both lead wires, and is used where the measurements can tolerate lead-wire resistance errors. Figure 3-4 shows this connection.

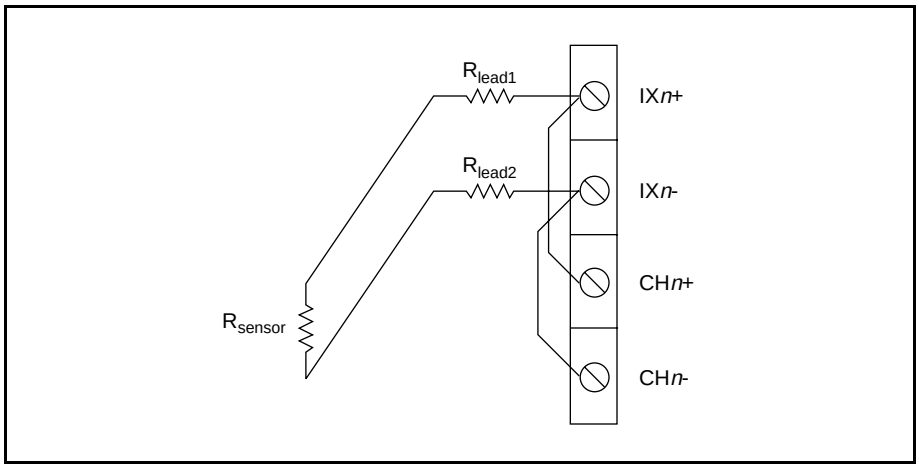


Figure 3-4. Two-Wire Sensor Connection

Analog Input Connections

You can use any unused analog input channels on the SC-2042-RTD to connect other analog differential input signals to your DAQ board. Refer to the *Signal Connections* chapter in your DAQ board user manual for further information.

Other Signal Connections

For all other input and output signals, refer to the appropriate sections in your DAQ board user manual for additional signal connection information.

Chapter 4
Theory of Operation

This chapter contains a functional overview of the SC-2042-RTD board and explains the operation of each functional unit making up the SC-2042-RTD.

Functional Overview

The SC-2042-RTD consists of eight channels, each comprising a current excitation source and a differential input signal interfacing to a DAQ board via a 50-pin connector. Sensor input signals hook up to screw terminals, and additional screw terminals are provided to break out all other pins on the 50-pin connector.

The key functional components of the SC-2042-RTD are:

- MIO I/O connector
- Lab/1200 I/O connector
- Breakout screw terminals
- Excitation output/analog input signal channels
- Power supply

The remainder of this chapter describes the theory of operation for each of these components.

The block diagram in Figure 4-1 illustrates the key functional components of the SC-2042-RTD.

