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BNC-208X Series
User Manual

Analog BNC Breakout Boards

September 1993 Edition

Part Number 320407-01

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Preface

This manual describes the electrical and mechanical aspects of the BNC-2080 and BNC-2081 boards and contains information about installing and making connections to the boards. The BNC-208X Series boards are analog breakout boards with BNC-style connectors. These breakout boards connect to the National Instruments multifunction data acquisition boards for the IBM PC/XT/AT, Personal System/2, and compatible computers, and Macintosh NuBus computers.

Organization of This Manual

The *BNC-208X Series User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the BNC-208X Series boards; lists the contents of your BNC-2080 and BNC-2081 kits; describes the optional equipment, signal conditioning accessories, and software support; and explains how to unpack your BNC-208X Series board.
- Chapter 2, *BNC-2080 Board*, describes the BNC-2080 board in detail, including its function, specifications, compatibility, connection, mounting, and application notes.
- Chapter 3, *BNC-2081 Board*, describes the BNC-2081 board in detail, including its function, specifications, compatibility, connection, mounting, and application notes.
- Chapter 4, *Installation and Connections*, explains how to install and make connections to the BNC-208X Series boards.
- The *Customer Communication* appendix contains forms you can use to request help from National Instruments or to comment on our products.
- The *Index* contains an alphabetical list of key terms and topics 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:

italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
Lab board	Lab board refers to the Lab-PC, Lab-PC+, Lab-NB, and Lab-LC boards.
Macintosh NuBus	Macintosh NuBus refers to the Macintosh NuBus family of computers.
MIO-16	MIO-16 refers to the AT-MIO-16, AT-MIO-16D, AT-MIO-16F-5, AT-MIO-16X, MC-MIO-16, NB-MIO-16, NB-MIO-16X, and PC-LPM-16 boards.

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PC	PC refers to PC/XT/AT/EISA and IBM PS/2 computers.
SC-205X	SC-205X refers to the SC-2050, SC-2051, SC-2052, and SC-2053 boards.
SC-206X	SC-206X refers to the SC-2060, SC-2061, and SC-2062 boards.
SC-207X	SC-207X refers to the SC-2070, SC-2071, and SC-2072 boards.

Abbreviations

The following metric system prefixes are used with abbreviations for units of measure in this manual:

Prefix	Meaning	Value
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}

The following abbreviations are used in this manual:

A	amperes
C	Celsius
dB	decibels
°	degrees
F	farads
f_c	cutoff frequency
Hz	hertz
in.	inches
m	meters
Ω	ohms
%	percent
π	pi
V	volts
W	watts

Acronyms

The following acronyms are used in this manual:

AC	alternating current
CMRR	common-mode rejection ratio
DC	direct current
DGND	digital ground
DIFF	differential input
I/O	input/output
LED	light-emitting diode
NRSE	nonreferenced single-ended input
RSE	referenced single-ended input
VDC	volts direct current

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Related Documentation

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

- *SC-205X Series User Manual* (part number 320385-01)
- *SC-206X Series User Manual* (part number 320200-01)
- *SC-207X Series User Manual* (part number 320239-01)

The following National Instruments documents may also be helpful to you depending on the type of system you are using with your BNC-208X Series boards:

- Macintosh NuBus users
  - *NB-MIO-16X User Manual* (part number 320157-01)
  - *NB-MIO-16 User Manual* (part number 320295-01)
  - *Lab-NB User Manual* (part number 320174-01)
- IBM PC/XT/AT users
  - *AT-MIO-16F-5 User Manual* (part number 320266-01)
  - *AT-MIO-16 User Manual* (part number 320476-01)
  - *Lab-PC User Manual* (part number 320205-01)
  - *Lab-PC+ User Manual* (part number 320502-01)
  - *PC-LPM-16 User Manual* (part number 320287-01)
- IBM PS/2 Micro Channel users
  - *MC-MIO-16 User Manual* (part number 320130-01)

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 the appendix at the end of this manual.

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Chapter 1
Introduction

This chapter describes the BNC-208X Series boards; lists the contents of your BNC-2080 and BNC-2081 kits; describes the optional equipment, signal conditioning accessories, and software support; and explains how to unpack your BNC-208X Series board.

The BNC-2080 and BNC-2081 boards are two analog breakout boards with signal-labeled BNC connectors and analog signal conditioning areas. The BNC-2080 and BNC-2081 breakout boards simplify the connection of analog signals, some digital signals, and two user-defined connections to the data acquisition board in laboratory, test, and production environments. The BNC-2080 can be configured to use 8 differential or 16 single-ended analog input channels available on the board. The boards have silkscreened component locations for resistors, and capacitors for building single-pole highpass and lowpass filters, and voltage dividers.

Table 1-1 lists the specific data acquisition boards that can currently be used with the BNC-208X Series boards.

Table 1-1. Data Acquisition Boards for Use with BNC-208X Series Boards

	NB Series (Macintosh NuBus)	**MC Series (IBM PS/2)**	**PC and AT Series (PC/XT/AT)**	**Lab Series (PC/XT/AT and Macintosh NuBus)**
BNC-2080	NB-MIO-16 NB-MIO-16X	MC-MIO-16	AT-MIO-16 AT-MIO-16D AT-MIO-16F-5 AT-MIO-16X PC-LPM-16	
BNC-2081				Lab-LC Lab-NB Lab-PC Lab-PC+

Note: When a board is referred to as an MIO-16 board, the reference applies to the AT-MIO-16, AT-MIO-16D, AT-MIO-16F-5, AT-MIO-16X, MC-MIO-16, NB-MIO-16, NB-MIO-16X, and PC-LPM-16 boards listed in Table 1-1. Similarly, when a board is referred to simply as a Lab board, the reference applies to the Lab-LC, Lab-NB, Lab-PC+ and Lab-PC boards listed in Table 1-1.

All analog signals from the data acquisition board are made available at BNC connectors. Each of the BNC-208X Series boards is connected directly to the data acquisition board (NB, MC, Lab, PC, or AT Series) by a 50-pin ribbon cable. The AT-MIO-16D requires an NB5 cable. The Lab-LC requires an NB10 cable. If any SC-206X Series digital signal conditioning boards are also being used with the same data acquisition board for conditioning of the digital I/O signals, then an SC-205X Series cable adapter board is required.

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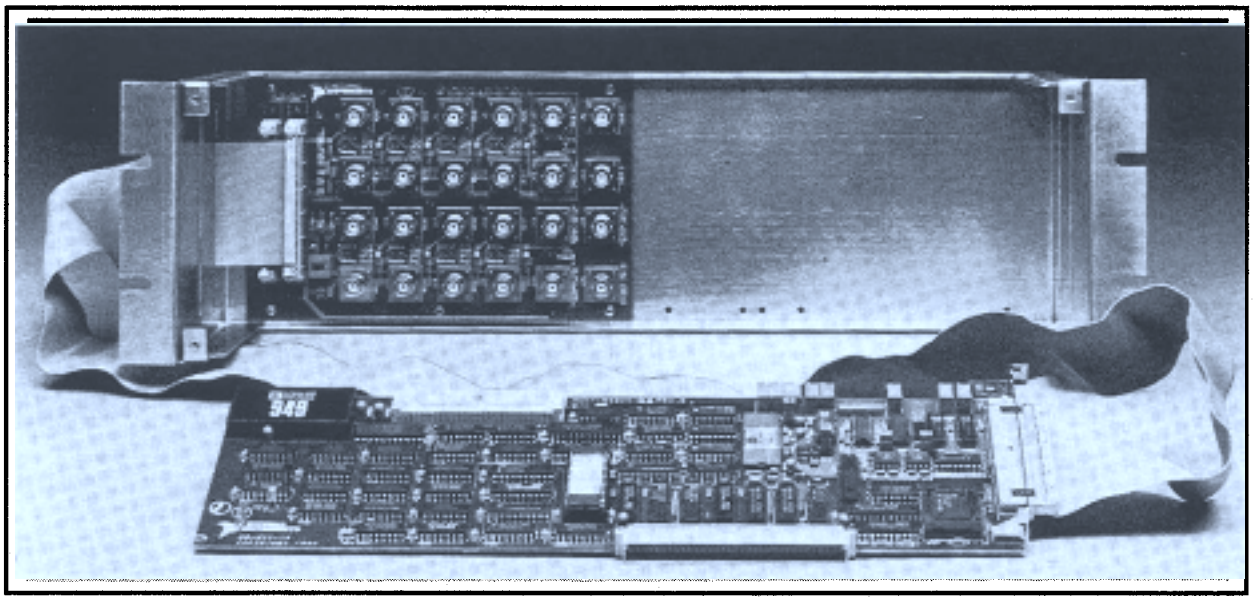


Figure 1-1. BNC-2080 Board Directly Connected to an MIO-16 Board

The BNC-208X Series boards can be mounted beside an SC-205X Series cable adapter board, an SC-206X Series signal conditioning board, and an SC-207X Series general-purpose termination breadboard in a 19-in. rack-mount chassis. You can mount your BNC-208X Series board on the left or right side of the rack mount. Mounting the BNC-208X Series board on the left side and running the cable under the BNC-208X Series board to connect to the any of the SC Series boards will make access to both boards easier. Figure 1-2 shows the BNC-208X, SC-207X, SC-206X, and SC-205X Series boards connected to an MIO-16 board.

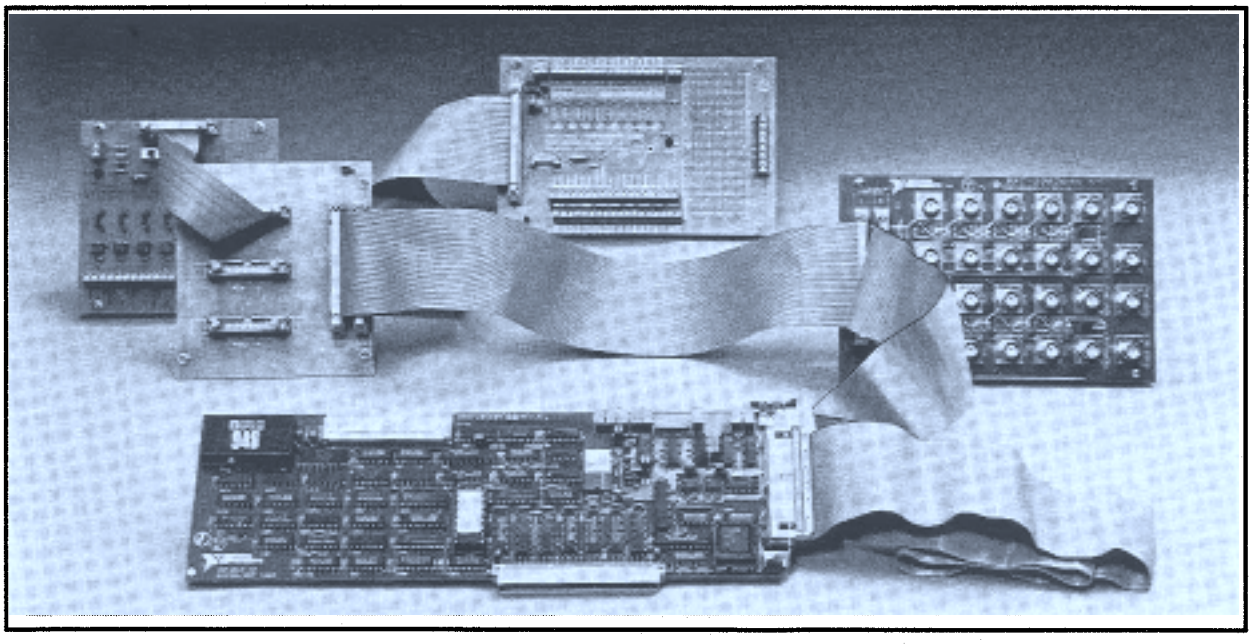


Figure 1-2. BNC-208X, SC-207X, SC-206X, and SC-205X Series Boards Connected to an MIO-16 Board

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What Your Kit Should Contain

There are three kit versions for each of the BNC-2080 and the BNC-2081 boards–one kit contains a 0.5 m cable, one kit contains a 1.0 m cable, and one kit contains no cable, listed as follows.

Kit Name	Kit Part Number	Kit Component	Board Part Number
BNC-2080 kit with 0.5 m cable	776579-05	BNC-2080 board 50-conductor 0.5 m NB1 cable	181630-01 180524-05
BNC-2080 kit with 1.0 m cable	776579-10	BNC-2080 board 50-conductor 1.0 m NB1 cable	181630-01 180524-10
BNC-2080 without cable	776579-90	BNC-2080 board	181630-01
BNC-2081 kit with 0.5 m cable	776599-05	BNC-2081 board 50-conductor 0.5 m NB1 cable	181635-01 180524-05
BNC-2081 kit with 1.0 m cable	776599-10	BNC-2081 board 50-conductor 1.0 m NB1 cable	181635-01 180524-10
BNC-2081 without cable	776599-90	BNC-2081 board	181635-01

You can identify which version of the BNC-208X Series kit you have by looking up the part number in the preceding table.

In addition to the board, each version of the BNC-208X Series kit contains the following component.

Kit Component	Part Number
BNC-208X Series User Manual	320407-01

If your kit is missing any of the components or if you received the wrong version, contact National Instruments.

Optional Equipment

Equipment	Part Number
Type NB5 cable (for the AT-MIO-16D)	
0.5 m	181304-05
1.0 m	181305-05
Rack-mount chassis kit with acrylic plastic cover	
Single height	180636-01
Double height	180636-02
Rack-mount chassis kit with metal wraparound cover	
Single height	181080-01
Double height	181080-02

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Signal Conditioning Accessories

Accessory	Part Number
SSR Series eight-channel backplane with 0.4 m cable for SC-2050 Series	776290-18
SC-2070 and 50-conductor cable	
0.5 m cable	776358-00
1.0 m cable	776358-10
SC-2071 and 50-conductor cable	
0.5 m cable	776358-01
1.0 m cable	776358-11
SC-2072 and 50-conductor cable	
0.5 m cable	776358-02
1.0 m cable	776358-12
SC-2072D and 50-conductor cable	
0.5 m cable	776358-102
1.0 m cable	776358-112
SC-2060 and 26-conductor cable	
0.2 m cable	776336-00
0.4 m cable	776336-10
SC-2061 and 26-conductor cable	
0.2 m cable	776336-01
0.4 m cable	776336-11
SC-2062 and 26-conductor cable	
0.2 m cable	776336-02
0.4 m cable	776336-12
SC-2050 and 50-conductor cable	
0.5 m cable	776335-00
1.0 m cable	776335-10
SC-2051 and 50-conductor cable	
0.5 m cable	776335-01
1.0 m cable	776335-11
SC-2052 and 50-conductor cable	
0.5 m cable	776335-02
1.0 m cable	776335-12
SC-2053 and 50-conductor cable	
0.5 m cable	776335-03
1.0 m cable	776335-13

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Software Support

The BNC-208X Series boards require no additional software support beyond that provided for the data acquisition board in use.

Unpacking

Your BNC-208X Series board is shipped in an antistatic package to prevent electrostatic damage to the board. Several components on the board can be damaged by electrostatic discharge. To avoid such damage in handling the board, take the following precautions:

- 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.

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Chapter 2
BNC-2080 Board

This chapter describes the BNC-2080 board in detail, including its function, specifications, compatibility, connection, mounting, and application notes.

The BNC-2080 is an analog breakout board that makes it easy to connect to all MIO-16 or PC-LPM-16 analog signals and a few digital signals via BNC connectors. All other MIO-16 signals are accessible via solder holes in the board next to data acquisition board input connectors. Passive analog input signal conditioning, such as filters and dividers, can also be added.

The BNC-2080 board is used with the National Instruments data acquisition boards for the Macintosh NuBus (NB Series), IBM PS/2 Micro Channel (MC Series), and PC/XT/AT and compatible computers.

Figure 2-1 shows the BNC-2080 board.

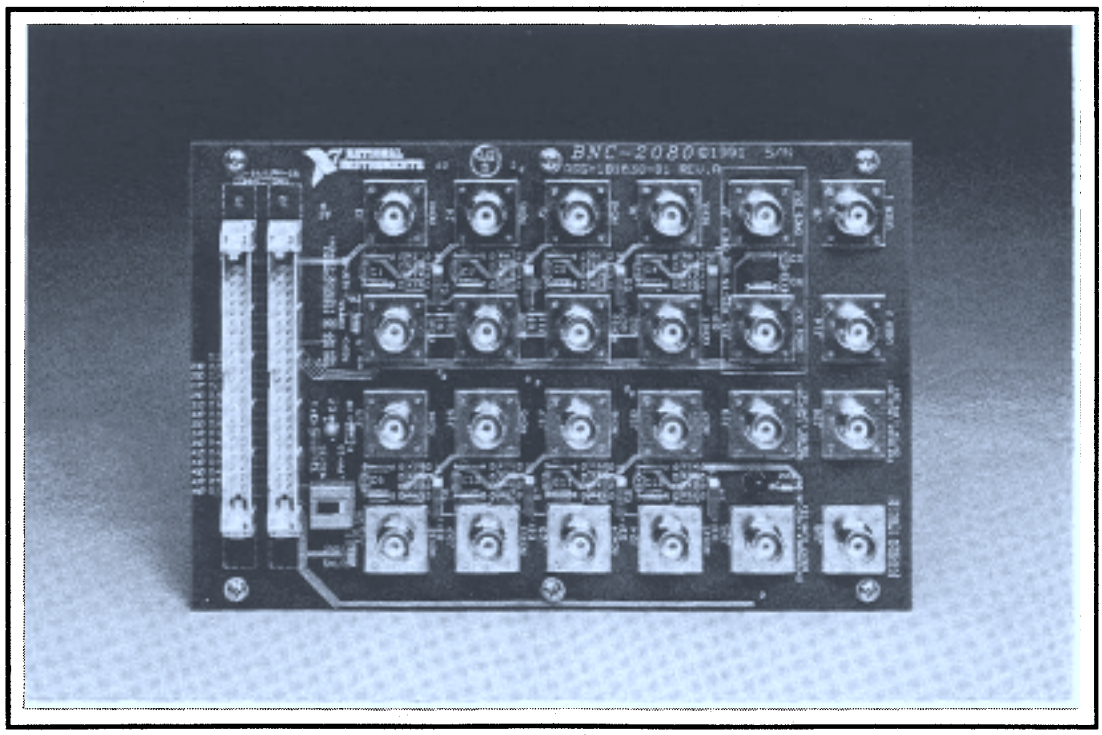


Figure 2-1. BNC-2080 Analog Breakout Board

The BNC-2080 board has BNC connectors for all analog signals, a few digital signals, and two user-defined connectors. With open component positions in the input paths, you can insert resistors and capacitors for conditioning the 16 single-ended or 8 differential analog input signals. The BNC-208X Series boards can also be used in conjunction with the other signal conditioning accessories, including the SC-207X Series boards. For connection of multiple signal conditioning accessories, an SC-205X Series cable adapter board must be used.

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Figure 2-2 illustrates the parts locator diagram for the BNC-2080 board.

