Model 7002-HD-MUX1 Differential Long Life Quad 1 × 40 Multiplexer Card

User's Manual

7002HDMUX1-900-01 Rev. A / November 2004

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number 7002HDMUX1-900-01).....November 2004

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting ca-

bles or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol indicates a connection terminal to the equipment frame.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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List of Tables

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1 General Information

Section 1 topics

Introduction

This section contains general information about the Model 7002-HD-MUX1 Differential Quad 1 x 40 Multiplexer Card. The Model 7002-HD-MUX1 is equipped with quad 40-channel multiplexers and a 4 x 4 interconnect matrix.

Features

Key features include:

- Differential Quad 1 x 40 multiplexer with programmable multiplex expansion and matrix input switching
- Card can be expanded for 1 x 80 and 1 x 160 configurations using built-in matrix switching
- 200V DC or 200V rms (283V peak AC) switching with 1A, 60W, 125VA maximum

Warranty information

Warranty information is located on the inside front cover of this manual. Should your Model 7002-HD-MUX1 require warranty service, contact the Keithley representative or authorized repair facility in your area for more information. When returning the card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

Manual addenda

Any improvements or changes concerning the card or manual will be explained in an addendum included with the card.

Return to **Section 1 topics**

Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

If a  screw is present, connect it to safety earth ground using the wire recommended in the documentation.

The  symbol on equipment indicates that you should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol indicates a connection terminal to the equipment frame.

The **WARNING** heading used in this manual explains dangers that could result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the multiplexer card. Such damage may invalidate the warranty.

Specifications

Model 7002-HD-MUX1 specifications are located at the end of this manual.

Unpacking and inspection

Inspection for damage

The Model 7002-HD-MUX1 is packaged in a re-sealable, anti-static bag to protect it from damage due to static discharge and from contamination that could degrade its performance. Before removing the card from the bag, observe the following handling precautions.

Handling precautions

- Always grasp the card by the side edges and covers. Do not touch the board surfaces or components.
- After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any damage to the shipping agent immediately.
- When the card is not installed in a switching mainframe, keep the card in its anti-static bag and store it in the original packing carton.

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Shipment contents

The following items are included with every order:

- Model 7002-HD-MUX1 Differential Quad 1 x 40 Multiplexer Card
- Model 7002-HD-MUX1 User's Manual as a PDF on the CD-ROM
- Additional accessories as ordered

Instruction manual

If an additional Model 7002-HD-MUX1 User's Manual is required, order the manual package, Keithley part number 7002HDMUX1-900-00. The manual package includes an instruction manual and any pertinent addenda.

Repacking for shipment

Should it become necessary to return the Model 7002-HD-MUX1 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Advise as to the warranty status of the card.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.
- Fill out and include the service form located at the back of this manual.

Mainframe compatibility

The Model 7002-HD-MUX1 Card is designed for use only in a Model 7002-HD mainframe. It cannot be used in either a Model 7001 or 7002 mainframe.

Return to **Section 1 topics**

Recommended cables and connectors

The recommended cables and connectors are listed below. See Section 2 for connection details, and Section 3 for signal considerations.

- 5-pin removable screw terminal: RIA Electronic Part # 31007105
- 4-pin removable screw terminal: RIA Electronic Part # 31007104
- 40-pin female IDC socket w/o strain relief: 3M Part # 89140-0101
- 40-pin female IDC socket w/ strain relief: 3M Part # 89140-0100
- Long snap in latch arms: 3M Part # 3505-33
- 40-conductor shielded/jacketed ribbon cable: 3M Part # 3517/40

Return to **Section 1 topics**

2 Connections and Installation

Section 2 topics

Introduction

WARNING **The following information is intended for qualified service personnel. Do not make Model 7002-HD-MUX1 connections unless qualified to do so.**

To prevent electric shock that could result in serious injury or death, adhere to following safety precautions:

- **Before removing or installing a Model 7002-HD-MUX1 in the mainframe, make sure the mainframe is turned off and disconnected from line power.**
- **Before making or breaking connections, make sure power is removed from all external circuitry.**
- **Do not connect signals that may exceed the maximum specifications of the Model 7002-HD-MUX1 or external wiring. Specifications for the Model 7002-HD-MUX1 are provided at the end of this manual.**

This section includes information on making connections to the Model 7002-HD-MUX1 and installing the card in the Model 7002-HD Switch System.