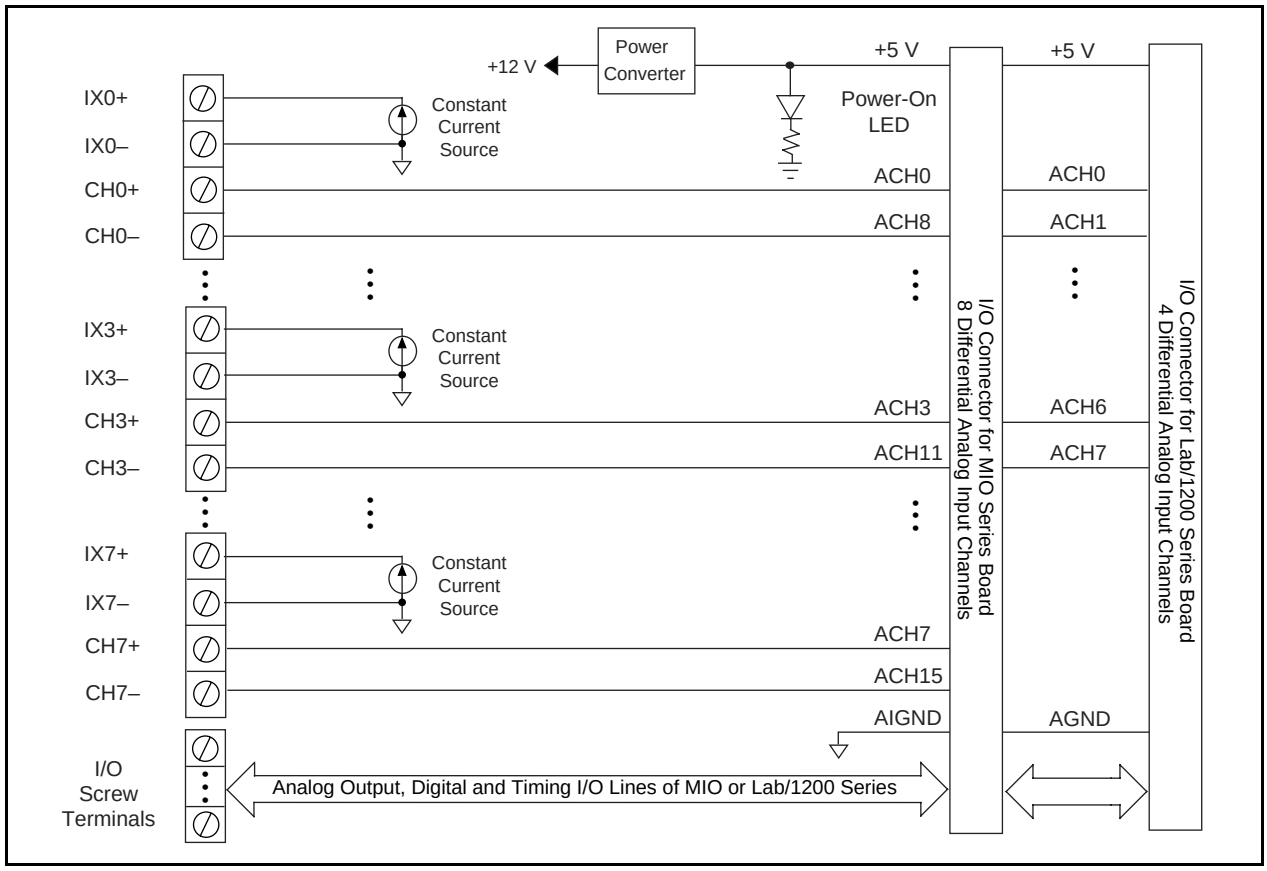


Figure 4-1. SC-2042-RTD Block Diagram

MIO and Lab/1200 I/O Connectors and Breakout Screw Terminals

The analog input signals of every channel are connected to the analog input pins of the MIO I/O connector and the Lab/1200 I/O connector. All other pins on these connectors are mapped to breakout screw terminals. These connectors carry signals to and from the DAQ board and also bring +5 V power from the DAQ board to the SC-2042-RTD. Refer to Chapter 3, *Signal Connections*, for the pin mappings of these connectors and screw terminals.

Excitation Output/Analog Input Signal Channels

Each channel has a current excitation source with output signals connected to screw terminals. The current output source is provided for excitation of RTDs, as well as other sensors, such as thermistors, that need current excitation to operate properly. The current excitation output has a value of 1 mA and can operate with a maximum permissible load of 8.5 kΩ. If you connect loads greater than 8.5 kΩ, the current source will lose regulation.

Note: ***Because the resistance of RTDs (and thermistors) varies widely over broad temperature ranges, ensure that your sensor does not exceed a maximum resistance of 8.5 kΩ for the entire temperature range that the sensor encounters.***

You should not leave any current excitation source unloaded. All eight current excitation sources share a common reference circuit; if you leave a current excitation source unloaded its internal circuit saturates, causing a small error current to flow through the reference circuit. This error current results in a slight degradation—0.01% for each unused source left unloaded—in the initial accuracy of the current excitation sources in use. Therefore, for each current excitation source not in use, simply short its output screw terminals together to maintain the initial accuracy of the current excitation sources in use.

Note: ***Lab/1200 boards have four differential input analog channels. Therefore, if you are using a Lab/1200 DAQ board, you can only use up to four (IX0± through IX3±) of the eight current excitation sources on the SC-2042-RTD. As mentioned above, you should short the IXn+ and IXn- output screw terminals of the four unused current excitation sources together.***

Each channel also provides an additional pair of screw terminals for differential sensing of sensor signals. These screw terminals interface the sensor signal inputs on each channel directly to the corresponding analog input channel on the DAQ board.

Power Supply

The +5 V supply on the DAQ board powers the SC-2042-RTD via the 50-pin I/O connector. From the +5 V power, an onboard DC-to-DC converter generates a +12 V source, which powers the current excitation sources. A green LED indicates that the board is receiving power.

Chapter 5
Calibration Procedures

This chapter discusses the calibration procedures for the SC-2042-RTD board.

Note: ***In many applications, the SC-2042-RTD factory-hardware calibration is sufficient to meet accuracy requirements, and no further calibration is needed.***

Calibration Equipment Requirements

According to standard practice, the equipment used to calibrate the SC-2042-RTD should be ten times as accurate as the SC-2042-RTD itself. Calibration equipment with four times the accuracy of the device under calibration is generally considered acceptable. To calibrate the SC-2042-RTD, you will need an ammeter with the following specifications:

Accuracy: ±0.009% standard
±0.023% sufficient

A multiranging digital multimeter (DMM) can perform this function. To make sure that the DMM does not introduce an additional offset, determine the DMM offset errors by shorting its leads together and reading the measured value. You must subtract the DMM offset value from all subsequent measurements.

Gain and Linearity Adjustments

There are no buffers or gain stages in the analog input channels of the SC-2042-RTD; therefore, gain and linearity adjustments are not applicable to this board. However, gain and linearity errors on your DAQ board may affect your measurements. Refer to your DAQ board user manual for information on performing gain and linearity adjustments.