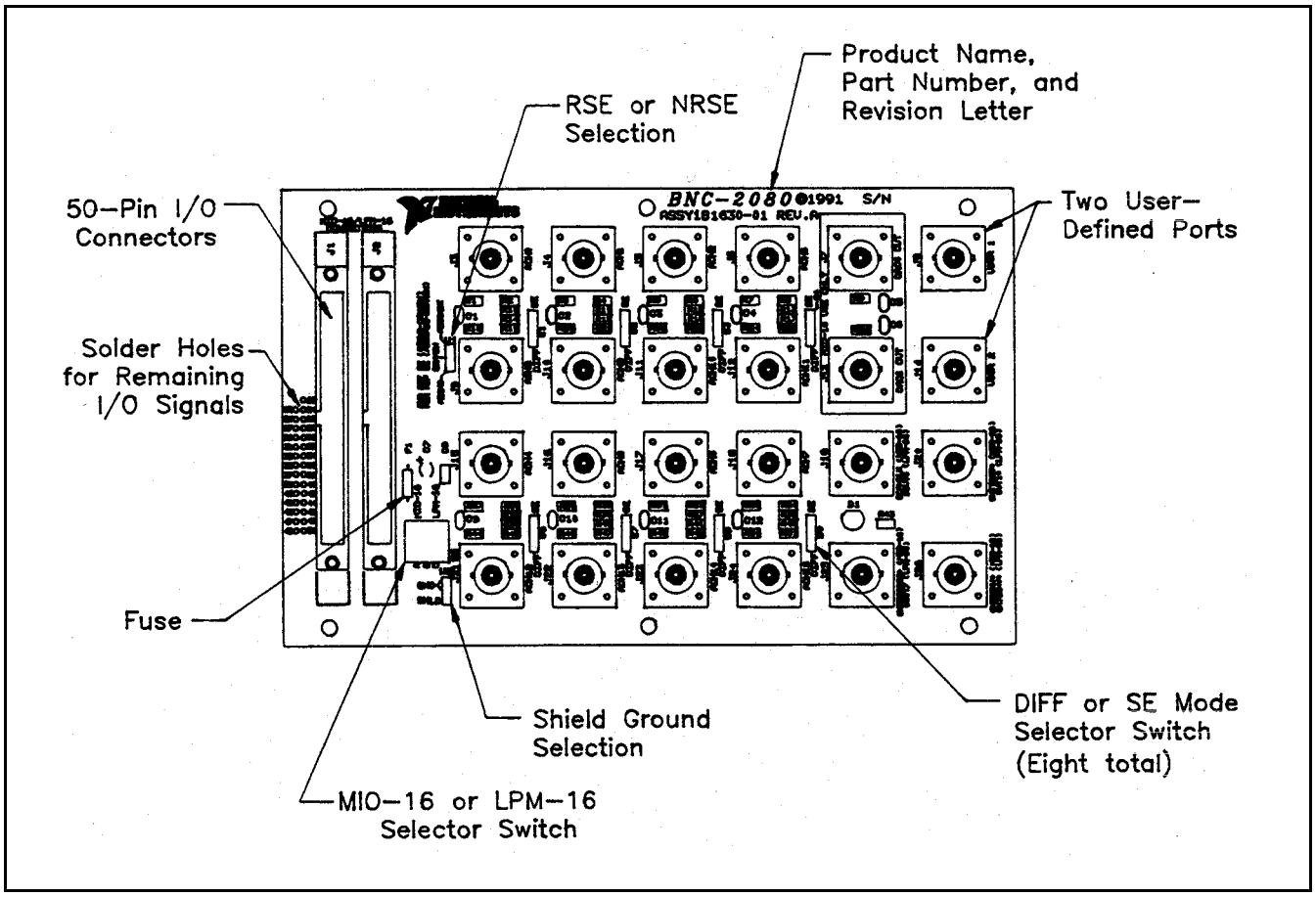


Figure 2-2. BNC-2080 Board Parts Locator Diagram

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Power Connections

Because the BNC-2080 board is an analog breakout board for both the MIO-16 and PC-LPM-16 boards, it has a flexible power connection scheme.

Switch S5 is responsible for selecting the power inputs from the I/O cable. Switch S5 is a three-position switch that configures the BNC-2080 to connect to pins 33 (DGND) and 34 (+5 V) in position *A*, to no I/O pins in position *B*, and to pins 49 (+5 V) and 50 (DGND) in position *C*.

Table 2-1 shows the setting to be used with each of the National Instruments data acquisition boards.

Table 2-1. Switch S5 Settings for National Instruments Data Acquisition Boards

Board	S5 Setting
AT-MIO-16	A
AT-MIO-16D	A
AT-MIO-16F-5	A
AT-MIO-16X	A
MC-MIO-16	A
NB-MIO-16	A
NB-MIO-16X	A
PC-LPM-16	C

Warning: If the data acquisition board does not use pins 33/34 or pins 49/50 for power connections, set switch S5 to position *B*. Failure to set switch S5 to position *B* under these conditions could result in damage to your external power supply, the BNC-2080, the expansion board connected to the BNC-2080, and/or your computer. National Instruments is *not* liable for damages resulting from such connections.

Analog Input

Each differential analog input has seven open positions for signal conditioning components. Six of these positions are designated as resistors, and one is designated as a capacitor. The board is shipped with jumpers in two positions for each input. The equivalent circuit of one input is shown in Figure 2-3. The board can be used when the MIO-16 board is configured for both 16 single-ended inputs and 8 differential inputs. For specific applications illustrating signal conditioning with both single-ended and differential inputs, refer to the section titled *Application Notes* later in this chapter.

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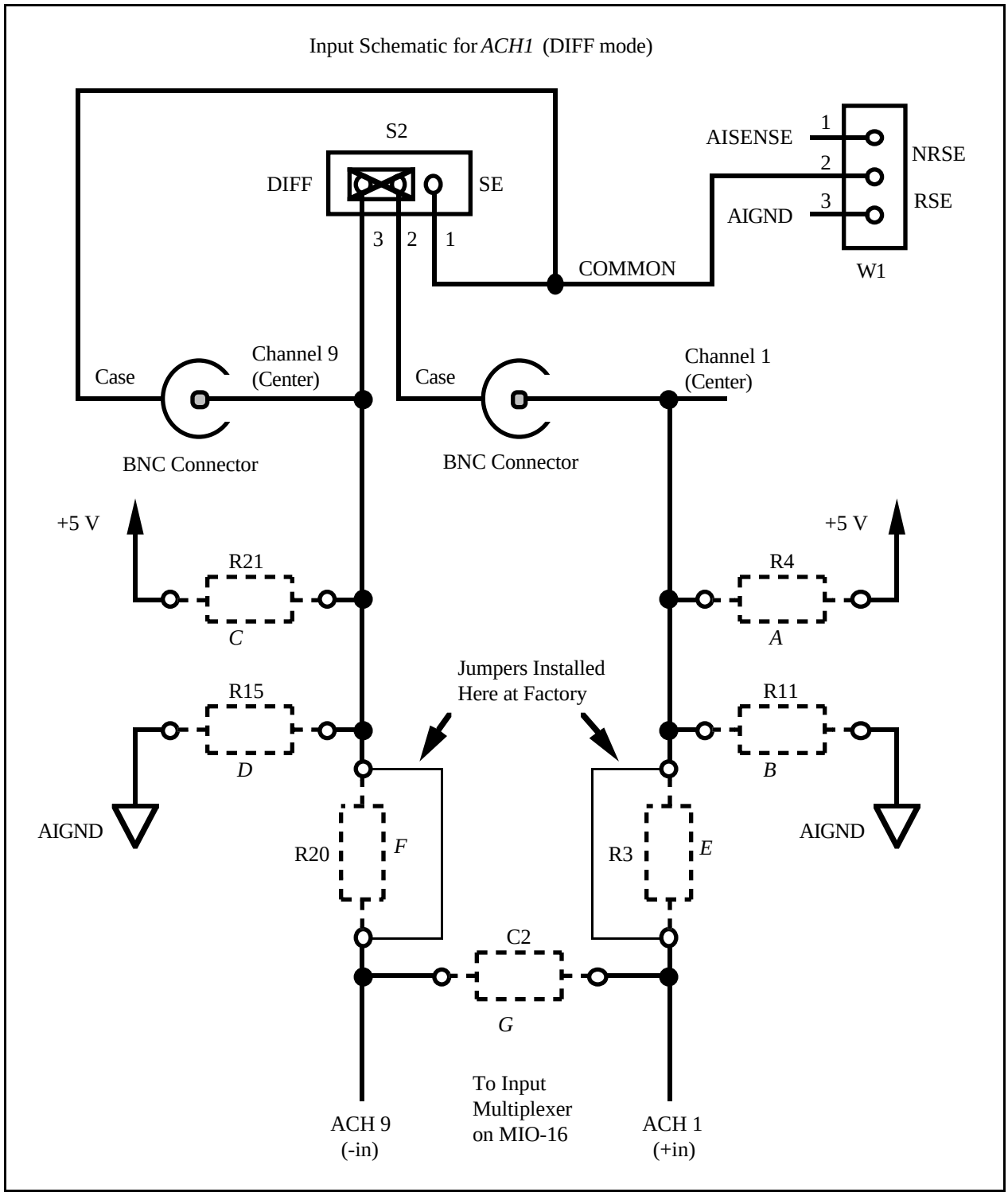


Figure 2-3. Onboard Equivalent Circuit for DIFF Mode

The components are numbered differently for each channel. Table 2-2 lists the components in each channel and their correspondence to the circuit shown in Figure 2-3.

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Table 2-2. DIFF Mode Channel Component Positions

Channel		(Position in Figure 2-3)						
Differential	**Single-Channel**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
0	(0, 8)	R2	R10	R19	R14	R1	R18	C1
1	(1, 9)	R4	R11	R21	R15	R3	R20	C2
2	(2, 10)	R6	R12	R23	R16	R5	R22	C3
3	(3, 11)	R8	R13	R25	R17	R7	R24	C4
4	(4, 12)	R28	R35	R45	R39	R27	R44	C9
5	(5, 13)	R30	R36	R47	R40	R29	R46	C10
6	(6, 14)	R32	R37	R49	R41	R31	R48	C11
7	(7, 15)	R34	R38	R51	R42	R33	R50	C12

When the board is shipped, jumpers are inserted in the *E* and *F* positions of the input network, as in Figure 2-3. These jumpers can be easily removed to build analog input signal conditioning circuits. Several applications showing the use of these open component positions are discussed in the section titled *Application Notes* later in this chapter.

Shield Ground

Jumper W2 is used to connect digital ground (DGND) to a grounded metal case. This option is useful only if the BNC-2080 board is on metal standoffs and is mounted in a grounded metal case. Shield grounding can be selected to reduce noise.

Figure 2-4 details the jumper settings for W2.

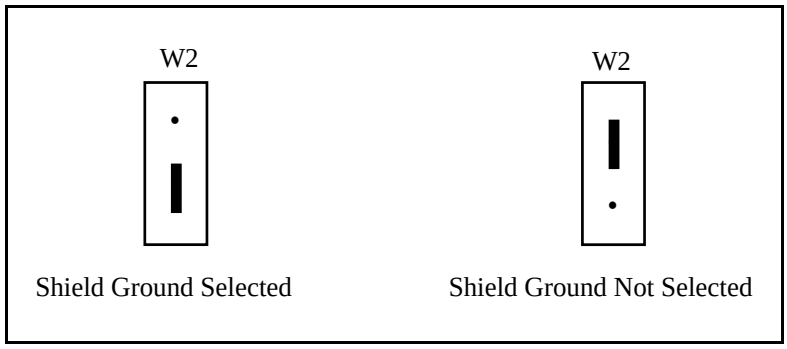


Figure 2-4. W2 Jumper Settings

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Fuse and Power LED

The +5-V line from the data acquisition board is protected by a 750-mA fuse. If the red power LED does not light when the data acquisition board is powered on, check both the 750-mA fuse on the BNC-2080 board and the output fuse (if any) on the MIO-16 board. Information on connecting power is given in Chapter 4, *Installation and Connections*.

Digital and Timing Signals

All of the analog signals and a few digital signals from the MIO-16 data acquisition board are made available at BNC connectors on the BNC-2080 board. Because these signals are not conditioned or changed in any way by the BNC-2080 board, refer to your MIO-16 board user manual for information on the use of these signals. If you want optical isolation of or relay control by the digital I/O lines, you must use the SC-2050 cable adapter board and the appropriate SC-2060 digital signal conditioning board. If you want access to all MIO-16 signals via screw terminals, you must use the SC-2070 or SC-2072 board. For more information on the SC-205X Series boards, the SC-206X Series boards, or the SC-207X Series boards, refer to either your National Instruments catalog, the *SC-205X Series User Manual*, the *SC-206X Series User Manual*, or the *SC-207X Series User Manual*.

Specifications

This section lists the specifications of the BNC-2080 analog breakout board. These ratings are typical at 25° C unless otherwise stated. The operating temperature range for this board is 0° to 70° C.

Analog Input

Number of channels	8 differential, 16 single-ended
Field connections	24 BNC connectors; 18 analog (MIO-16) 16 analog (LPM-16), [See note], 4 digital, and 2 user-defined
Signal conditioning capability	Seven open component positions per channel that include connections from each input to ground, +5 V, each other, and series connections to the inputs of the data acquisition boards
Other signals	Solder holes for remaining MIO-16 signals

Note: The DAC0 OUT and DAC1 OUT BNC connectors are for use with *only* the MIO-16 boards. These connectors are connected to ±12 VDC when the LPM-16 board is in use.

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Power Requirements

Power consumption (at +5 VDC ±5%)

Typical	12 mA with no signal conditioning installed
Maximum	750 mA from host computer

Note: The power specifications pertain to the power supply of the host computer. The maximum power consumption of the BNC-2080 board is a function of the signal conditioning components installed. If the board is being powered from the host computer, the maximum +5-V current draw is fuse-limited to 750 mA.

Physical

Board dimensions (including standoffs)	7.9 by 4.9 by 1.725 in.
I/O connectors	Two 50-pin male ribbon-cable connectors
BNC connectors	24

Operating Environment

Temperature	0° to 70° C
Relative humidity	5% to 90% noncondensing

Storage Environment

Temperature	-55° to 125° C
Relative humidity	5% to 90% noncondensing

Board-to-Board Cabling

The BNC-2080 board directly connects to any of the data acquisition boards listed in Table 2-3.

Table 2-3. Data Acquisition Boards Used with the BNC-2080 Board

	NB Series (Macintosh NuBus)	MC Series (IBM PS/2)	AT Series (PC AT)
BNC-2080	NB-MIO-16 NB-MIO-16X	MC-MIO-16	AT-MIO-16 AT-MIO-16D* AT-MIO-16F-5 AT-MIO-16X PC-LPM-16

*Requires an NB5 cable, available separately.

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The data acquisition boards listed in Table 2-3, except for the AT-MIO-16D, connect to the BNC-2080 board as shown in Figure 2-5. The AT-MIO-16D connects to the BNC-2080 via a 100-conductor type NB5 ribbon cable, available separately.

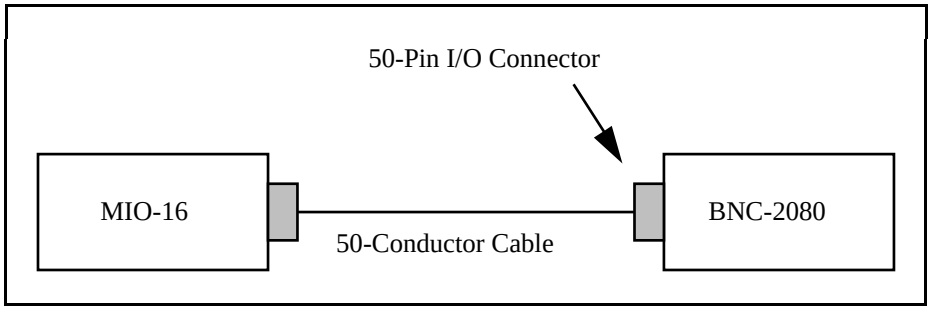


Figure 2-5. Direct Connection between an MIO-16 Board and the BNC-2080 Board

If any signal conditioning of the digital I/O ports with the National Instruments SC-206X Series boards is desired, then the SC-2050 cable adapter board must be used with the data acquisition boards listed in Table 2-2.

Figure 2-6 shows a connection using the SC-2050 cable adapter board.

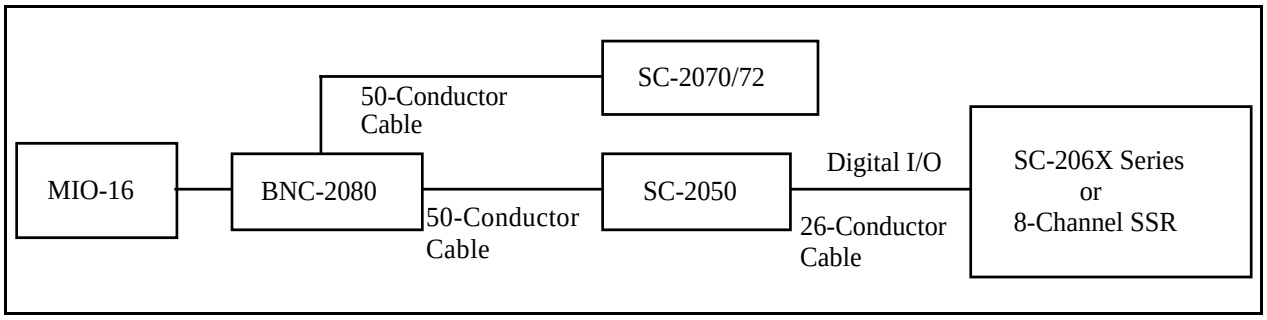


Figure 2-6. Connection between an MIO-16 Board, the BNC-2080 Board, and the SC-2070/72 Board or the MIO-16, and the BNC-2080 and SC-206X Series Boards via the SC-2050 Board

Warning: Do not connect the BNC-2080 board to any board other than a National Instruments MIO-16 data acquisition board, the SC-2070/72 board, or the SC-2050 cable adapter board. The BNC-2080 board is not compatible with any other data acquisition boards or cable adapter boards. Attempts to use the BNC-2080 board with products for which it is not intended can result in damage to the BNC-2080 board, the data acquisition board, or the host computer. National Instruments is *not* liable for damages resulting from these connections.

The BNC-2080 board uses a 50-pin ribbon-cable connector to connect to the 50-pin I/O connector on either a data acquisition board, the SC-2070/72, or the SC-2050 cable adapter board. The BNC-2080 has two MIO-16 connectors for connecting to the SC-2070/72 board or the SC-206X Series board via the SC-2050 board. For more information, see Chapter 4, *Installation and Connections*.

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Mounting

The BNC-2080 board is equipped with metal standoffs so the board can be placed on a workbench near the host computer. You can use an optional rack-mount chassis, which can be fitted with a flat, acrylic plastic cover. When the BNC-2080 board is mounted in the chassis, the board can be grounded to its metal standoffs, and therefore to the rack. For more information, see Chapter 4, *Installation and Connections*.

Application Notes

The open component positions on the BNC-2080 board make adding signal conditioning components to the analog input signals easier. Several applications are covered in this section, including filtering and attenuation.

The figures in this section give examples on a specific input channel. If you want to install the circuit on a different channel, consult Table 2-3 to determine the equivalent component positions for the other channels.

Soldering and Desoldering on the BNC-2080 Board

The applications discussed here require you to make modifications to the printed circuit board, usually by removing jumpers and adding components. The BNC-2080 board is shipped with wire jumpers in the *E* and *F* positions (see Table 2-3 and Figure 2-3). Use a low-wattage soldering iron (20 to 30 W) when soldering to the board. To desolder on the BNC-2080, vacuum-type tools work best. Use care when desoldering to avoid damaging component pads. Only rosin-core, electronic-grade solder should be used. Acid-core solder damages the printed circuit board and components.

Channel Configurations

MIO-16 Analog Input

This section discusses the input configuration of the MIO-16 board and the corresponding configurations of the BNC-2080.

The analog input channels of an MIO-16 data acquisition board can be configured for one of three input modes: differential (DIFF) input mode, referenced single-ended (RSE) input mode, or nonreferenced single-ended (NRSE) input mode.

Although the open component positions are placed to facilitate use with differential inputs, any of the three modes can be selected. If the MIO-16 board is configured in the RSE mode, all 16 analog input channels are referenced to AIGND. If the MIO-16 board is configured in the NRSE mode, resistors should not be inserted into positions *B* or *D* of Figure 2-3 for any channel. Doing so can cause inaccurate readings because of incorrect ground reference. Resistors can be inserted into these positions in the RSE mode. For information on the input configurations, see your MIO-16 board user manual.