Handling precautions

To maintain high-impedance isolation between channels, care should be taken when handling the card to avoid contamination from such foreign materials as body oils. Such contamination can reduce isolation resistance. To avoid possible contamination, always grasp the card by the side edges or covers. Do not touch board surfaces, components, or connector insulators.

Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the card in a clean environment. If the card becomes contaminated, it should be thoroughly cleaned as explained in "Handling and cleaning precautions" on page 4-2.

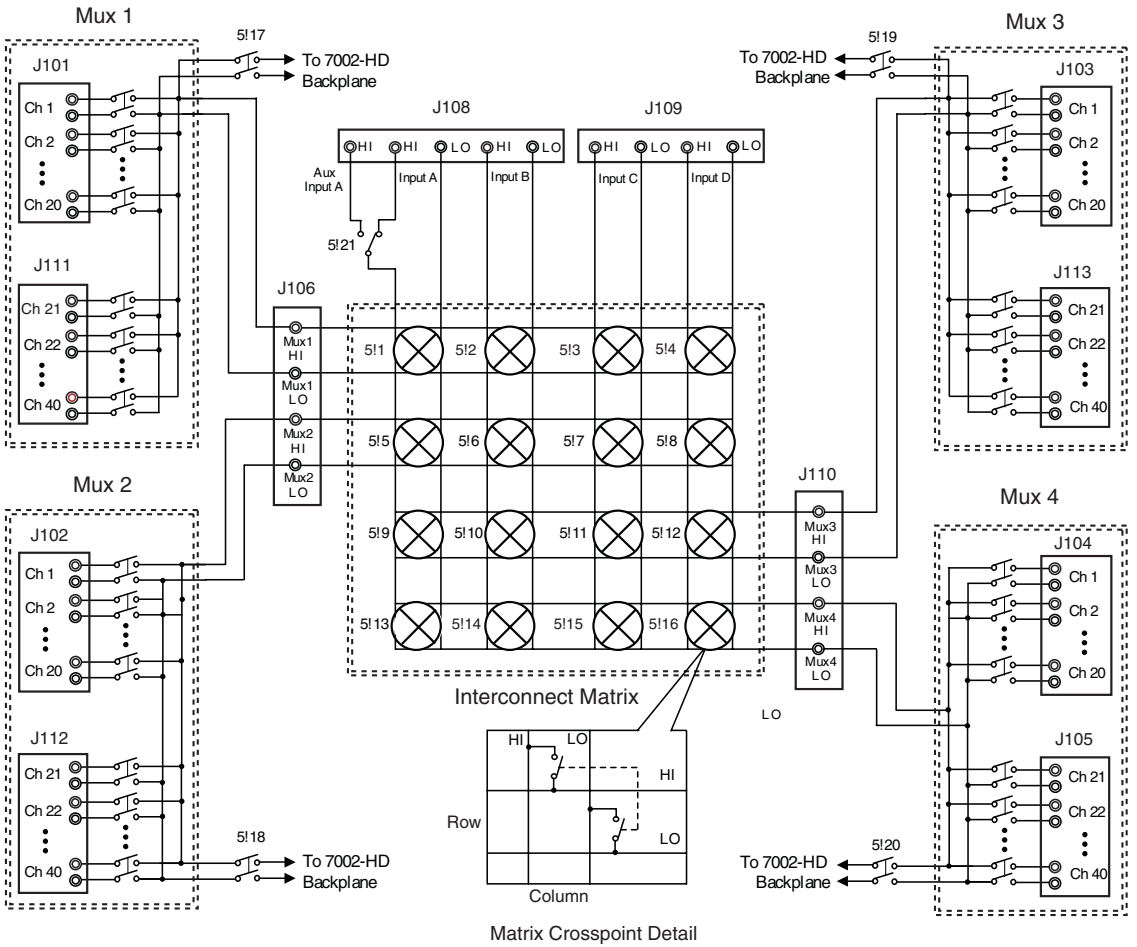
Connections

The following paragraphs provide information for connecting external test circuitry to the Model 7002-HD-MUX1.