Offset Adjustment

As with gain and linearity adjustments, offset adjustment is not applicable to the SC-2042-RTD. However, because all analog input signals on its I/O connector are routed to screw terminals, the SC-2042-RTD is a useful aid in the offset adjustment of the DAQ board analog channels.

Offset adjustment requires you to apply an input signal of zero to the channel being calibrated. Zero input can mean shorting the board inputs to zero, or it can mean applying zero excitation (i.e., disconnecting the current excitation source) to the sensor you are using. In the former case, you can remove only DAQ board offset; in the latter case, you can remove sensor offset as well. In either case, take measurements with the zero input signal and average these measurements to

reduce uncertainty. This average represents the offset. Next, subtract the offset from all subsequent measurements. Notice that the offset changes with gain; thus, during calibration, set the DAQ board channel to the gain at which you will take the subsequent measurements. For further information about offset adjustment, refer to the calibration chapter in your DAQ board user manual.

Excitation Calibration

There is one current excitation source calibration circuit that is common to all channels. This circuit has one potentiometer (R3) that you must adjust in order to calibrate all eight current excitation sources simultaneously. The calibration potentiometer (pot) is set at the factory and you should not need to readjust it for most applications. However, if you wish to recalibrate the SC-2042-RTD, you must perform the following steps.

1. If you are using a rack-mount kit, remove the cover to expose the calibration pot.

2. Set your DMM to DC current measurement.

3. Select an unused current excitation source and disconnect the short circuit from its output terminals. If all the current excitation sources are being used, select any one and disconnect the sensor.

4. Connect the DMM across the positive and negative output screw terminals of the current excitation source you selected. These are labeled IX*n*+ and IX*n*-, where *n* is the channel number.

5. Make sure that you leave none of the seven remaining current excitation sources open-circuited. Either leave the sensor connected to the current source or short the positive output screw terminal (IX*n*+) to the negative output screw terminal (IX*n*-).

6. Adjust the calibration pot until the current being measured is 1 mA. All eight current excitation sources are now calibrated.

7. Disconnect the DMM and reconnect the sensor or short circuit to the current excitation source.

   Note: ***Remember to leave any unused current excitation source with its output terminals shorted together.***

8. Replace the rack-mount chassis cover, if used.

Appendix A
Specifications

This appendix lists the specifications for the SC-2042-RTD. These are typical at 25° C unless otherwise noted.

Stability

Recommended warm-up time ..... 10 min

Current Excitation

Channels 8
Level ..... 1.00 mA, ±0.09%
Max load resistance ..... 8.5 kΩ
Drift ..... ±50 ppm/°C

Power Requirement (from DAQ Board)

+5 VDC (±5 %) ..... 60 mA

Physical

Dimensions ..... 4.6 by 20.1 by 12.4 cm (1.8 by 7.9 by 4.9 in.)
I/O connectors
- I/O signals ..... 68 labeled screw terminals
- DAQ board connector ..... Two 50-pin male ribbon-cable connectors

Environment

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

Appendix B
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.

National Instruments provides comprehensive technical assistance around the world. In the U.S. and Canada, applications engineers are available Monday through Friday from 8:00 a.m. to 6:00 p.m. (central time). In other countries, contact the nearest branch office. You may fax questions to us at any time.

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Belgium	02 757 00 20	02 757 03 11
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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	05 404 0890
Netherlands	03480 33466	03480 30673
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 20 51 51	056 20 51 55
Taiwan	02 377 1200	02 737 4644
U.K.	01635 523545	01635 523154

Technical Support Form

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

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

Name _____

Company _____

Address _____

_____

Fax (___)_____ Phone (___)_____

Computer brand _____ Model _____ Processor _____

Operating system _____

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 _____

_____

_____

_____

SC-2042-RTD Hardware and Software Configuration Form

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

National Instruments Products

- DAQ Hardware Revision _____
- Interrupt Level of Hardware _____
- DMA Channels of Hardware
- Base I/O Address of Hardware _____
- NI-DAQ, LabVIEW, LabWindows/CVI Version _____

Other Products

- Computer Make and Model _____
- Microprocessor _____
- Clock Frequency _____
- Type of Video Board Installed
- Operating System _____
- 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: **August 1995**

Part Number: **371200A-01**

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

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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}

°	degrees
Ω	ohms
A	amperes
ACH#	DAQ board analog input channel number
C	Celsius
CH#±	positive/negative input channel number
DAQ	data acquisition
DC	direct current
in.	inches
I/O	input/output
IX#±	current excitation source positive/negative output channel
LED	light-emitting diode
m	meters
MB	megabytes
min	minutes
ppm	parts per million
RTD	resistive temperature device
s	seconds
tempco	temperature coefficient
V	volts
VI	virtual instrument
VDC	volts direct current

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Numbers/Symbols

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