The BNC-2080 board can be configured to work with all three MIO-16 input configurations. The DIFF mode is configured by flipping the switches next to each pair of BNC connectors to DIFF. This must be done to *all* eight switches in order to have eight differential channels. In DIFF mode, the first eight analog (ACH0 through ACH7) BNC connectors are used. The remaining eight

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analog (ACH8 through ACH15) BNC connectors are not used. The MIO-16 board must also be configured for differential input. The jumper W1 position is irrelevant in DIFF mode.

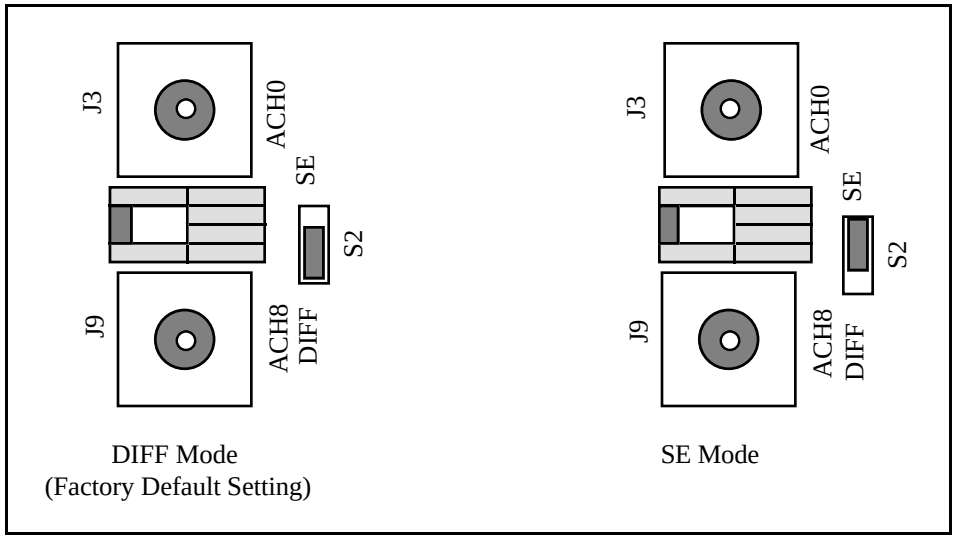


Figure 2-7. Switch Configurations for Differential Mode or Single-Ended Mode

Note: All of the switches are required to be in the same position; that is, S1 through S4 and S6 through S9 must all be in either the DIFF position or in the SE position.

The single-ended mode is configured by flipping the switches next to each pair of BNC connectors to SE. This must be done to *all* eight switches in order to have 16 single-ended channels. In the single-ended mode, *all* 16 BNC connectors are in use. In the single-ended mode, *all* 16 BNC cases are tied to the COMMON signal. The COMMON signal can be switched between AIGND and AISENSE through jumper W1. See Figure 2-8. AISENSE is tied to COMMON for NRSE mode configuration and AIGND is tied to COMMON for RSE mode configuration.

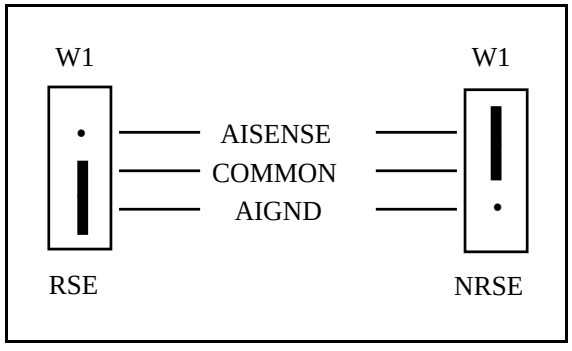


Figure 2-8. W1 Ground Reference Jumper

The three configurations of the BNC-2080 board corresponding to the input mode configuration of the MIO-16 are shown in Figure 2-9 and Figure 2-10.

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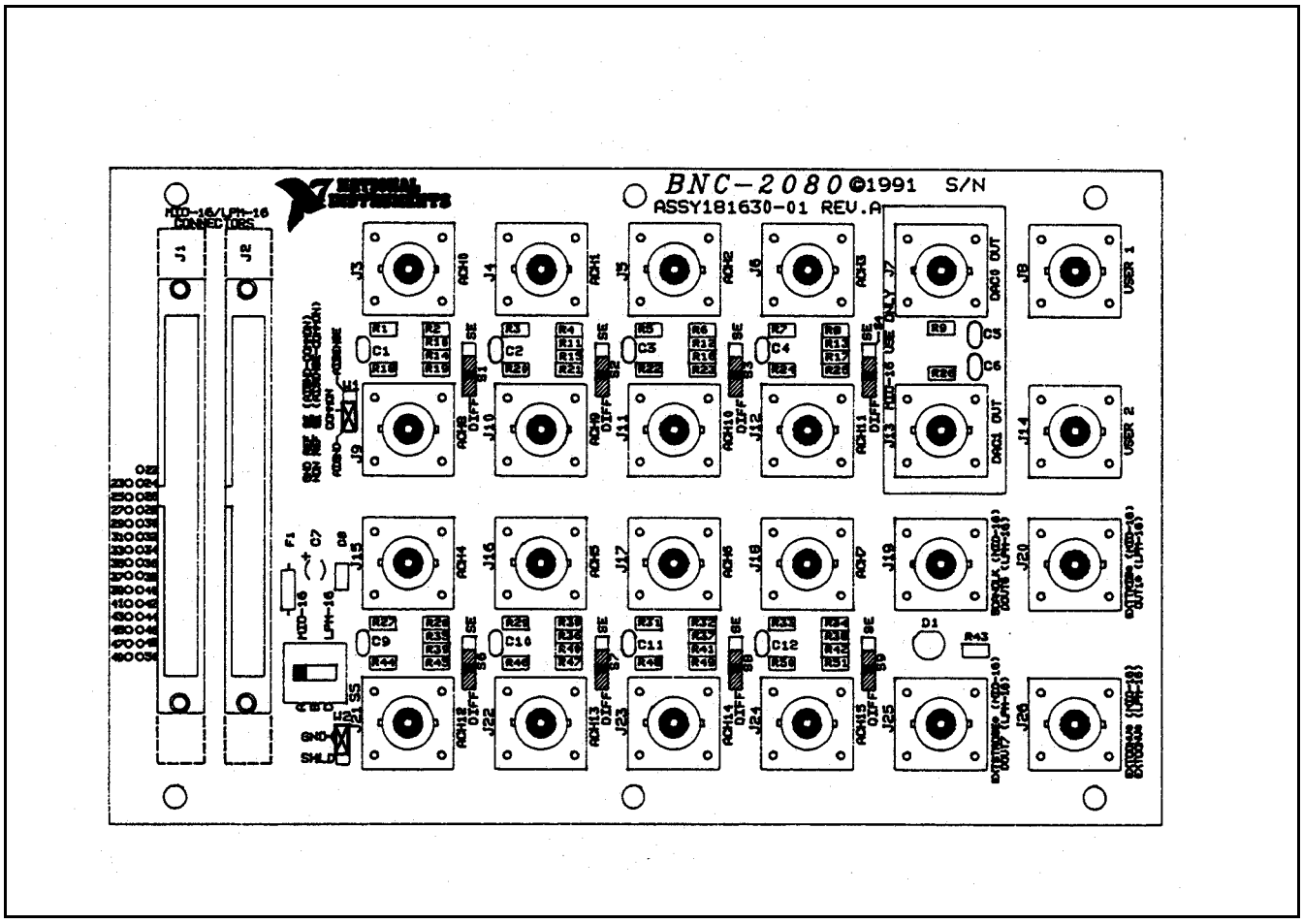


Figure 2-9. BNC-2080 Switch Configurations for an MIO-16 Configured in DIFF Mode (Factory Default Setting)

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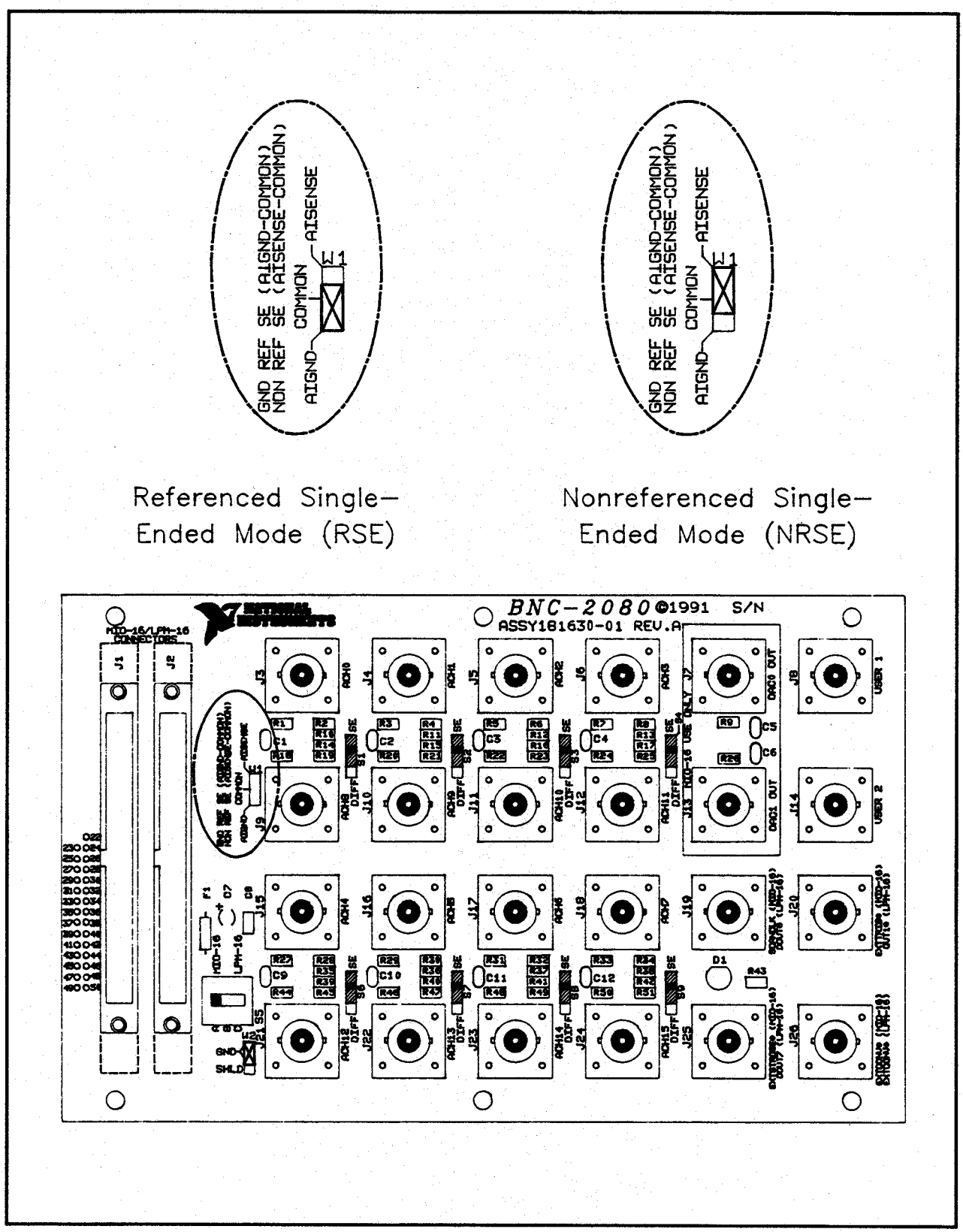


Figure 2-10. BNC-2080 Switch Configurations for an MIO-16 Configured in RSE and NRSE Modes

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As described in Chapter 2 of your MIO-16 board user manual, the input configuration of the MIO-16 depends on the type of signal source. There are two types of signal sources: nonreferenced or floating signals and ground-referenced signals. To measure floating signal sources, the MIO-16 should be configured for the RSE mode or DIFF mode with bias resistors. To measure ground-referenced signal sources, the MIO-16 should be configured for the NRSE mode or DIFF mode. Both types of signal sources and the recommended methods for MIO-16 board connection are discussed as follows.

Connecting Nonreferenced (or Floating) Signal Sources

A floating signal source is a signal source that is not connected in any way to the building ground system, but has an isolated ground-reference point. If an instrument or device has an isolated output, that instrument or device falls into the floating signal source category. Some examples of floating signal sources are outputs for: thermocouples, transformers, battery-powered devices, optical isolators, and isolation amplifiers. The ground reference of a floating source must be tied to the ground of the data acquisition board to establish a local or onboard reference for the signal.

Differential Inputs

To provide a return path for the instrumentation amplifier bias currents, floating sources must have a 10-kΩ to 100-kΩ resistor to AIGND on one input if DC-coupled, or both inputs if AC-coupled. For more detailed information on connections to floating signal sources and differential inputs, refer to the configuration chapter in your MIO-16 board user manual. These bias resistors can be installed in positions *B* and *D* (Table 2-2 and Figure 2-3) of the BNC-2080 board. Figure 2-11 shows both the schematic and the component placement for a single 100-kΩ bias return resistor on the negative input from a floating source connected to Channel 1 (the *D* position in Table 2-2). Additional signal conditioning circuitry, such as filters and attenuators, as described in the sections *Building Lowpass Filters*, *Building Highpass Filters*, and *Building Attenuators* (*Voltage Dividers*) later in this chapter, can be built in the open component positions.

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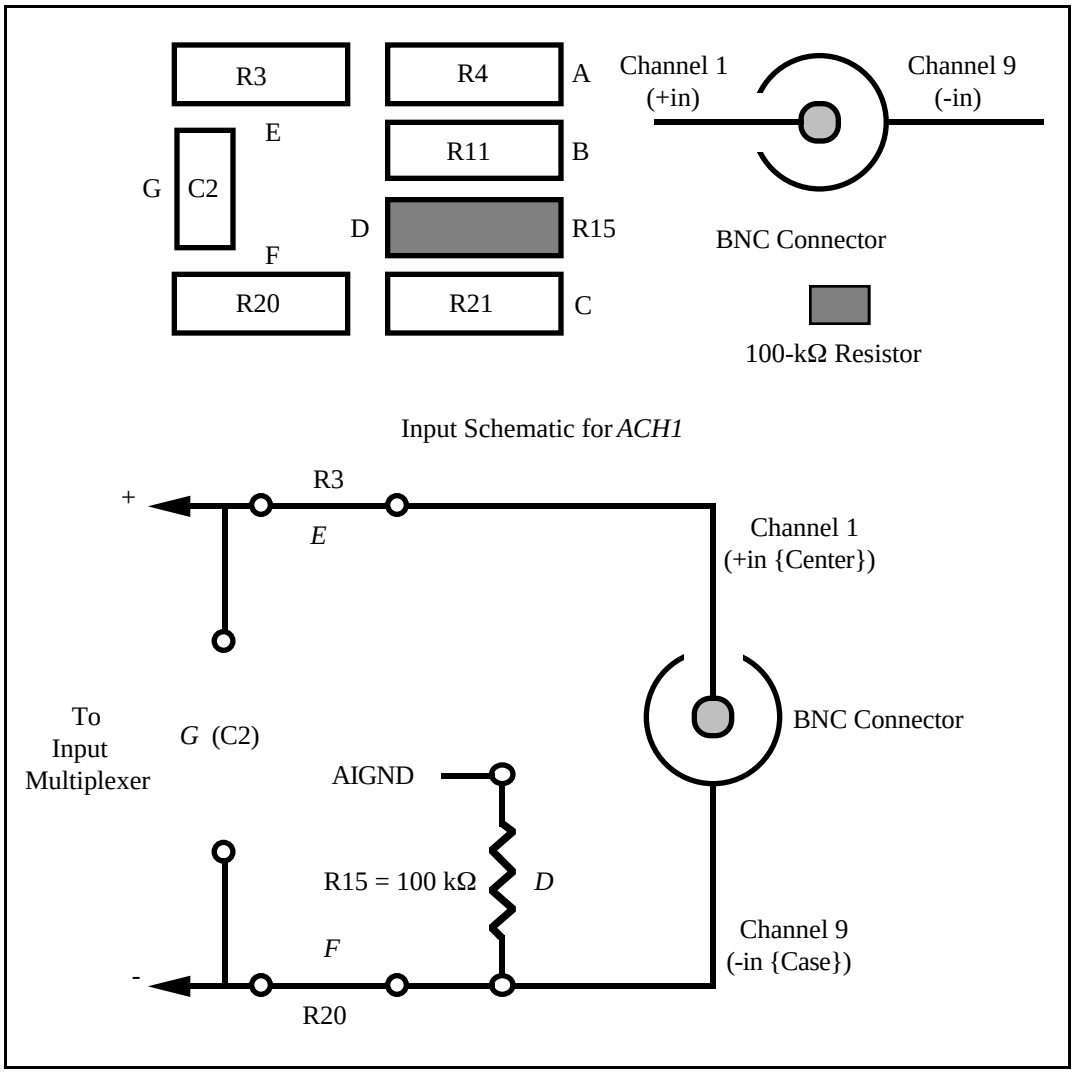


Figure 2-11. Bias Return Resistor for DC-Coupled Floating Source on Channel 1 in DIFF Mode

Single-Ended Inputs

When measuring floating signal sources, the MIO-16 board should be configured to supply a ground reference. Therefore, the MIO-16 should be configured for RSE mode. In this configuration, the negative input of the MIO-16 instrumentation amplifier is tied to the analog ground. Therefore, the BNC-2080 board should be used in its factory configuration. In the factory configuration, jumpers are in the two series positions, *E* and *F* (see Table 2-2). In this configuration, all of the signal grounds should be tied to AIGND. Signal conditioning circuitry such as filters and attenuators, as described in the sections titled *Building Lowpass Filters*, *Building Highpass Filters*, and *Building Attenuators (Voltage Dividers)* later in this chapter, can be built in the open component positions.

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Connecting Ground-Referenced Signal Sources

A grounded signal source is connected in some way to the building system ground; therefore, the signal source is already connected to a common ground point with respect to the data acquisition board (assuming the host computer is plugged into the same power system). The nonisolated outputs of instruments and devices that plug into the building power system fall into this category.

Differential Inputs

If the MIO-16 data acquisition board is configured for differential inputs, ground-referenced signal sources connected to the BNC-2080 board need no special components added to the BNC-2080 board. The inputs of the BNC-2080 board can be left in the factory-original condition, that is, with only jumpers in the two series positions, *E* and *F* (see Table 2-3). Signal conditioning circuitry, such as filters and attenuators, as described in the sections titled *Building Lowpass Filters*, *Building Highpass Filters*, and *Building Attenuators* (*Voltage Dividers*) later in this chapter, can be built in the open component positions.

Single-Ended Inputs

When measuring ground-referenced signals, the external signal supplies its own reference ground point and the MIO-16 should not supply one. Therefore, the MIO-16 board should be configured for the NRSE mode. In this configuration, all of the signal grounds should be tied to AISENSE, which connects to the negative input of the instrumentation amplifier on the MIO-16 board. The inputs of the BNC-2080 board can be left in the factory-original condition, that is, with jumpers in the series position (*E* or *F*, depending on the channel). The open positions that connect the input to AIGND, *B* and *D* (see Table 2-2 and Figure 2-3), should not be used in this configuration. Referencing the signal to AIGND can cause inaccurate measurements resulting from an incorrect ground reference.

Building Lowpass Filters

Simple, R-C lowpass filters are easily installed in the BNC-2080 board on any differential input channel. The filters are useful for accurate measurement and noise rejection. By substituting resistance and capacitance values into the following formula (hereafter referred to as Formula 2-1), you can calculate a simple, one-pole R-C filter to have a -3-dB point cutoff frequency (f_C):

$$f_C = \frac{1}{(2\pi RC)} \qquad \text{(Formula 2-1)}$$

The frequency response rolls off at a rate of -20 dB per decade of increase thereafter. A Bode plot of the amplitude versus normalized frequency is shown in Figure 2-12.