Functional diagram

Figure 2-1 shows a functional schematic diagram of the Model 7002-HD-MUX1. The card has a total of four 1 x 40 multiplexers (Mux1 through Mux4) and a 4 x 4 interconnect matrix. Each multiplexer and matrix crosspoint provides differential switching (HI and LO). The output of each multiplexer can be individually connected to the Model 7002-HD backplane by closing the corresponding channel. For example, closing 5!17 connects Mux1 to the backplane. See "Channel mapping" on page 3-2 for details on channel mapping and programming the Model 7002-HD mainframe to close, open, and scan channels.

Figure 2-1
Model 7002-HD-MUX1 simplified schematic



Multiplexers

The Model 7002-HD-MUX1 includes four 1 x 40 differential pair multiplexers. The output of each multiplexer is connected to a 4 x 4 matrix to permit a single card to act as a 1x160 multiplexer. Figure 2-2 shows a simplified diagram of one differential 1x40 multiplexer. Each relay is controlled by closing the channel m!x on the mainframe where m is the multiplexer number (1 through 4) and x is the channel (1 through 40).

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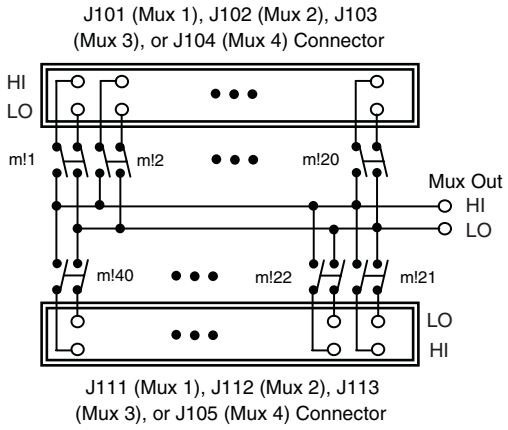
WARNING **Multiple channel operation should only be performed by experienced test engineers who recognize the dangers associated with multiple channel closures.**

CAUTION **When closing multiple channels, it is possible to connect incompatible test equipment and/or DUTs causing high currents to flow. This situation can cause serious damage to test equipment and DUTs.**

Figure 2-2
Simplified schematic of one 1 x 40 differential multiplexer



Matrix

The outputs of the four multiplexers are routed through a 4 x 4 matrix. This arrangement allows these signals to be connected to any of four differential inputs. An auxiliary input can also be selected using 5!21. This method is convenient for switching between two terminals such as the high voltage and amps terminal input of a DMM. Figure 2-3 depicts how the matrix interfaces the multiplexer outputs with additional input signals. As with the multiplexer, the high and low signals are routed together via a single channel closure.

The Model 7002-HD mainframe has an internal card expansion backplane. The Model 7002-HD-MUX1 has four backplane relays (5!17:5!20) that can be closed to connect the differential signals output from each of the four multiplexers to the backplane. By interconnecting two 7002-HD-MUX1 cards in this way, a 1 x 320 channel differential multiplexer can be created.

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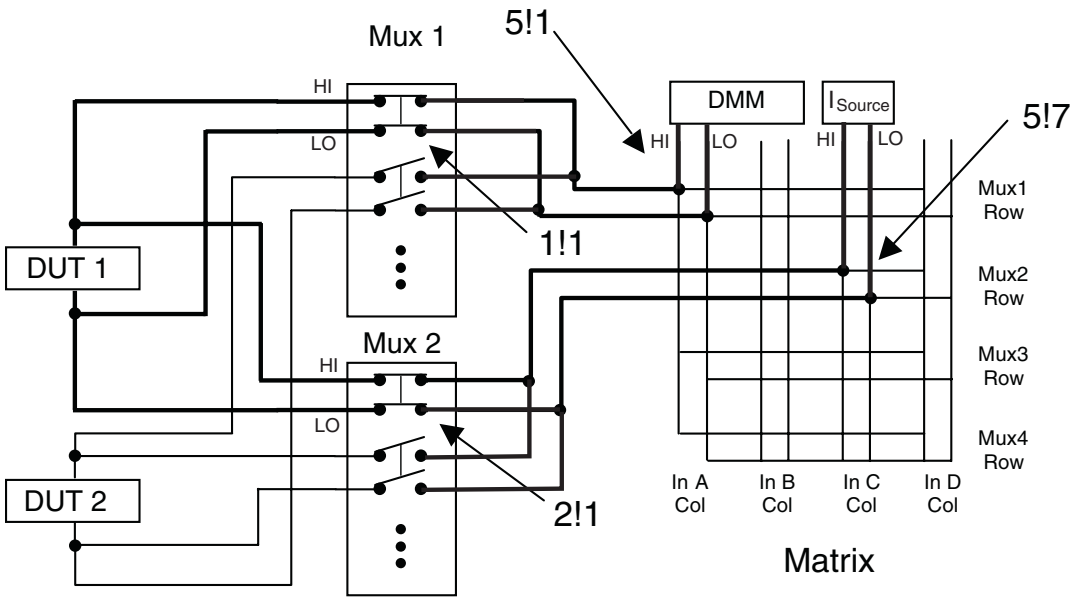
Figure 2-3
Combining multiplexers with matrix



As an example, consider an application used for four-wire resistance measurements using a programmable current source. Using a single card, 80 devices could be connected at once and then scanned. If multiplexers 1 and 3 are used for voltage measurements and multiplexers 2 and 4 are used for current sourcing, the configuration shown in Figure 2-3 could be used to perform a measurement on the first DUT. Channels 1!1, 2!1, 5!1, and 5!7 must be closed to make the connection to DUT 1.

If the same measurement is to be performed on DUT 2, the following actions must be taken.

1. Open channels 1!1 and 2!1 to isolate DUT 1.
2. Close channels 1!2 and 2!2 to connect to DUT 2.

NOTE Programmed closed channels such as 1!1 and 2!1 will remain closed until an open command for 1!1 or 2!1 (respectively) or an open all command is sent. Model 7002-HD-MUX1 relays are non-latching (removal of AC mains to the Model 7002-HD will open all channels).

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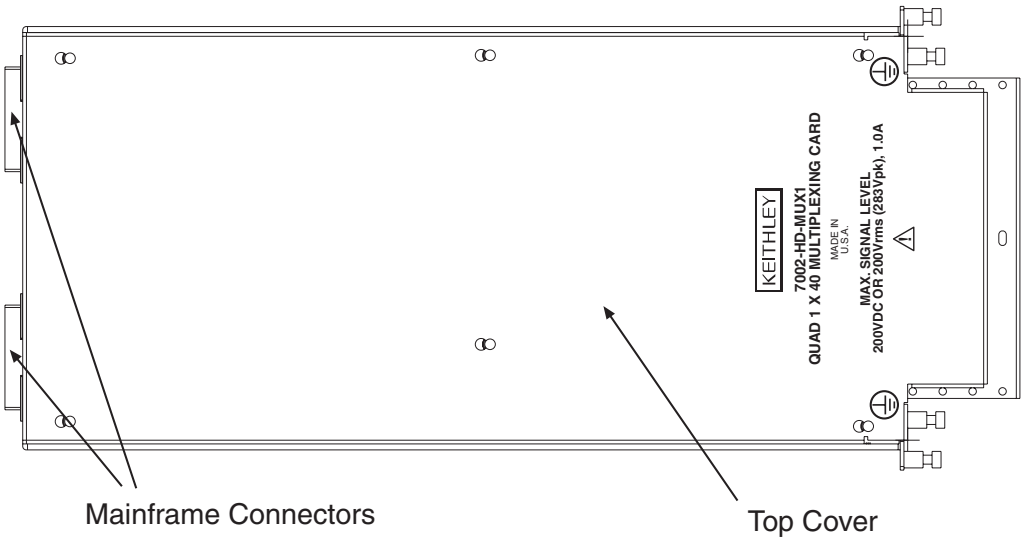
Card configuration

Card layout

The general layout of the Model 7002-HD-MUX1 is shown in Figure 2-4. Note that the top cover must be removed to access connectors to make signal connections.