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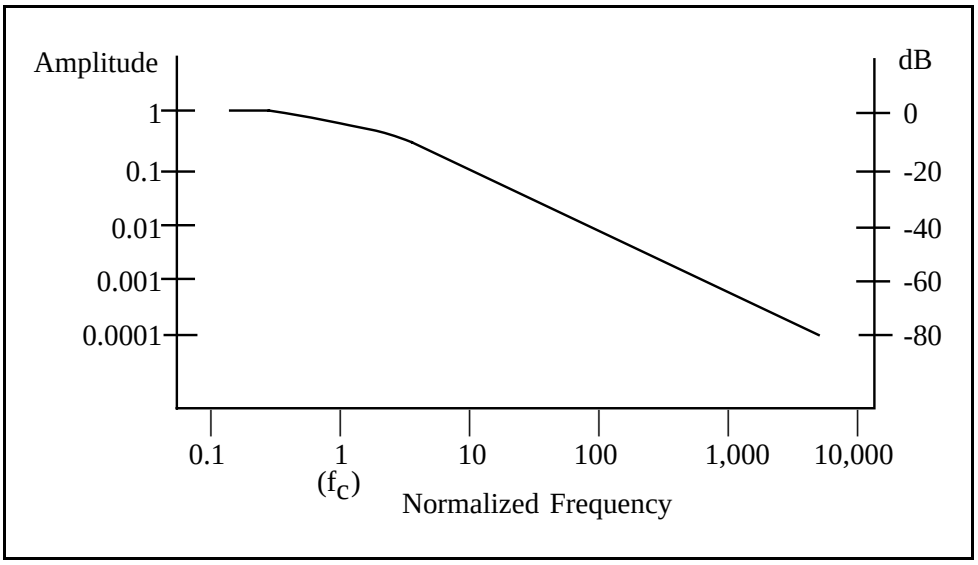


Figure 2-12. Normalized Frequency Response of Lowpass Filter

When measuring low-frequency signals (about 4 Hz), if you have 400-Hz noise on your inputs, you can add a lowpass filter with a cutoff frequency of 4 Hz. The 400-Hz noise then attenuates by 40 dB. Notice that your 4-Hz signal also attenuates, but by only 3 dB. Do not neglect any potential attenuation of signals of interest by this low-order filter.

You must also choose the filter component values. The resistance or the capacitance can be selected arbitrarily; one value determines the other. Picking the capacitor first and letting its value determine the resistance required is preferable because more standard resistor values are available. If a capacitance of 1 μF is available, the resistance is (by substitution into Formula 2-1) 39,789 Ω, or about 39.8 kΩ. This resistance must be divided by two to get the resistor value on each input of a differential channel. Therefore, in this example, each input has a 19.89-kΩ resistor (or the closest standard value) in its series positions, *E* and *F*. The closest standard 5% tolerance resistors are 20 kΩ. The closest standard 0.5% resistors are 19.8 kΩ. National Instruments recommends using 1% or better tolerance resistors in this application because differences between the resistor values degrade the common-mode rejection ratio (CMRR). Figure 2-13 shows both the schematic and the component placement for a 4-Hz lowpass filter placed on differential input Channel 1. If the input signal source is floating, a bias return resistor must be placed in the *D* position (*R15* in this case).

The BNC-2080 board open component locations do not facilitate R-C lowpass filters with the MIO-16 board configured for single-ended inputs. Therefore, if the MIO-16 board is configured for single-ended inputs, lowpass filters must be built on the custom breadboard area.

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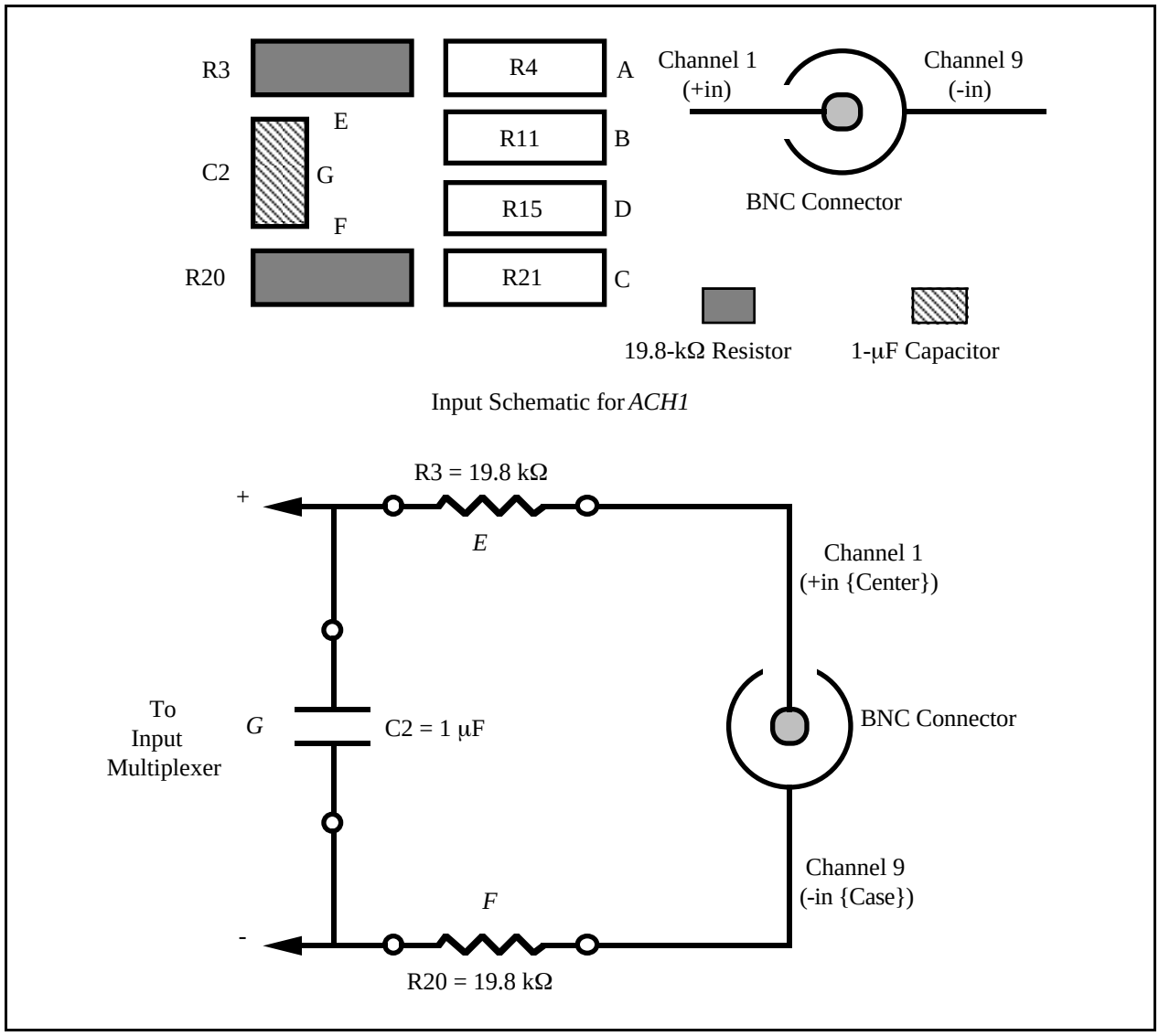


Figure 2-13. Lowpass Filter on Differential Channel 1

Building Highpass Filters

Simple, R-C highpass filters are easily installed in the BNC-2080 board on any differential input channel. The filters are useful for accurate high-frequency measurement and low-frequency noise rejection. By substituting resistance and capacitance values into the following formula, hereafter referred to as Formula 2-2, you can calculate a simple, one-pole R-C filter to have a -3-dB point f_C:

$$f_C = \frac{1}{(2\pi RC)} \qquad \text{(Formula 2-2)}$$

The frequency response rolls off at a rate of -20 dB per decade decrease thereafter. A Bode plot of the amplitude versus normalized frequency is shown in Figure 2-14.

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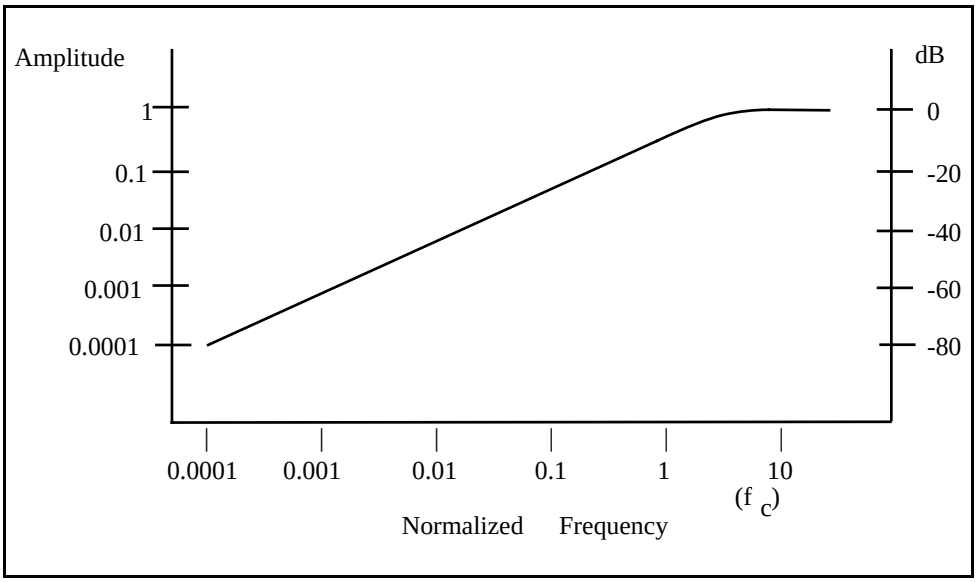


Figure 2-14. Normalized Frequency Response of Highpass Filter

When measuring high-frequency signals (about 50 kHz), if you have 50-Hz noise on your inputs, you can add a highpass filter with a cutoff frequency of 50 kHz. The 50-Hz noise then attenuates by 60 dB. Notice that your 50-kHz signal also attenuates, but by only 3 dB. Do not neglect any potential attenuation of signals of interest if you add a low-order filter.

You must also choose the filter component values. The resistance or the capacitance can be selected arbitrarily; one value determines the other. Picking the capacitor first and letting its value determine the resistance required is preferable because more standard resistor values are available. The filter circuit has one series capacitor on each input of the differential channel. Because the two capacitors are in series, the capacitance value that must be substituted into Formula 2-2 is the series capacitance of the two capacitors in series. For two capacitors in series, the net capacitance is the reciprocal of the sum of the reciprocals of the two capacitances. For example, two 0.001-µF capacitors in series have a net capacitance of 0.0005 µF. The two capacitors should be the same value, or the CMRR is degraded. If capacitors of 0.001 µF are available, the resistance is (by substitution into Formula 2-2) 6,366 Ω, or about 6.4 kΩ. Therefore, in this example, the input channel has a 6.37-kΩ resistor (or the closest standard value) in its capacitor position, *G*. The closest standard 5% tolerance resistors are 6.2 kΩ. The closest standard 1% resistors are 6.34 kΩ. Figure 2-15 shows both the schematic and the component placement for a 50-kHz highpass filter placed on differential input Channel 1. If the input signal source is floating, a bias return resistor must be placed in the *D* position (*R15* in this case).

Note: Highpass filters generally exhibit poorer common-mode rejection characteristics than lowpass filters because capacitors are in the series input paths. Capacitors have poorer tolerances than resistors, and matching of the input impedances is crucial for good common-mode rejection.

The BNC-2080 board open component locations do not facilitate R-C highpass filters with the MIO-16 board configured for single-ended inputs. Therefore, if the MIO-16 board is configured for single-ended inputs, highpass filters must be built on the custom breadboard area.

Note: Due to space constraints, when a resistor is inserted in position *G* (capacitor position) it must be inserted vertically before bending the other lead to the board.

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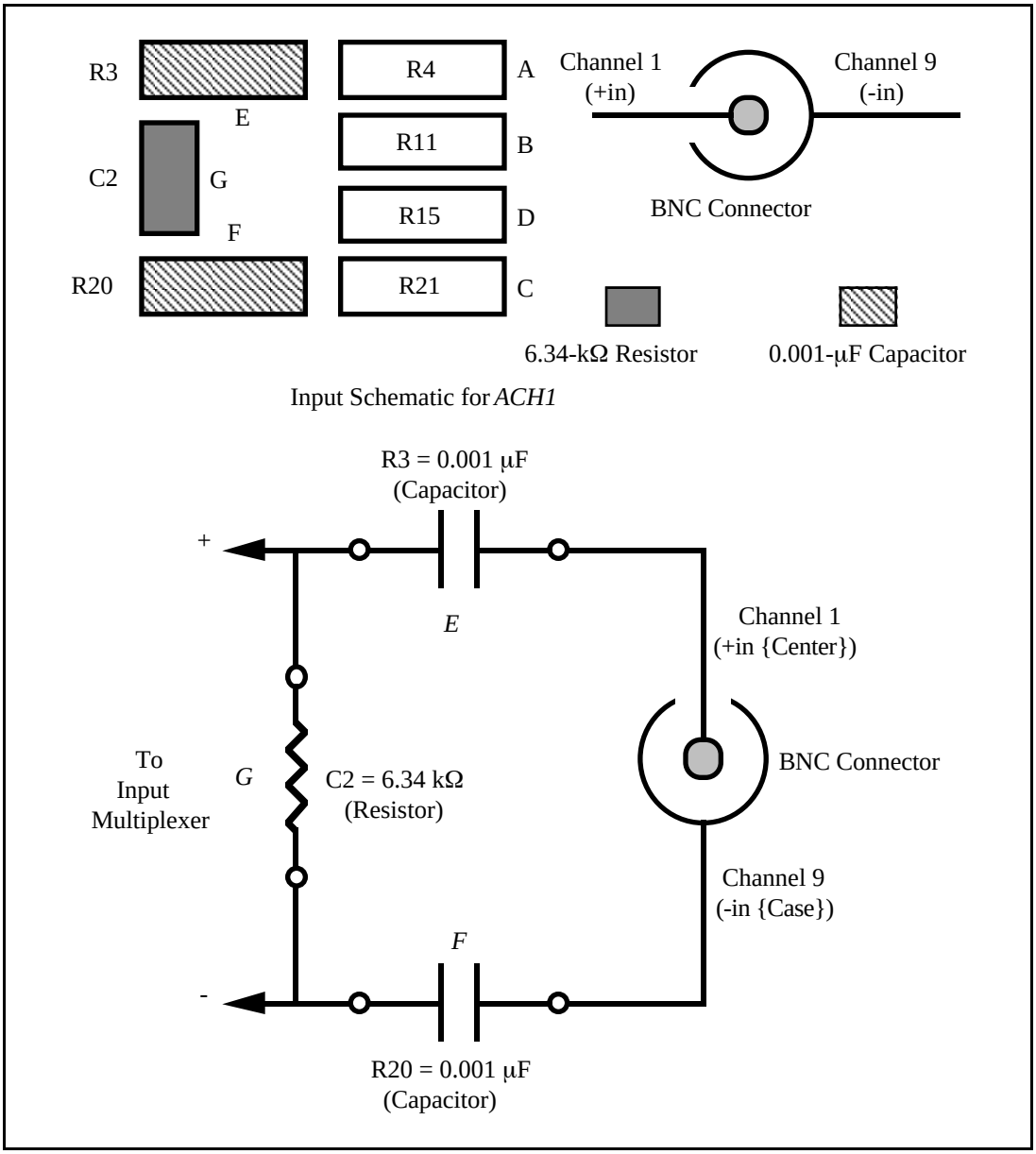


Figure 2-15. Highpass Filter on Differential Channel 1

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Building Attenuators (Voltage Dividers)

Attenuators can be connected to the analog inputs of the BNC-2080 board when the inputs from its data acquisition board are in DIFF mode. The BNC-2080 board open component positions do not facilitate voltage dividers with the MIO-16 board configured for single-ended inputs. Therefore, if the MIO-16 board is configured for single-ended inputs, attenuators must be built on a separate breadboard. Attenuators can be used to reduce a signal that is outside the normal input range of the data acquisition board (±10 V maximum).

Warning: The BNC-2080 board is not designed for any input voltages greater than 42 V, even if a user-installed voltage divider reduces the voltage to within the input range of the data acquisition board. Input voltages greater than 42 V can result in damage to the BNC-2080 board, any and all boards connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator. National Instruments is *not* liable for damage or injury resulting from such misuse.

A three-resistor circuit for attenuating voltages at the differential inputs of the BNC-2080 board is shown in Figure 2-16. The figure also shows the placement of the resistors on the open component positions for differential Channel 1. The gain *G* of this attenuator is given by the following formula:

$$G = \frac{R_G}{(R_E + R_F + R_G)} \qquad \text{(Formula 2-3)}$$

Therefore, the input to the MIO-16 board (V_{MIO}) is as follows:

$$V_{MIO} = V_{SC} * G$$

where V_{SC} is the voltage applied to the BNC connectors of the BNC-2080. The accuracy of this gain equation depends on the tolerances of the resistors used.

Note: Due to space constraints, when a resistor is to be inserted in position *G* (capacitor position) it must be inserted vertically before bending the other lead to the board.

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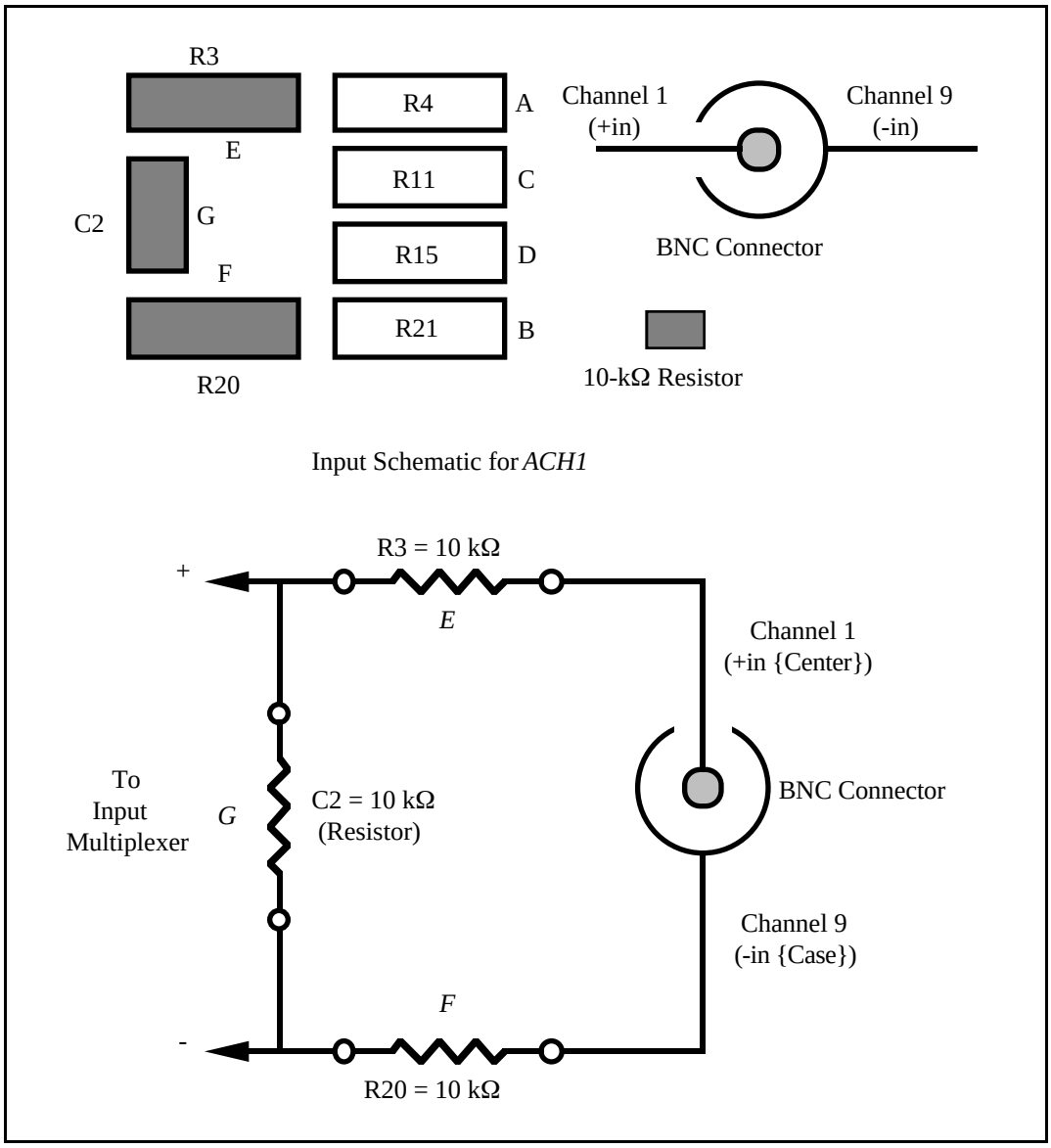


Figure 2-16. Attenuator for Use with Differential Inputs

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Example:

Using the values in Figure 2-13,

$$G = \frac{10\ k\Omega}{(10\ k\Omega + 10\ k\Omega + 10\ k\Omega)} = \frac{1}{3}$$

Therefore,

$$V_{MIO} = \frac{1}{3} \quad V_{SC}$$

When the MIO-16 is configured for ±10-V inputs, the board can acquire ±30-V signals with this attenuator circuit.