WARNING Replace the top cover before installing and operating the Model 7002-HD-MUX1 card.

Figure 2-4
Model 7002-HD-MUX1 configuration



Connector locations

Figure 2-5 shows the general configuration of the Model 7002-HD-MUX1. 40-pin IDC header connectors are used for each input of twenty differential channels to the multiplexers. Multiplexers 1-3 use vertically inserted connectors with the pin out as shown in Figure 2-6. These cables should be folded as shown in Figure 2-9 on page 2-9 so they can run parallel out of the back of the card. The connectors for multiplexer 4 are horizontally connected, and Figure 2-7 illustrates its pinout. The matrix columns are driven by terminal block inputs. Terminal blocks are also utilized to provide access to the matrix rows driven by the multiplexer outputs. Figure 2-8 on page 2-9 depicts the pin configuration for these terminal connectors.

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Figure 2-5
Model 7002-HD-MUX1 card connector configuration

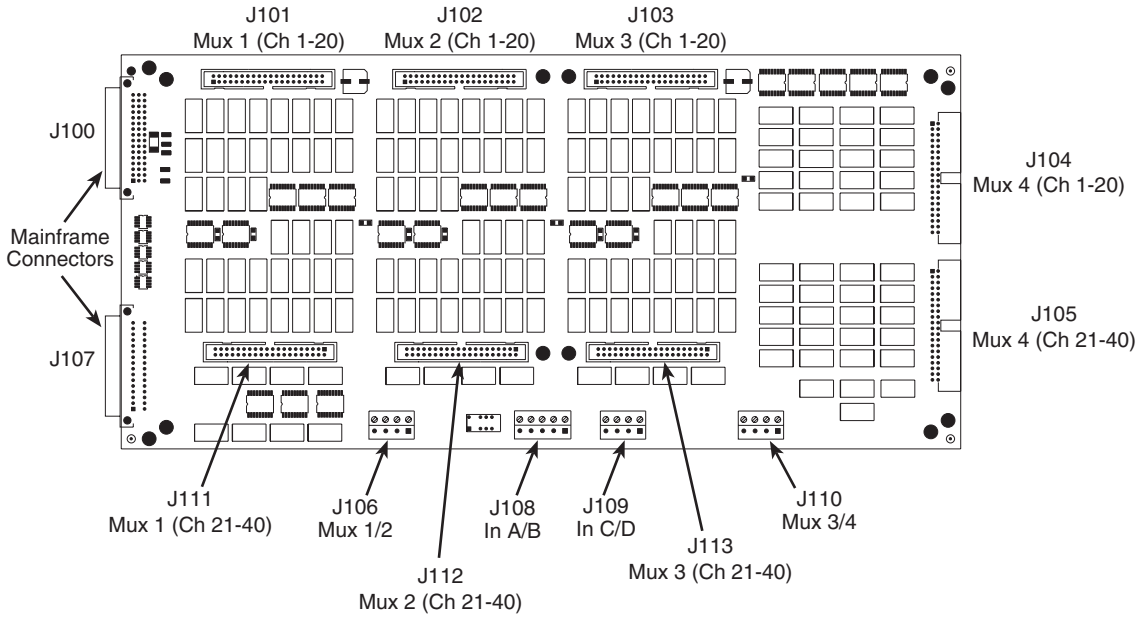

Figure 2-6
Top view - Model 7002-HD-MUX1 IDC header connectors

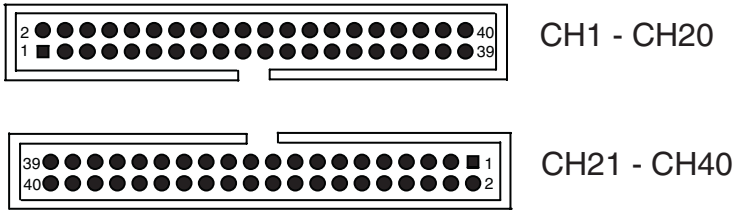

Figure 2-7
Rear view - Model 7002-HD-MUX1 IDC header connectors

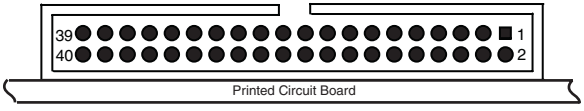

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Figure 2-8
Top view - Model 7002-HD-MUX1 terminal block connectors

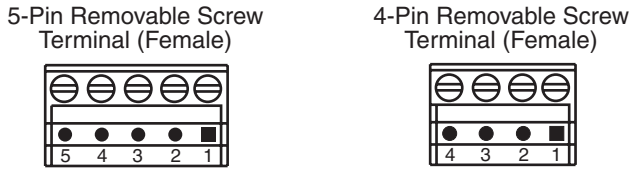
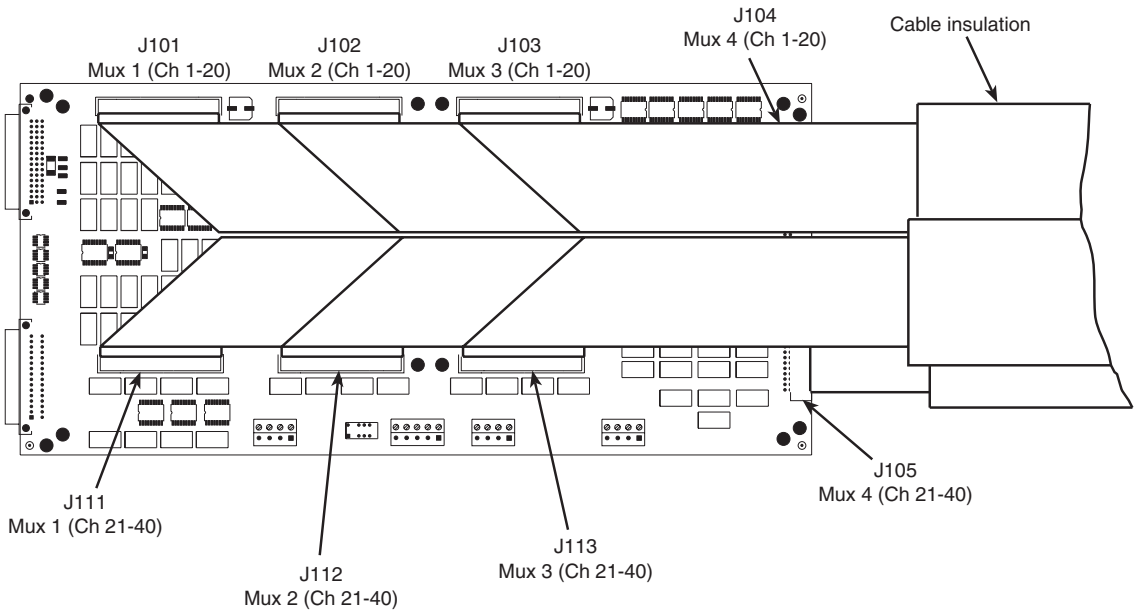


Figure 2-9
Top view - Model 7002-HD-MUX1 ribbon cabling



Connector terminal assignments

Table 2-1 summarizes multiplexer input connectors along with the channels associated with each. Multiplexer terminal assignments are listed in Table 2-2 on page 2-11 and Table 2-3 on page 2-12, while matrix terminal assignments are shown in Table 2-4 on page 2-13.

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Table 2-1
Multiplexer input connectors

Multiplexer	40-pin input connector	Channel range
Mux 1		1-20
	J111	21-40
Mux 2	J102	1-20
	J112	21-40
Mux 3		1-20
	J113	21-40
Mux 4	J104	1-20
	J105	21-40

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Table 2-2
Multiplexer pin identification for channels 1-20

Multiplexer inputs 40-pin headers J101, J102, J103, and J104					
Pin	**Input channel**	**Polarity**	**Pin**	**Input channel**	**Polarity**
1	1	LO		11	LO
2	1	HI		11	HI
3	2	LO	23	12	LO
4	2	HI	24	12	HI
5	3	LO		13	LO
6	3	HI		13	HI
7	4	LO	27	14	LO
8	4	HI	28	14	HI
9	5	LO		15	LO
10	5	HI		15	HI
11	6	LO	31	16	LO
12	6	HI	32	16	HI
13	7	LO		17	LO
14	7	HI		17	HI
15	8	LO	35	18	LO
16	8	HI	36	18	HI
17	9	LO		19	LO
18	9	HI		19	HI
19	10	LO	39	20	LO
20	10	HI	40	20	HI

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Table 2-3
Multiplexer pin identification for channels 21-40

Multiplexer inputs 40-pin headers J111, J112, J113, and J105					
Pin	**Input channel**	**Polarity**	**Pin**	**Input channel**	**Polarity**
1	21	LO		31	LO
2	21	HI		31	HI
3	22	LO	23	32	LO
4	22	HI	24	32	HI
5	23	LO		33	LO
6	23	HI		33	HI
7	24	LO	27	34	LO
8	24	HI	28	34	HI
9	25	LO		35	LO
10	25	HI		35	HI
11	26	LO	31	36	LO
12	26	HI	32	36	HI
13	27	LO		37	LO
14	27	HI		37	HI
15	28	LO	35	38	LO
16	28	HI	36	38	HI
17	29	LO		39	LO
18	29	HI		39	HI
19	30	LO	39	40	LO
20	30	HI	40	40	HI

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Table 2-4
Matrix pin identification

Matrix connections terminal blocks				
Function	**Polarity**	**Matrix role**	**Connector**	**Pin**
Aux Input A	HI	Column 1	J108	5
Input A	HI	Column 1	J108	4
	LO	Column 1	J108	3
Input B	HI	Column 2	J108	2
	LO	Column 2	J108	1
Input C	HI	Column 3	J109	4
	LO	Column 3	J109	3
Input D	HI	Column 4	J109	2
	LO	Column 4	J109	1
Mux 1 Out	HI	Row 1	J106	4
	LO	Row 1	J106	3
Mux 2 Out	HI	Row 2	J106	2
	LO	Row 2	J106	1
Mux 3 Out	HI	Row 3	J110	4
	LO	Row 3	J110	3
Mux 4 Out	HI	Row 4	J110	2
	LO	Row 4	J110	1

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Cables and wiring

Recommended cables and connectors

Table 2-5 summarizes recommended cables and connectors, including part numbers along with the connection for each.

Table 2-5
Recommended cables and connectors

Description	Part number	Connection
5-pin removable screw terminal	RIA Electronic Part # 31007105	J108
4-pin removable screw terminal	RIA Electronic Part # 31007104	J106, J109, J110
40-pin female IDC socket w/o strain relief	3M Part # 89140-0101	J101-J103, J111-J113
40-pin female IDC socket w/ strain relief	3M Part # 89140-0100	J104, J105
	3M Part # 3517/40	J101-J105, J111-J113

Wiring procedure

CAUTION **The maximum signal level, any channel to any channel, is: 200V DC or 200V rms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum. Exceeding these signal levels may result in card damage, possibly voiding the warranty.**

WARNING **The maximum common-mode voltage is: 200V DC or 200V rms (283V peak for AC waveforms) between any terminal and chassis. Exceeding these levels may cause a shock hazard.**

Use the following procedure to wire the Model 7002-HD-MUX1:

1. Make sure all power is discharged from the Model 7002-HD-MUX1.
2. Remove the top cover to allow access to connectors.

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3. Make your connections to the ribbon cables that will be attached to the IDC connectors using the information on previous pages. The outer shielding and jacketing of the 40-conductor ribbon cable will need to be stripped away from the portion of the cable routed internal to the 7002-HD-MUX1 card to provide adequate clearance within the card. The cable's outer shielding should be left intact once outside of the card to offer a second insulation barrier against high voltage test signals.
4. For screw terminal blocks, use a small flat-blade screwdriver to loosen terminal screws and install wires as desired.
5. Route ribbon cables and wires so they are routed out the back of the card (see Figure 2-9 on page 2-9).
6. Secure the top cover before installing the card.