If the use of thermocouples is required in your applications, using National Instruments SC-2070 board is better suited for the task. The SC-2070 board is equipped with an onboard temperature sensor for use with thermocouple cold-junction compensation.

PC-LPM-16

The analog input section of an PC-LPM-16 data acquisition board consists of 16 ground-referenced single-ended channels; therefore, the only valid configuration for the BNC-2080 is also RSE mode. In this mode, all 16 analog input BNC connectors are used. Switches S1 through S4 and S6 through S9 must be in the SE position, and jumper W1 should be in the AIGND-COMMON position, as shown in Figure 2-17 and Figure 2-18, respectively.

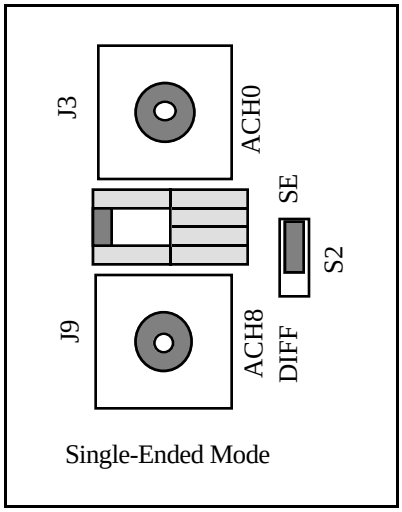


Figure 2-17. Switch Configurations for SE Mode (PC-LPM-16)

Note: All the switches are required to be in the same position; that is, S1 through S4 and S6 through S9 must all be in the SE position for use with the PC-LPM-16.

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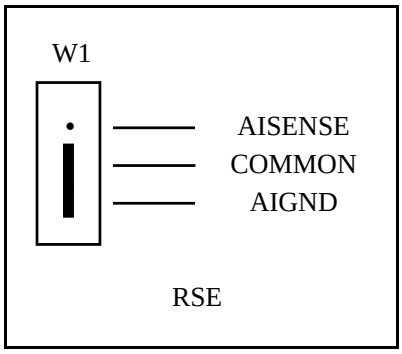


Figure 2-18. Ground Reference Jumper Position for Use with the PC-LPM-16

The application information given for MIO-16 in the RSE input mode also applies to the PC-LPM-16.

MIO-16 Analog Output

Analog output BNC connectors each have two open component positions for optional signal conditioning components. One of these is designated as a resistor and the other as a capacitor. The equivalent circuit for DAC0 OUT is shown in Figure 2-19. DAC1 OUT circuitry is identical to that of DAC0 OUT.

When the board is shipped, 0-Ω jumpers are inserted into the *R9* position. These can be easily removed to build passive analog output signal conditioning circuits such as voltage dividers and lowpass filters.

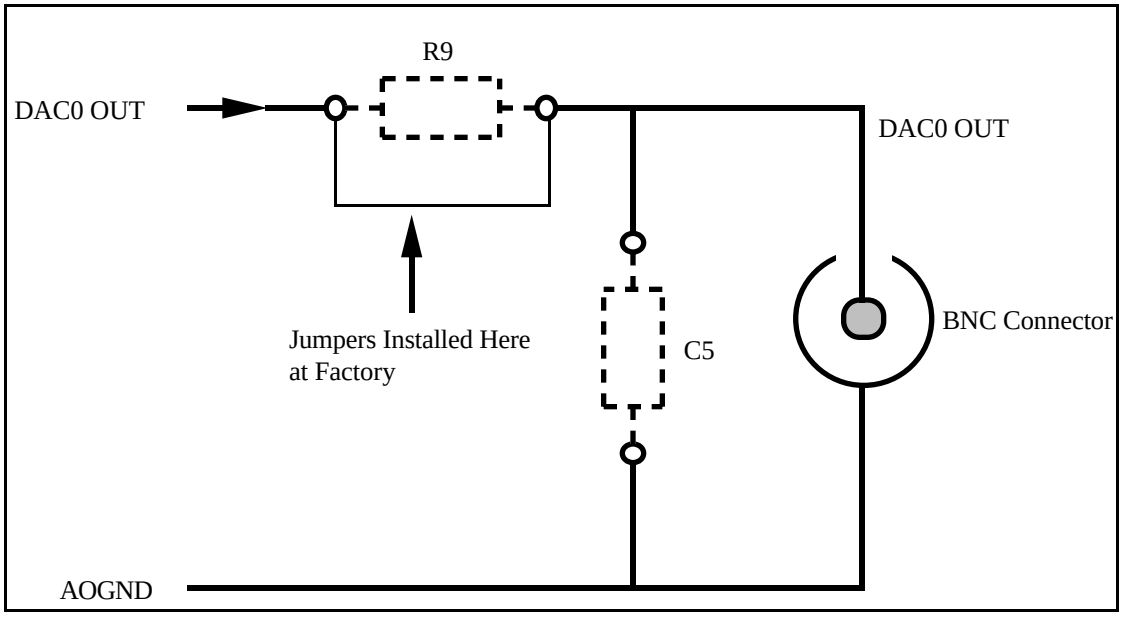


Figure 2-19. Analog Output Schematic for DACs, DAC0 OUT Shown

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Chapter 3
BNC-2081 Board

This chapter describes the BNC-2081 board in detail, including its function, specifications, compatibility, connection, mounting, and application notes.

The BNC-2081 is an analog breakout board that makes it easy to connect to all Lab data acquisition board analog signals, a few digital signals, and two user-defined connectors via BNC-type connectors. Analog input signal conditioning can be added, such as filters and dividers. All other Lab signals can be accessed by solder holes in the board located next to the Lab input connectors. In addition, there is a connector to provide access to all digital I/O ports. This connector is in the standard pinout for connection to one of National Instruments DIO-24 boards.

The BNC-2081 board is used with the National Instruments Lab data acquisition boards for the Macintosh (Lab-NB and Lab-LC), IBM PC/XT/AT, and compatible computers (Lab-PC and Lab-PC+).

Figure 3-1 shows the BNC-2081 board.

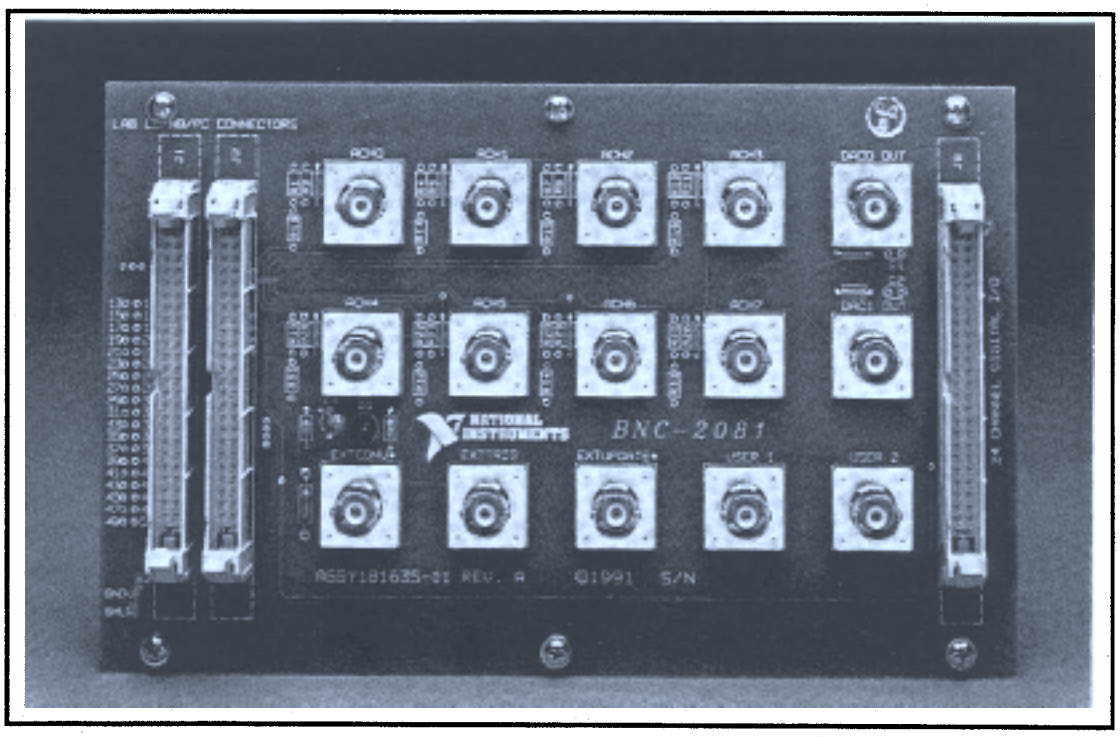


Figure 3-1. BNC-2081 Analog Breakout Board

The BNC-2081 board has BNC connectors for eight single-ended input channels. Open component positions at each analog input facilitate the addition of user-selected signal conditioning. With open component positions in the input paths, you can insert user-supplied resistors and capacitors for conditioning the eight single-ended analog input signals.

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Figure 3-2 illustrates the parts locator diagram for the BNC-2081 board.

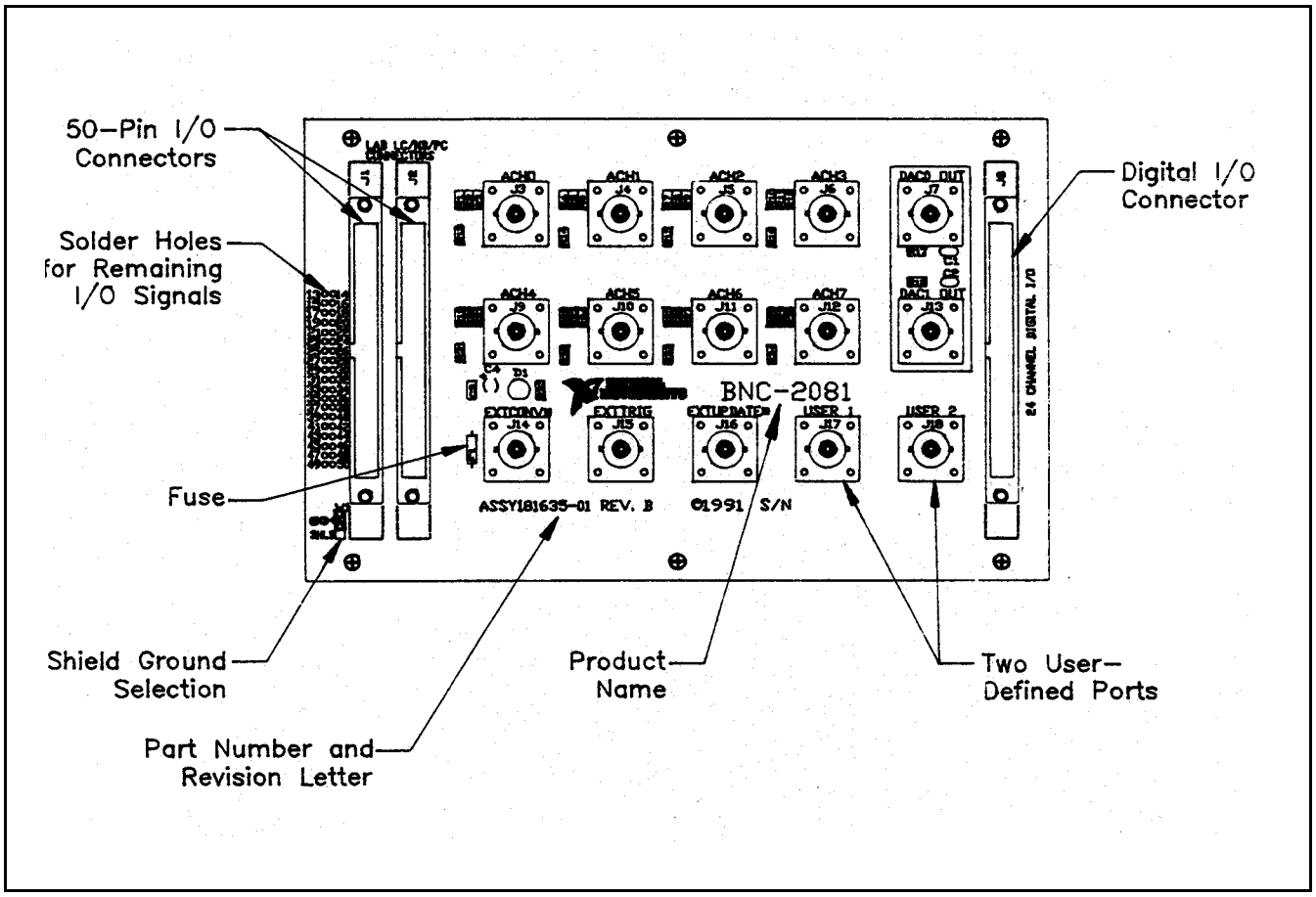


Figure 3-2. BNC-2081 Board Parts Locator Diagram

Analog Input

Each analog input has four open positions for signal conditioning components. All signal conditioning components are designated as resistors, but capacitors can be inserted for the construction of R-C filters. The board is shipped with wire jumpers in one position for each input. The equivalent circuit of one input is shown in Figure 3-3. For specific applications illustrating signal conditioning with single-ended inputs, refer to *Application Notes* later in this chapter.

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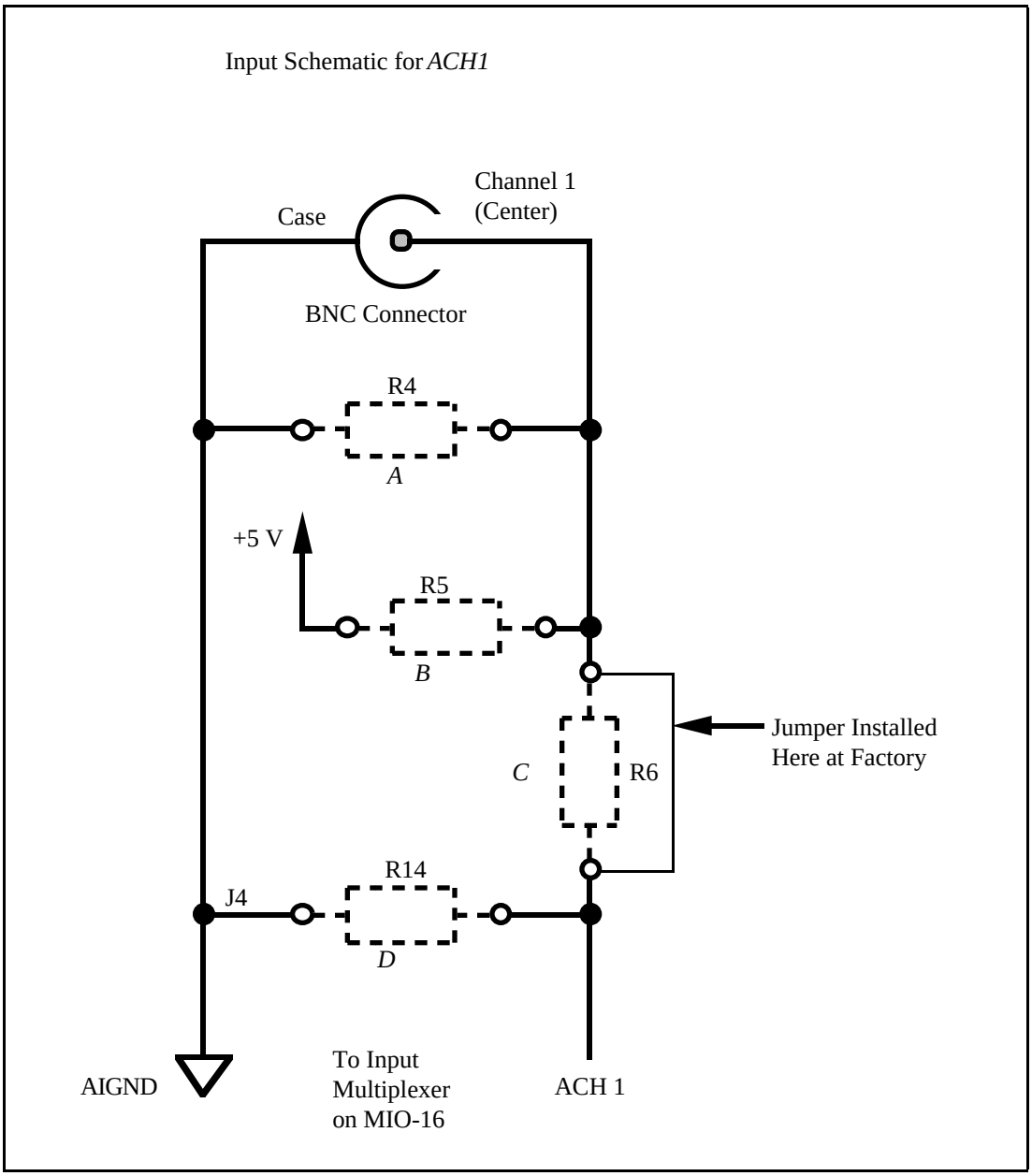


Figure 3-3. Onboard Equivalent Circuit

The components are numbered differently for each channel. Table 3-1 is a listing of the components in each channel and their correspondence to the circuit shown in Figure 3-3.

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Table 3-1. Component Positions in Each Channel

Channel	Position in Figure 3-3			
	A	**B**	**C**	**D**
0	R1	R2	R3	R13
1	R4	R5	R6	R14
2	R7	R8	R9	R15
3	R10	R11	R12	R16
4	R19	R20	R21	R31
5	R22	R23	R24	R32
6	R25	R26	R27	R33
7	R28	R29	R30	R34

When the board is shipped, a jumper is inserted in the *C* position of the input network. The jumper can be easily removed to build analog input signal conditioning circuits. A few specific applications showing the use of these open component positions are discussed in *Application Notes* later in this chapter.

Shield Ground

Jumper W1 is used to connect digital ground (DGND) to a grounded metal case. This option is useful only if the BNC-2081 board is on metal standoffs and mounted in a grounded metal case. Shield grounding can be selected to reduce noise.

Figure 3-4 shows the jumper settings for W1.

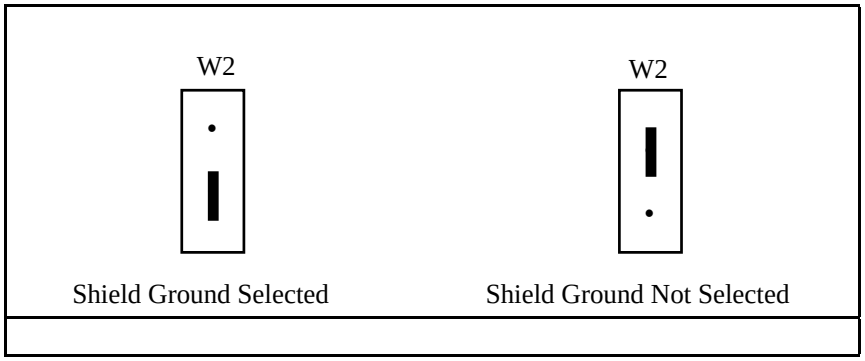


Figure 3-4. W1 Jumper Settings

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Fuse and Power LED

The +5-V line from the data acquisition board is protected by a 750-mA fuse. If the red power LED does not light when the data acquisition board is powered on, check the 750-mA fuse on the BNC-2081 board and the output fuse (if any) on the Lab data acquisition board. Information on power connection is given in Chapter 4, *Installation and Connections*.

Digital and Timing Signals

All of the signals from the Lab data acquisition board are made available either by BNC connectors or via solder holes on the BNC-2081 board. Because these signals are not conditioned or changed in any way by this board, refer to your Lab board user manual for information on the use of these signals. If you want screw terminal access to all signals, a National Instruments SC-2071 board can be used in conjunction with the BNC-2081 board. If you want optical isolation of or relay control by the digital I/O lines, you must use a National Instruments SC-2053 cable adapter board and the appropriate SC-206X Series digital signal conditioning board. For more information on these products, refer to either your National Instruments catalog, the *SC-205X Series User Manual*, the *SC-206X Series User Manual*, or the *SC-207X Series User Manual*.

Specifications

This section lists the specifications of the BNC-2081 analog breakout board. These ratings are typical at 25° C unless otherwise stated. The operating temperature range for this board is 0° to 70° C.

Analog Input

Number of channels	Eight single-ended
Field connections	15 BNC connectors
Signal conditioning capability	Four open component positions per channel that include connections from the input to ground, +5 V, and a series connection to the input of the data acquisition board
Other signals	Solder holes for remaining Lab board I/O signals
DIO connector	DIO-24 connector for digital ports

Power Requirements

Power consumption (at +5 VDC ±5%)	
Typical	12 mA with no user circuitry connected
Maximum	750 mA from host computer

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Note: The power specifications pertain to the power supply of the host computer. The maximum power consumption of the BNC-2081 board is a function of the signal conditioning components installed. If the board is being powered from the host computer, the maximum +5-V current is fuse-limited to 750 mA.

Physical

Board dimensions (including standoffs)	7.9 by 4.9 by 1.725 in.
I/O connectors	Three 50-pin male ribbon-cable connectors
BNC connectors	15

Operating Environment

Temperature	0° to 70° C
Relative humidity	5% to 90% noncondensing

Storage Environment

Temperature	-55° to 125° C
Relative humidity	5% to 90% noncondensing

Board-to-Board Cabling

The BNC-2081 board directly connects to any of the data acquisition boards listed in Table 3-2.

Table 3-2. Data Acquisition Boards Used with the BNC-2081 Board

	Lab Board (PC/XT and Macintosh NuBus)
BNC-2081 Board	Lab-LC Lab-NB Lab-PC Lab-PC+

The BNC-2081 board directly connects to the Lab-PC, Lab-PC+ and Lab-NB using the 50-pin NB1 cable supplied with the BNC-2081. The Lab-LC board connects to the BNC-2081 using an NB10 cable, available separately.

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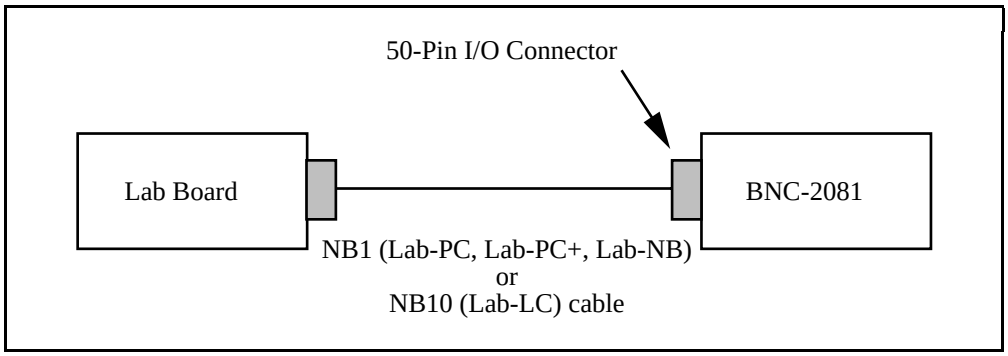


Figure 3-5. Direct Connection between a Lab Board and the BNC-2081 Board

For digital signal conditioning with the National Instruments SC-206X Series boards, the SC-2053 cable adapter board must be used with the Lab board. Figure 3-6 shows a connection using the SC-2053 cable adapter board.

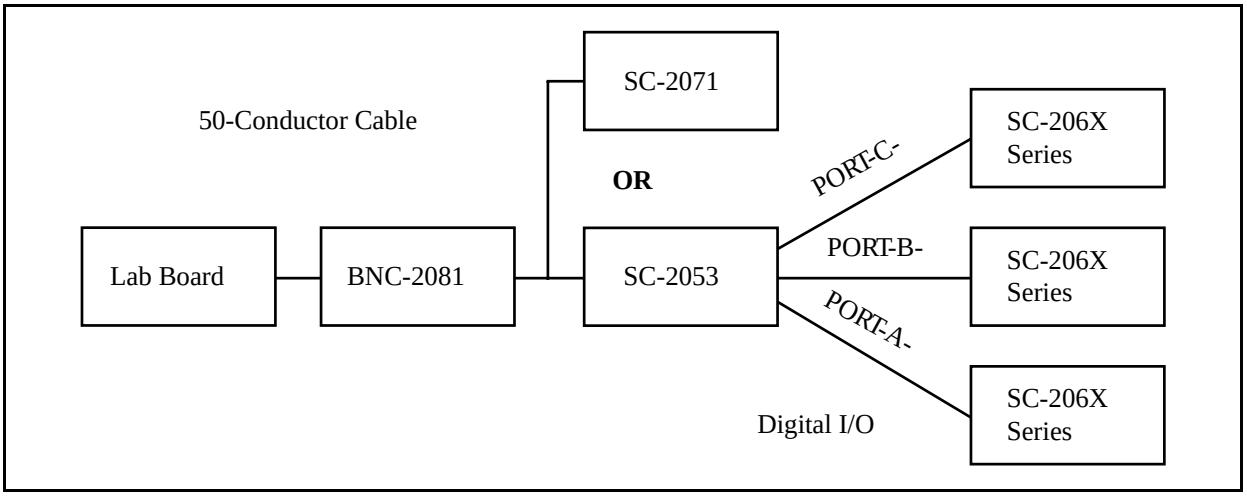


Figure 3-6. Connection between a Lab Board, the BNC-2081, and the SC-2071 Board, or the Connection between a Lab Board, the BNC-2081, and the SC-206X Series Board, via the SC-2053 Board

Warning: Do not connect the BNC-2081 board to any board other than a National Instruments Lab data acquisition board, the SC-2053 cable adapter board, or the SC-2071 board. The BNC-2081 board is not compatible with any other data acquisition boards or cable adapter boards. Attempts to use the BNC-2081 board with products for which it was not intended can result in damage to the BNC-2081 board, the data acquisition board, or the host computer. National Instruments is *not* liable for damages resulting from these connections.

The BNC-2081 board uses a 50-pin ribbon-cable connector to connect to the 50-pin I/O connector on either a Lab data acquisition board, an SC-2053 cable adapter board, or the SC-2071. If the BNC-2081 board is to be used with the SC-2053 or the SC-2071 boards and is mounted in a rack, the cable should run underneath the BNC-2081 board for easier access to the BNC-2081. For more information, see Chapter 4, *Installation and Connections*.

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Mounting

The BNC-2081 board is equipped with metal standoffs so the board can be placed on a workbench near the host computer. You can use an optional rack-mount chassis, which can be fitted with a flat, acrylic plastic cover. When the BNC-2081 board is mounted in the chassis, the board can be grounded to its metal standoffs, and therefore to the rack. For more information, see Chapter 4, *Installation and Connections*.

Application Notes

The open component positions on the BNC-2081 board make adding signal conditioning components to the analog input signals easier. Several applications are covered in this section, including filtering and attenuation.

The figures in this section give examples on a specific input channel. If you want to install the circuit on a different channel, consult Table 3-1 to determine the equivalent component positions for the other channels.

Soldering and Desoldering on the BNC-2081 Board

With the applications discussed here, you must make modifications to the printed circuit board, usually by removing jumpers and adding components. The BNC-2081 board is shipped with one jumper in the *C* position (see Table 3-1 and Figure 3-3). Use a low-wattage soldering iron (20 to 30 W) when soldering to the board. To desolder on the BNC-2081, vacuum-type tools work best. Use care when desoldering to avoid damaging component pads. Only rosin-core, electronic-grade solder should be used. Acid-core solder damages the printed circuit board and components.

Connecting Nonreferenced (or Floating) Signal Sources

A floating signal source is a signal source that is not connected in any way to the building ground system, but has an isolated ground-reference point. If an instrument or device has an isolated output, that instrument or device falls into the floating signal source category. Some examples of floating signal sources are outputs for: thermocouples, transformers, battery-powered devices, optical isolators, and isolation amplifiers. The ground reference of a floating source must be tied to the ground of the data acquisition board.

No special components are needed to measure signals from floating sources connected to the BNC-2081 board. Because the negative side of the single-ended inputs is grounded, all floating sources are referenced to the same ground. The inputs of the BNC-2081 board can be left in the factory-original condition, that is, with a jumper in the series position, *C* (see Table 3-1). Signal conditioning circuitry, such as the filters and attenuators described in *Building Lowpass Filters*, *Building Highpass Filters*, and *Building Attenuators* (*Voltage Dividers*) later in this chapter, can be used.

Connecting Ground-Referenced Signal Sources

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A grounded signal source is connected in some way to the building system ground; therefore, the signal source is already connected to a common ground point with respect to the data acquisition board, assuming the host computer is plugged into the same power system. The nonisolated outputs of instruments and devices that plug into the building power system fall into this category.

In the case of grounded signal sources connected to the single-ended inputs of the BNC-2081 board, a small DC error can be measured because of differences between the ground potentials of the signal source and the Lab board. This error is unavoidable with the BNC-2081 board because the Lab data acquisition board is configured only for RSE. No special components are needed to measure signals from grounded sources connected to the BNC-2081 board. The inputs of the BNC-2081 board can be left in the factory-original condition, that is, with a jumper in the series position *C* (see Table 3-1 and Figure 3-3). Signal conditioning circuitry such as the filters and attenuators as described in the sections titled *Building Lowpass Filters*, *Building Highpass Filters*, and *Building Attenuators* (*Voltage Dividers*) later in this chapter, can be used.

Building Lowpass Filters

Simple, R-C lowpass filters are easily installed in the BNC-2081 board on any input channel. The filters are useful for accurate measurement and noise rejection. By substituting resistance and capacitance values into the following formula (hereafter referred to as Formula 3-1), you can calculate a simple, one-pole R-C filter to have a -3-dB point f_C:

$$f_C = \frac{1}{(2\pi RC)} \qquad \text{(Formula 3-1)}$$

The frequency response rolls off at a rate of -20 dB per decade of increase thereafter. A Bode plot of the amplitude versus normalized frequency is shown in Figure 3-7.

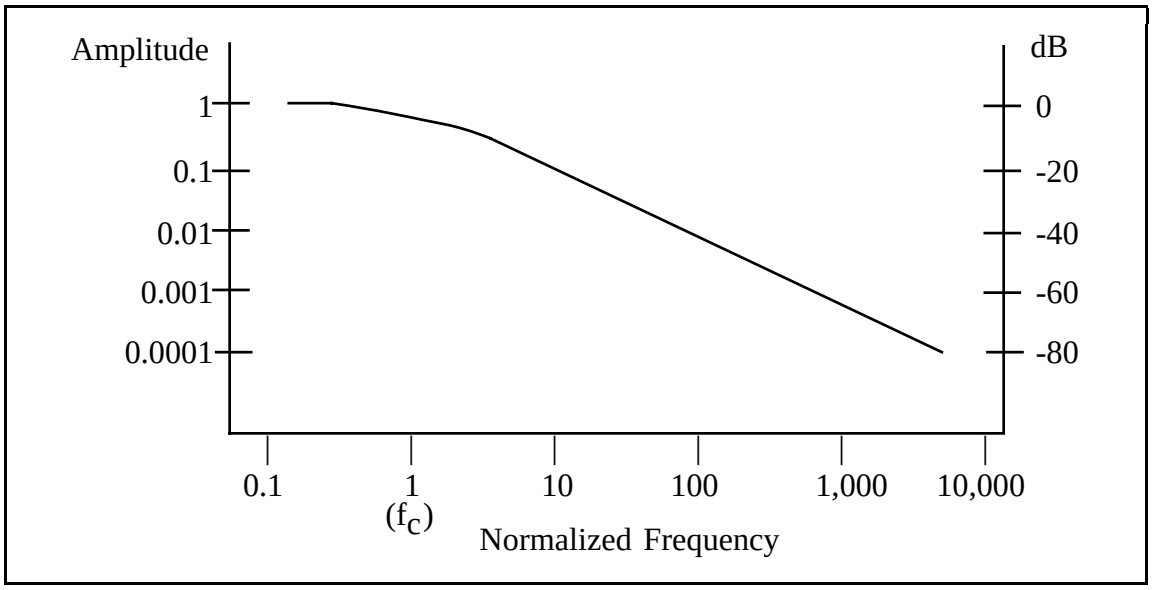


Figure 3-7. Normalized Frequency Response of Lowpass Filter

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When measuring low-frequency signals (about 4 Hz), if you have 400-Hz noise on your inputs, you can add a lowpass filter with a cutoff frequency of 4 Hz. The 400-Hz noise then attenuates by 40 dB. Notice that your 4-Hz signal also attenuates, but by only 3 dB. Do not neglect any potential attenuation of signals of interest by this low-order filter.

You must also choose the filter component values. The resistance or the capacitance can be selected arbitrarily; one value determines the other. Picking the capacitor first and letting its value determine the resistance required is preferable because more standard resistor values are available. If a capacitance of 1 µF is available, then the resistance is, by substitution into Formula 3-1,
39,789 Ω, or about 39.80 kΩ. Therefore, in this example, the input has a 39.80-kΩ resistor (or the closest standard value) in its series position, *C*. The closest standard 5%-tolerance resistor is
39 kΩ. For a lowpass filter on a single-ended input, 5%-tolerance resistors suffice. Figure 3-8 shows both the schematic and the component placement for a 4-Hz lowpass filter placed on Channel 1.

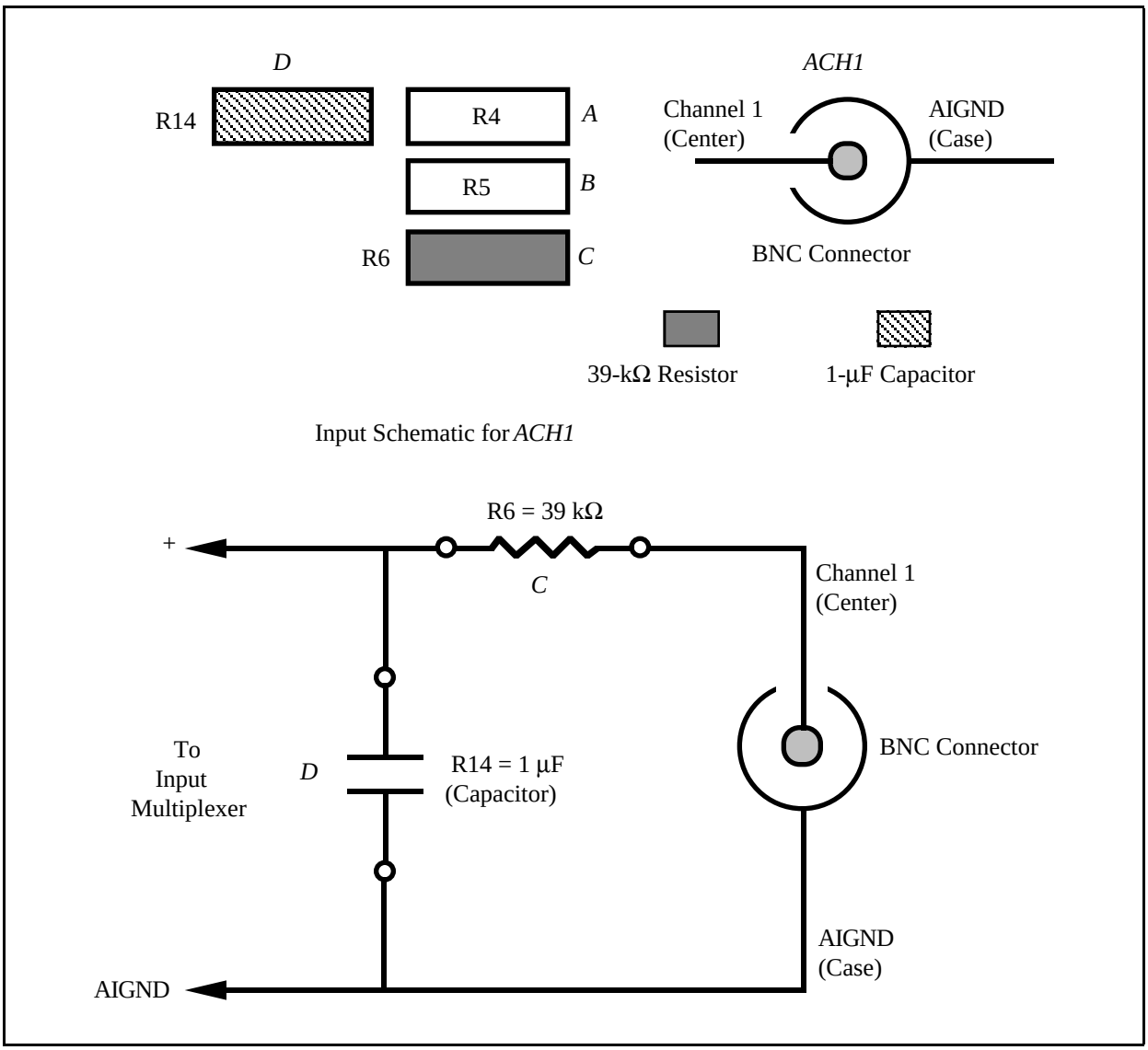


Figure 3-8. Lowpass Filter on Channel 1

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Building Highpass Filters

Simple, R-C highpass filters are easily installed in the BNC-2081 board on any input channel. The filters are useful for accurate high-frequency measurement and low-frequency noise rejection. By substituting resistance and capacitance values into the following formula (hereafter referred to as Formula 3-2), you can calculate a simple, one-pole R-C filter to have a -3-dB point f_C:

$$f_C = \frac{1}{(2\pi RC)} \qquad \text{(Formula 3-2)}$$

The response rolls off at a rate of -20 dB per decade drop in frequency thereafter. A Bode plot of the amplitude versus normalized frequency is shown in Figure 3-9.

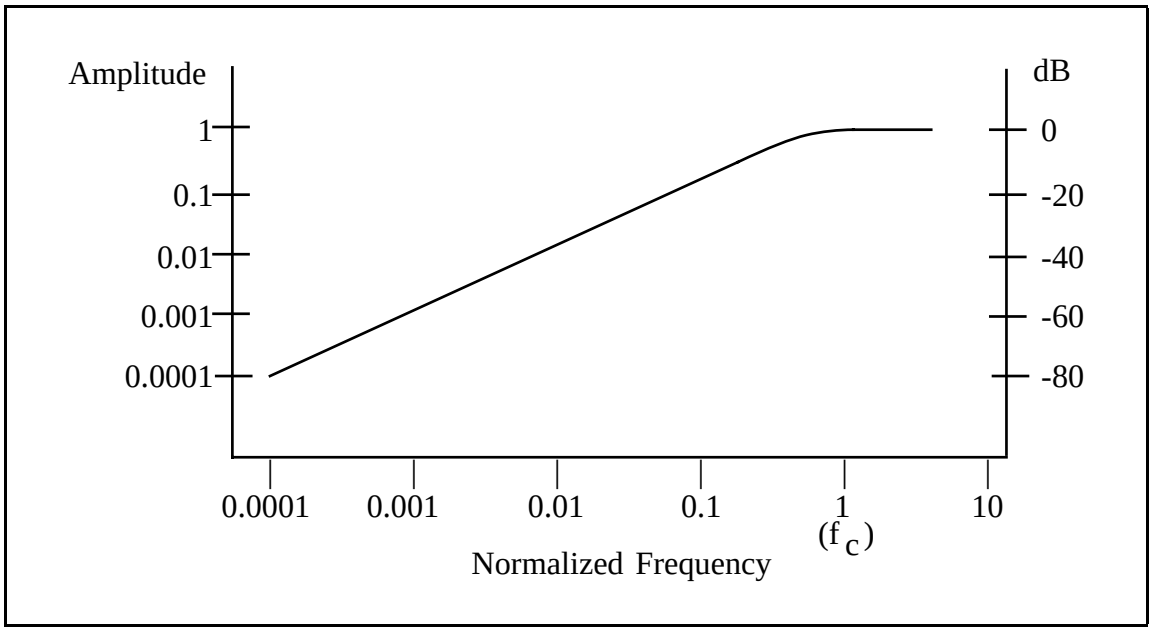


Figure 3-9. Normalized Frequency Response of Highpass Filter

When measuring high-frequency signals (about 20 kHz), if you have 20-Hz noise on your inputs, you can add a highpass filter with a cutoff frequency of 20 kHz. The 20-Hz noise then attenuates by 60 dB. Notice that your 20-kHz signal also attenuates, but by only 3 dB. Do not neglect any potential attenuation of signals of interest if you add a low-order filter.

You must also choose the filter component values. The resistance or the capacitance can be selected arbitrarily; one value determines the other. Picking the capacitor first and letting its value determine the resistance required is preferable because more standard resistor values are available. If a 0.001-µF capacitor is available, the resistance is (by substitution into Formula 3-2) 7,958 Ω, or about 8.0 kΩ. Therefore, in this example, the input channel has a 7.96-kΩ resistor (or the closest standard value) in position *D* and a 0.001-µF capacitor in position *C*. The closest standard 5% tolerance resistor is 8.2 kΩ. Resistor tolerance is not a concern in this application because most capacitors have poor tolerances (for example, 20% to 30%). Figure 3-10 illustrates both the schematic and the component placement for a 20-kHz highpass filter placed on input Channel 1.

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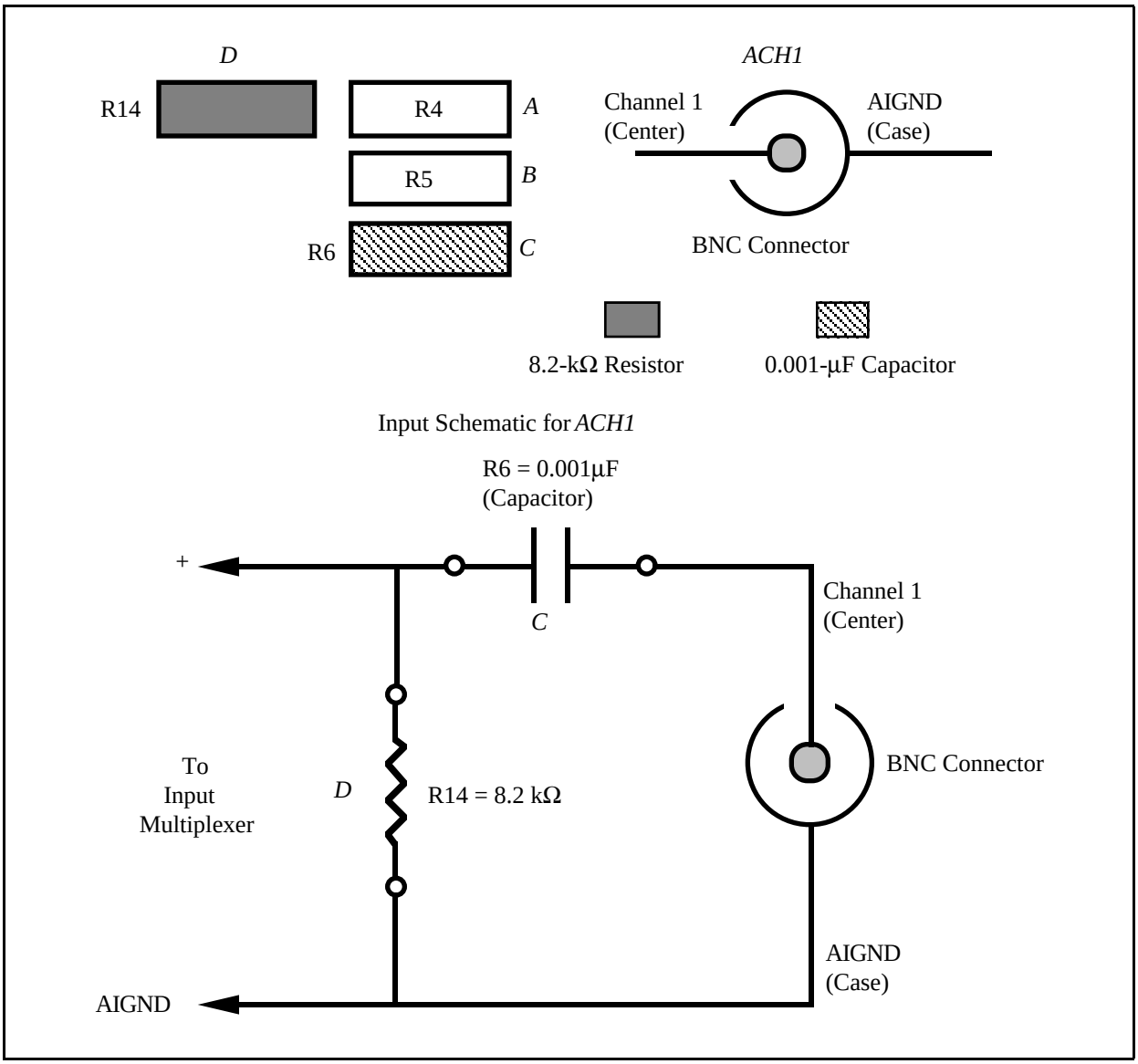


Figure 3-10. Highpass Filter on Channel 1

Building Attenuators (Voltage Dividers)

Attenuators can be connected to the analog inputs of the BNC-2081 board. Attenuators can be used to reduce a signal that is outside the normal input range of the data acquisition board (±10 V maximum).

Warning: The BNC-2081 board is not designed for any input voltages greater than 42 V, even if a user-installed voltage divider reduces the voltage to within the input range of the data acquisition board. Input voltages greater than 42 V can result in damage to the BNC-2081 board, any and all boards connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator. National Instruments is *not* liable for damage or injury resulting from such misuse.

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A two-resistor circuit for attenuating voltages at the single-ended inputs of the BNC-2081 board is shown in Figure 3-11. The figure also shows the placement of the resistors on the open component positions for Channel 1. The gain, *G*, of this attenuator is given by the following formula:

$$G = \frac{R_D}{(R_C + R_D)} \qquad \text{(Formula 3-3)}$$

Therefore, the input to the Lab board (V_{Lab}) is as follows:

$$V_{Lab} = V_{SC} * G$$

where V_{SC} is the voltage applied to the BNC connectors of the BNC-2081 board. The accuracy of this gain equation depends on the tolerances of the resistors used. The input impedence of the channel with the voltage attenuator is $R_C + R_D$. This should be kept sufficiently high to avoid any loading effect on the voltage you are measuring.

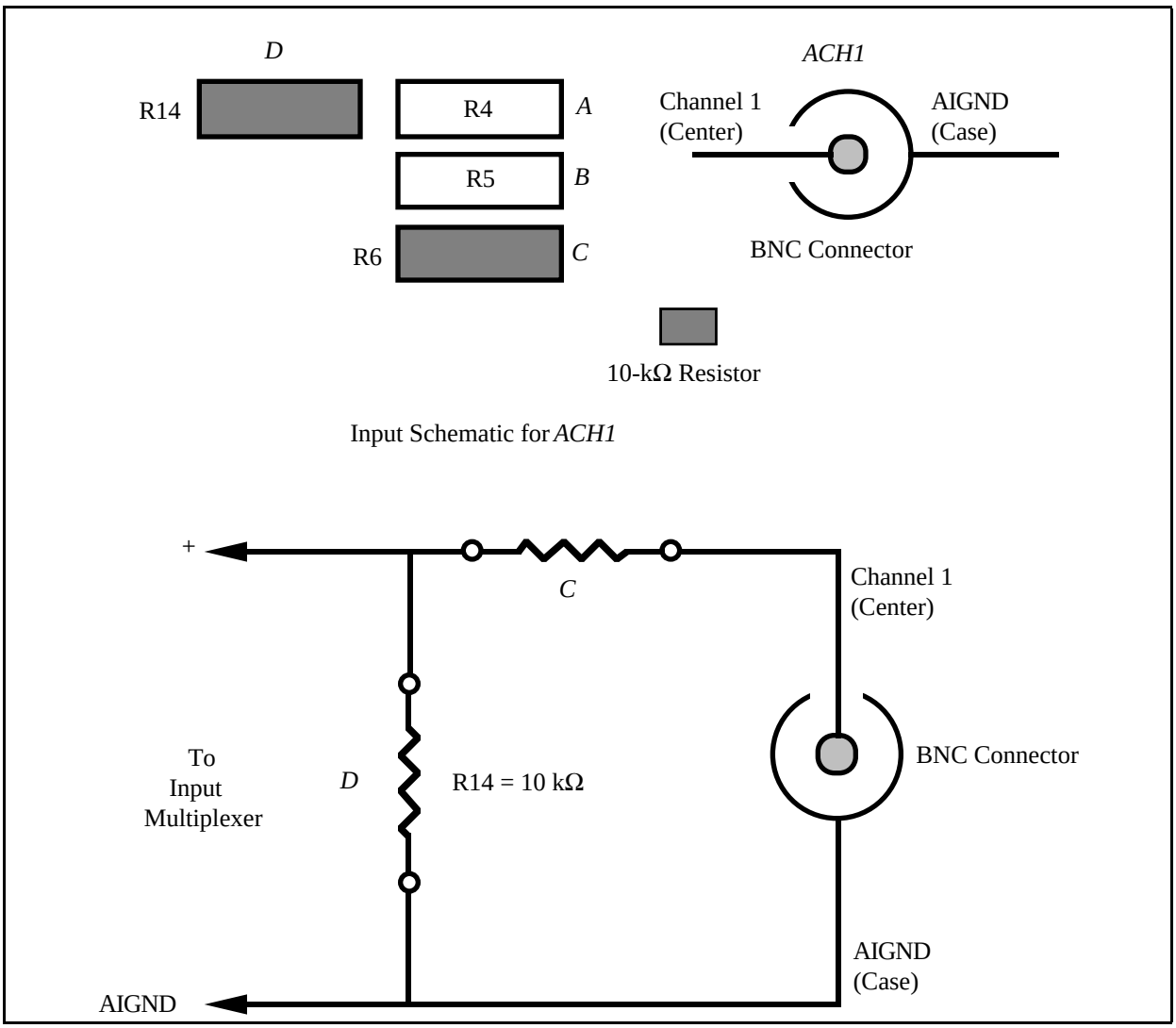


Figure 3-11. Attenuator for Use with BNC-2081 Board Inputs

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Example:

Using the values in Figure 3-12,

$$G = \frac{10\ k\Omega}{10\ k\Omega + 10\ k\Omega} = \frac{1}{2}$$

Therefore, $V_{Lab} = (1/2)\ V_{SC}$

When the Lab board is configured for ±5-V inputs, the board can acquire ±10-V signals with this attenuator circuit. The input impedence of the circuit is 10 kΩ + 10 kΩ = 20 kΩ. The source impedence of the circuit is as follows:

10 kΩ || 10 kΩ = 5 kΩ.

Lab Board Analog Output

Analog output BNC connectors each have two open component positions for optional signal conditioning components. One of these is designated as a resistor and the other as a capacitor. The equivalent circuit for DAC0 OUT is shown in Figure 3-12. Circuitry for DAC1 OUT is the same.

When the board is shipped, 0-Ω jumpers are inserted into the *R17* an *R18* positions. These can be easily removed to build passive analog output signal conditioning circuits such as voltage dividers and lowpass filters. Figure 3-12 shows the DAC0 OUT schematic. Figure 3-13 shows the analog output schematic for DACs with DAC0 OUT shown.

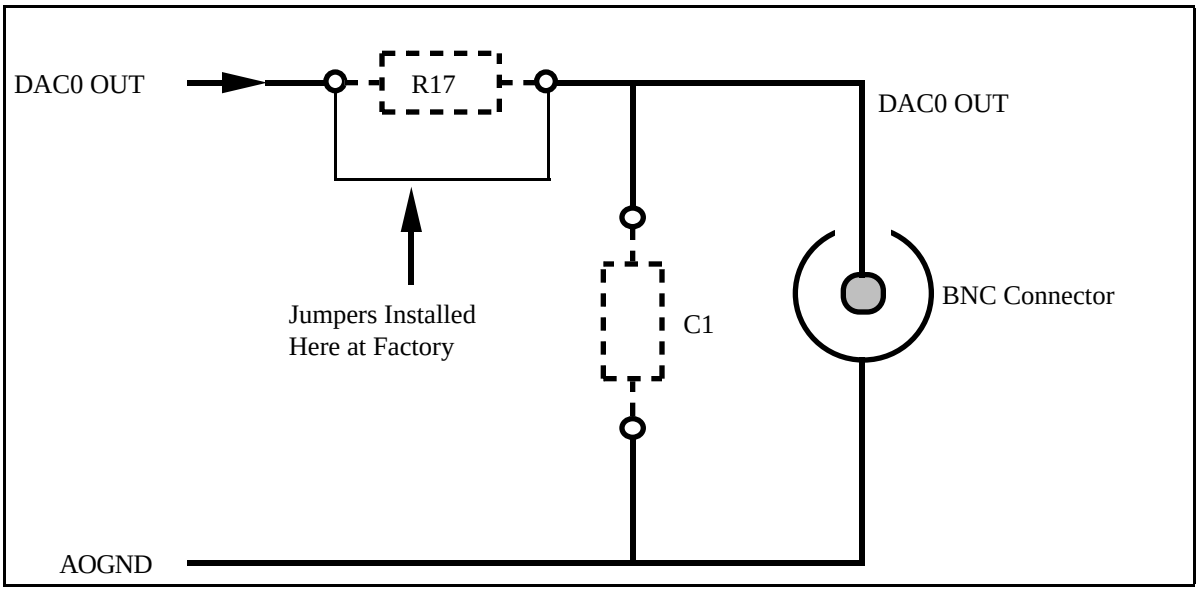


Figure 3-12. DAC0 OUT Schematic

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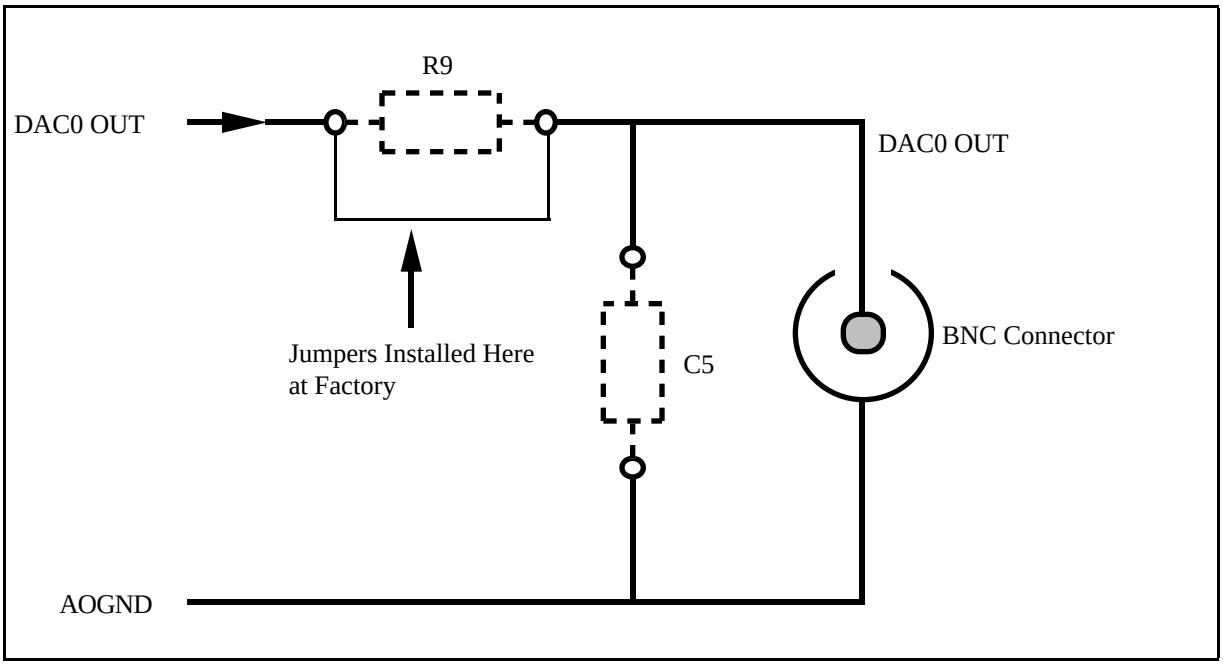


Figure 3-13. Analog Output Schematic for DACs, DAC0 OUT Shown

Additional Signal Connection Information

For more information about signal connection, refer to Chapter 2 of your Lab board user manual.

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Chapter 4
Installation and Connections

This chapter explains how to install and make connections to the BNC-208X Series boards.

Hardware Installation

Most of the sections that follow apply to all the BNC-208X Series boards. However, several topics are more board-specific than others. Unless a given topic is delineated by board, the topic applies to all BNC-208X Series boards.

Hardware Installation for the BNC-2080 and the BNC-2081

The following are general instructions for installing your BNC-2080 or BNC-2081 board in your computer data acquisition system. Consult the user manual or technical reference manual of your computer for specific instructions and warnings. Notice that the installation instructions are the same for both BNC-2080 and the BNC-2081 boards.

Caution: Turn the host computer off before making any connections.

1. Determine what signal conditioning is desired for the analog inputs and install the necessary components into the open component positions. If no signal conditioning is needed on an input, then the factory-installed jumpers (on the BNC-2080) or jumper (on the BNC-2081) must be in place.

2. Check that jumpers W1 and W2 (on the BNC-2080) and jumper W1 (on the BNC-2081) are set correctly for the current application.

3. Mount the BNC-208X Series board into a 19-in. rack (optional).

4. Connect the BNC-208X Series board to the data acquisition board using a 50-pin ribbon cable. (If an SC-205X Series board or SC-207X Series board is used with the BNC-208X Series board, install and mount the SC-205X Series and SC-207X Series boards as instructed in the *SC-205X Series User Manual* and the *SC-207X Series User Manual*. Then connect the SC-207X Series board and the SC-205X Series board to the BNC-208X Series board using the 50-pin cable. Connect the BNC-208X Series board to the data acquisition board.)

5. Connect field signals to the BNC-208X Series board at the BNC connectors or solder holes in the board for remaining digital signals.

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6. Attach the appropriate cover to the rack mount (optional).

7. Turn the computer on.

8. When finished, turn off any powered external signals to the BNC-208X Series board before turning off the computer.

Warning: The BNC-208X Series boards have not been designed for use with high voltage. Although the open component positions are configured so that voltage dividers can be installed to reduce a high input voltage to within the ±10-V data acquisition board input range, the maximum safe input voltage at any point on the BNC-208X Series boards is 42-V peak. Input voltages larger than 42 V, even if attenuated by a voltage divider on the BNC-208X Series board, can result in damage to the BNC-208X Series board, the data acquisition boards, or the host computer. High voltage can also cause an electric shock hazard to you. National Instruments is *not* liable for damages or injuries resulting from these connections.

Installing the SC-205X Series Cable Adapter Boards

Consult the *SC-205X Series User Manual* for instructions on the installation of your SC-205X Series board if any of these boards are being used.

Installing the SC-207X General-Purpose Termination Breadboards

Consult the *SC-207X Series User Manual* for instructions on the installation of your SC-207X Series board if any of these boards are being used.

Rack Mounting

Your BNC-208X Series board can be installed on half of a 19-in. rack-mount chassis. You can mount one BNC-208X Series board alongside an SC-205X Series cable adapter board, an SC-206X Series digital signal conditioning board, or an SC-207X Series general-purpose termination breadboard. You can mount your BNC-208X Series board on the left or right side of the 19-in. rack mount. Mounting the BNC-208X Series board on the left side of the rack and any other of the SC Series boards on the right side of the rack will make access to both boards easier. Run the connecting 50-position cable underneath the BNC-208X Series board to the adjoining board. The BNC-208X Series board occupies half of a 19-in. rack, as shown in Figure 4-1 and Figure 4-2.

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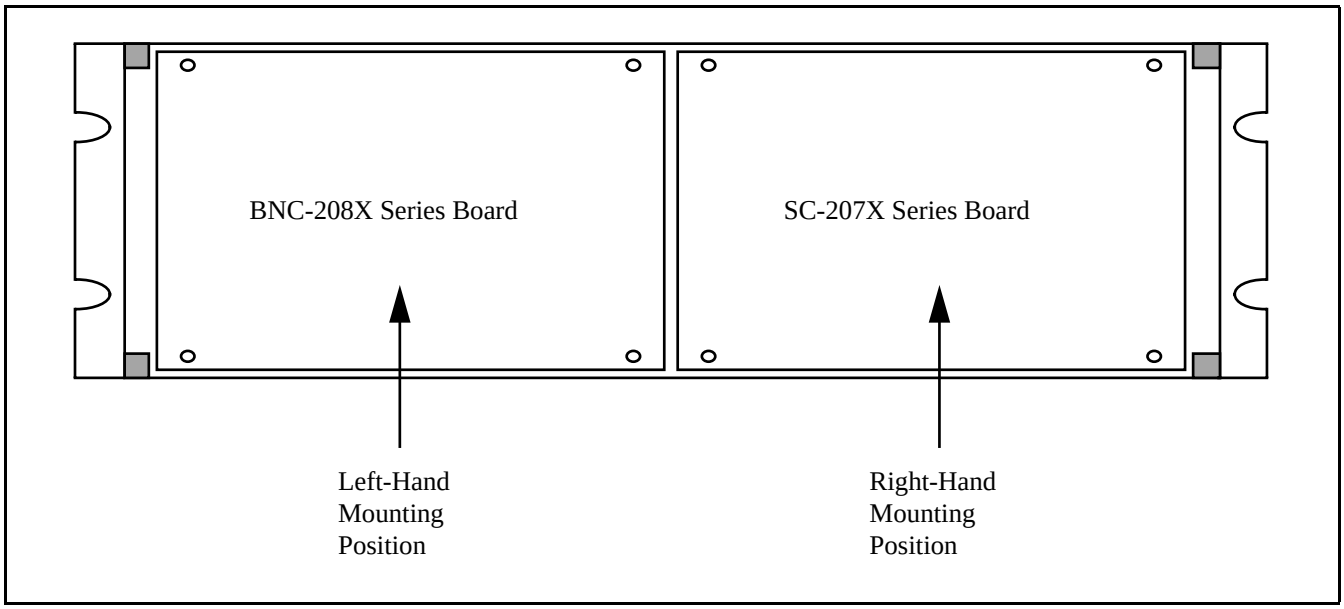


Figure 4-1. Mounting Locations for the BNC-208X Series Board and SC-207X Series Board

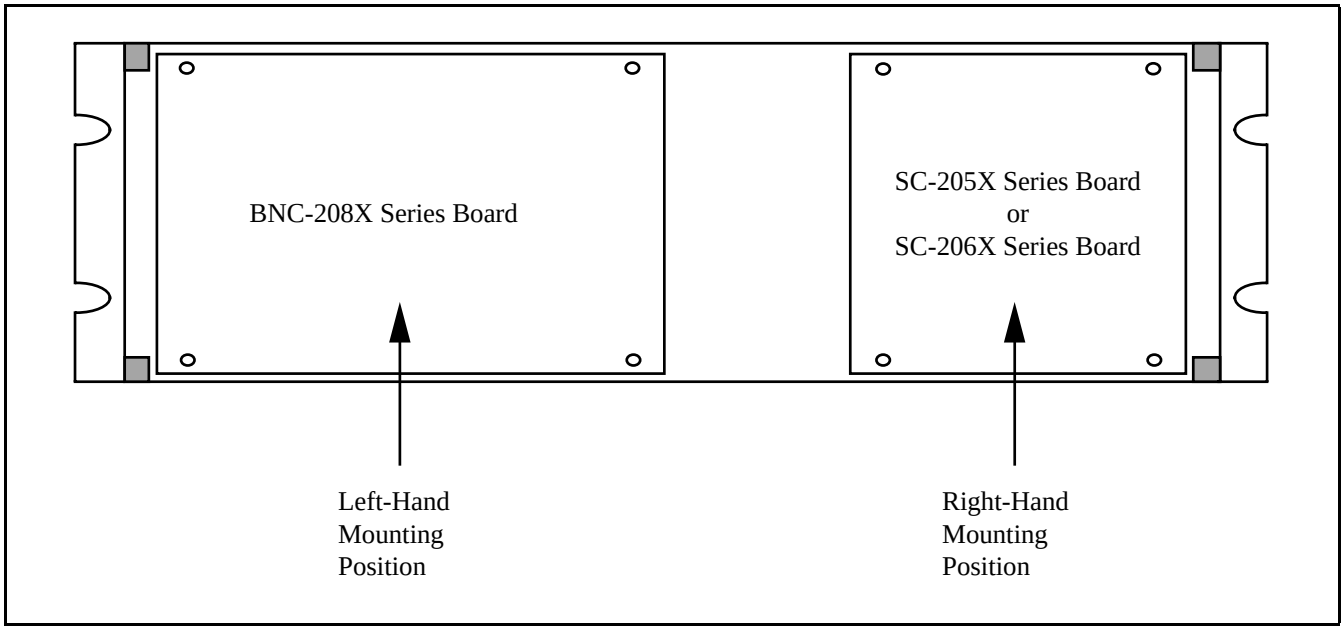


Figure 4-2. Mounting Locations for the BNC-208X Series Board and SC-205X Series Board or SC-206X Series Board

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Mount the BNC-208X Series board in the chassis by removing the screws on the bottoms of the four standoffs attached to the board and using the same screws to attach the board to the mounting rack. The two standoffs in the center of the board are for support only and have no screws to attach the board to the rack as shown in Figure 4-3.

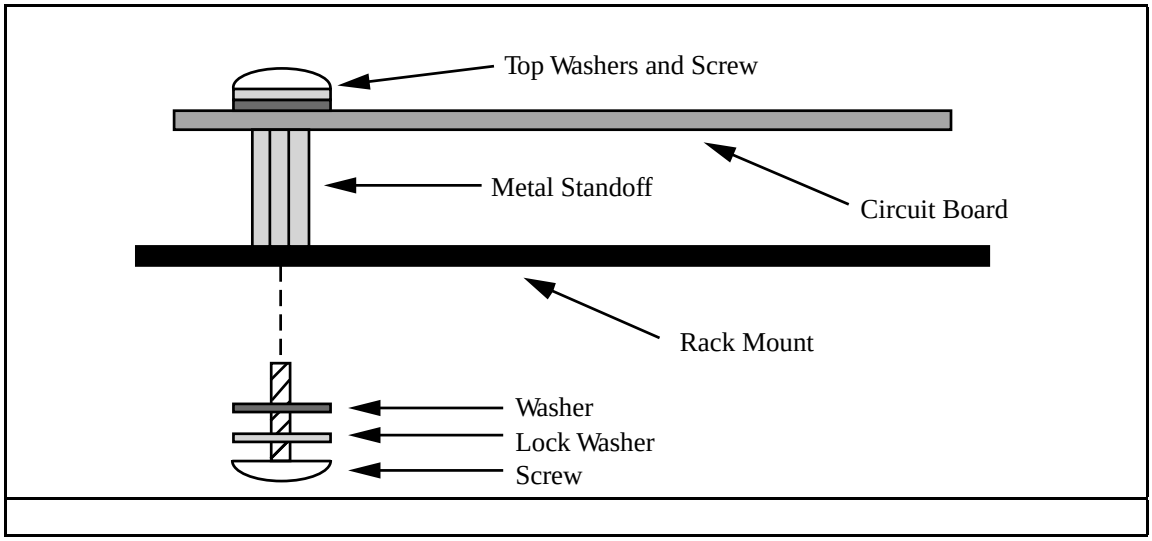


Figure 4-3. Attaching a Mountable Board to the Chassis

Be sure to include the washers around the screws when attaching your board to the rack mount as shown in Figure 4-3.

Notice that jumper W2 (BNC-2080) and jumper W1 (BNC-2081) can connect the digital ground for both boards to the metal standoffs attached to the board. Rack mounting does not automatically ground the boards to the metal chassis unless the appropriate jumper is set.

If two BNC-208X Series boards connected to different data acquisition boards need to be stacked, double-height mounting within one rack-mount chassis is possible. Because only one BNC-208X Series board can be used with each data acquisition board, this situation occurs only if two or more data acquisition boards are being used. You need a hardware kit for double-height mounting consisting of two brackets that are installed in the rack mount. A second row of boards can be mounted on these brackets in the same way as the first row.

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Figure 4-4 illustrates double-height mounting.

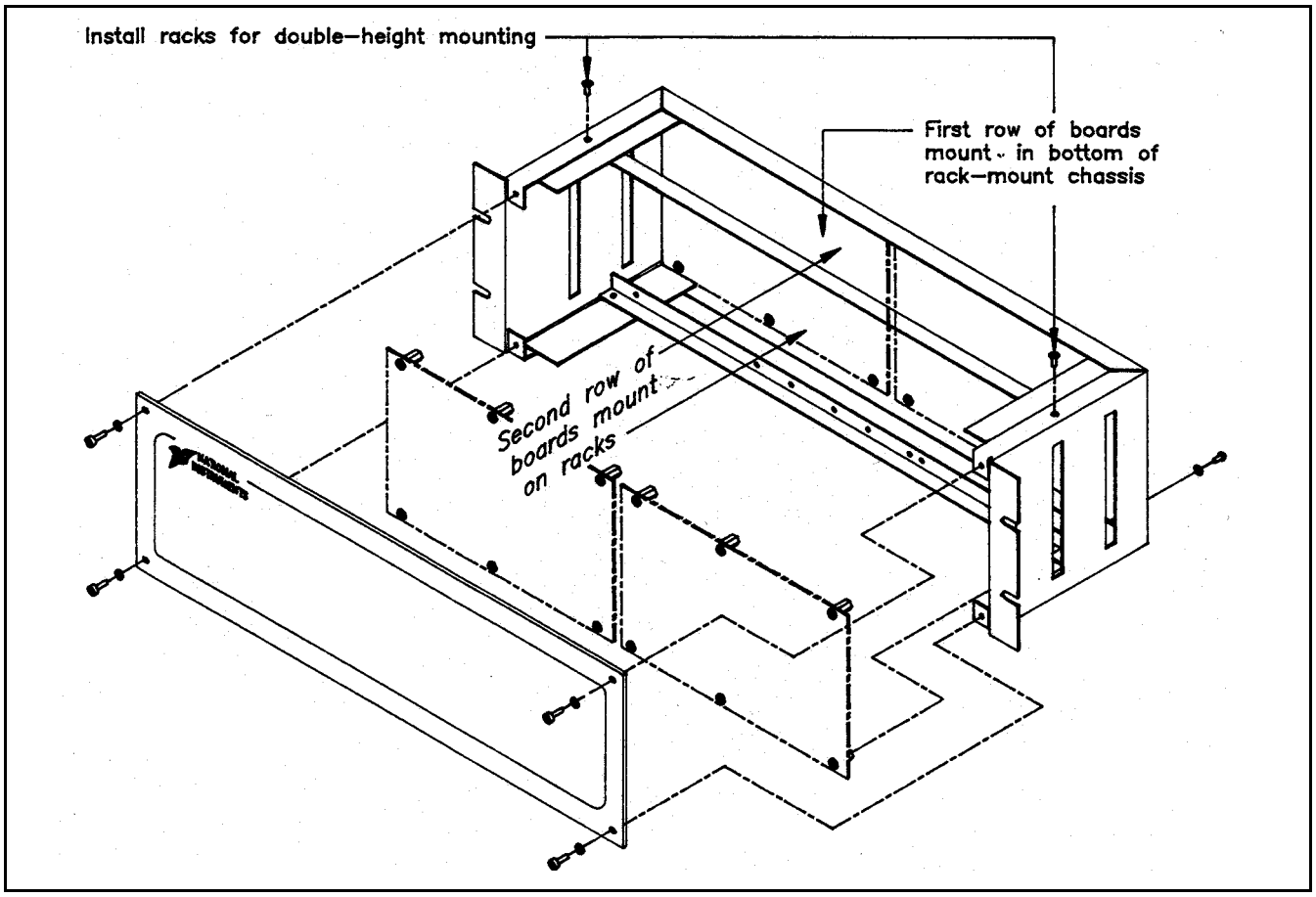


Figure 4-4. Double-Height Mounting

External Power Connection (If Necessary)

Your BNC-208X Series board draws very little current from the computer power supply. If several high-current SC-206X Series digital signal conditioning boards, such as the SC-2062 board, are being used on the same data acquisition board as the BNC-208X Series board, some of these boards need to be powered by an external +5-VDC supply. Because the SC-206X Series boards draw much more current than the SC-207X Series or the BNC-208X Series, the SC-206X Series boards should be powered from the external supply, and the SC-207X Series board or the BNC-208X Series board can be run from the host computer power supply. If an external power supply is needed for the SC-206X or SC-207X Series boards, see the *External Power Connection* section of the *SC-206X Series User Manual* and the *SC-207X Series User Manual*.

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BNC-208X Series Board Connection

Figure 4-5 illustrates the connections from the BNC-2080 or BNC-2081 boards directly to data acquisition boards via a 50-conductor cable and to other SC-Series boards, using an appropriate cable.

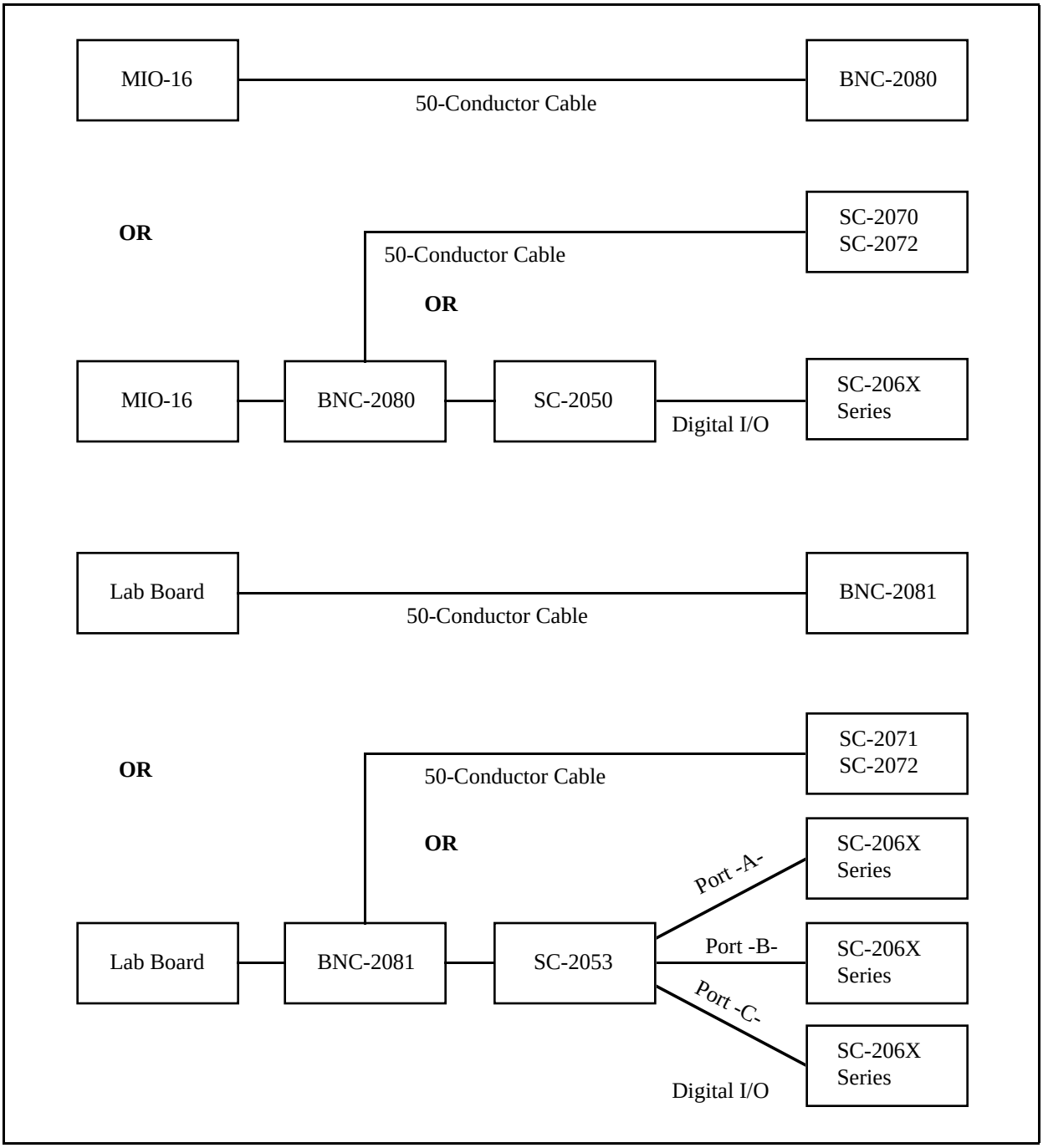


Figure 4-5. Connections between Data Acquisition Boards and BNC-208X Series Boards and between SC-205X Series Boards and BNC-2080 and BNC-2081 Boards

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A 50-pin ribbon cable connects your BNC-208X Series board to either an SC-205X Series board, an SC-207X Series board, or directly to the data acquisition board. Remember to turn the host computer off before making any connections. One end of the ribbon cable connects to the BNC-208X Series board at connector J1 or J2. The other end of the ribbon cable connects either to the data acquisition board or to one of the two 50-pin headers on the SC-205X Series board or the SC-207X Series board you installed for use with the data acquisition board. Connecting the data acquisition board to J2 and using J1 (running cable under board) to daisy chain to any other board in the rack is the easiest method for connecting two or more boards to the MIO-16.

Signal Connections

Ribbon-Cable Connectors

The pinout for the 50-pin ribbon-cable connector on the BNC-2080 board is exactly the same as the 50-pin connector on the MIO-16 and LPM-16 data acquisition boards. The pinout for the 50-pin ribbon-cable connector on the BNC-2081 board is exactly the same as the 50-pin connector on the Lab data acquisition board. For more information on these connectors, refer to your data acquisition board user manual.

Rack-Mount Chassis Cover Attachment

The optional 19-in. rack-mount accessory includes a flat, acrylic plastic cover that can be installed using the four screws included in the kit. Covering the top and bottom is required for safety reasons if an SC-206X Series board in the same enclosure is to be used in high-voltage situations. Remember that voltages above the 42-V peak cannot be applied to the SC-207X Series inputs.

Warning: The SC-206X Series boards *must be completely enclosed* if any onboard voltages or any voltages connected to the relays can exceed 42 V.

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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 _____

_____

_____

_____

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List any error messages _____

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