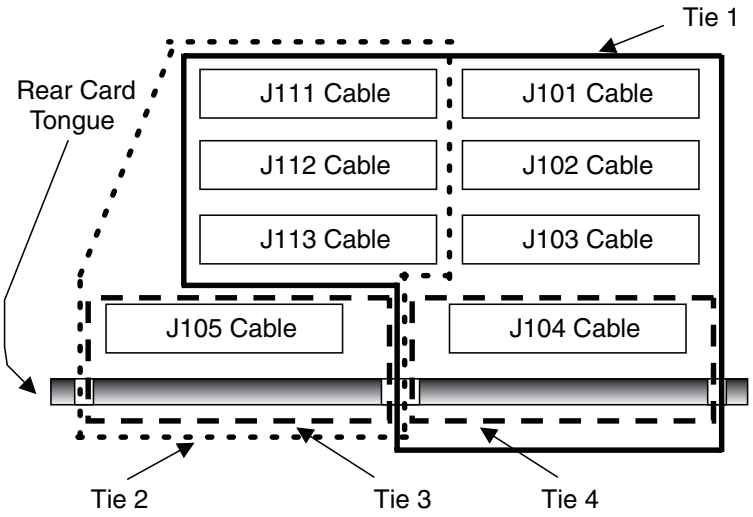
WARNING Replace the top cover before installing and operating the Model 7002-HD-MUX1 card.

Securing cables

Cable ties can be used to secure the exiting ribbon cables to the rear tongue of the card. This method is useful for providing additional strain relief for the cables and to facilitate locking the top cover in place by keeping the cables running together. Figure 2-10 illustrates the recommended way to secure the ribbon cables using cable ties. While modified approaches may be considered for specific application strain relief, this approach is recommended since it keeps the cables exiting the card in an orderly fashion to minimize interference with the top cover.

The cable ties that hold the J104 and J105 cables (Tie 3 and 4 in Figure 2-10) are not necessary if snap-in latch arms are used to secure the connectors. Tie 1 in the figure is used to ensure that the two stacks of cables remain close together and parallel as they exit the card. This promotes a parallel pattern inside of the card and helps to avoid interference with the top cover connection points. Since this path requires a cable tie longer than eight inches, it may be necessary to fasten together two cable ties to reach all the way around as shown. Tie 2 ensures that the parallel cable stacks do not overlap each other by pulling the cables originating from J111-J113 away from the J101-J103 cables. By ensuring that the Mux 1-3 cables run in two parallel but non-overlapping stacks, these cable ties can provide strain relief while also facilitating the placement of the top cover. Additional cable ties can be used for added strain relief if needed.

Figure 2-10
Rear view - securing cables



Typical connecting schemes

CAUTION **The maximum signal level, any channel to any channel, is: 200V DC or 200V rms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum. Exceeding these signal levels may result in card damage, possibly voiding the warranty.**

WARNING **The maximum common-mode voltage is: 200V DC or 200V rms (283V peak for AC waveforms) between any terminal and chassis. Exceeding these levels may cause a shock hazard.**

WARNING **When multiplexing multiple cards, be sure to provide insulation on all terminals for the maximum voltage used in the system.**

Multiplexer expansion

A larger multiplexer can be formed by inserting a second 7002-HD-MUX1 card into the mainframe and closing the backplane relays. When a mux out backplane relay is closed on both cards (for example, 5!17 and 10!17), the respective 1 x 40 multiplexer expands to 1 x 80. Figure 2-11 shows this expansion to quad 1 x 80 multiplexers by closing relays 5!17:5!20 and 10!17:10!20. If all four multiplexers are expanded, two cards can offer up to 1 x 320 channels differentially by joining the four 1 x 80 multiplexers together using the interconnect matrix.

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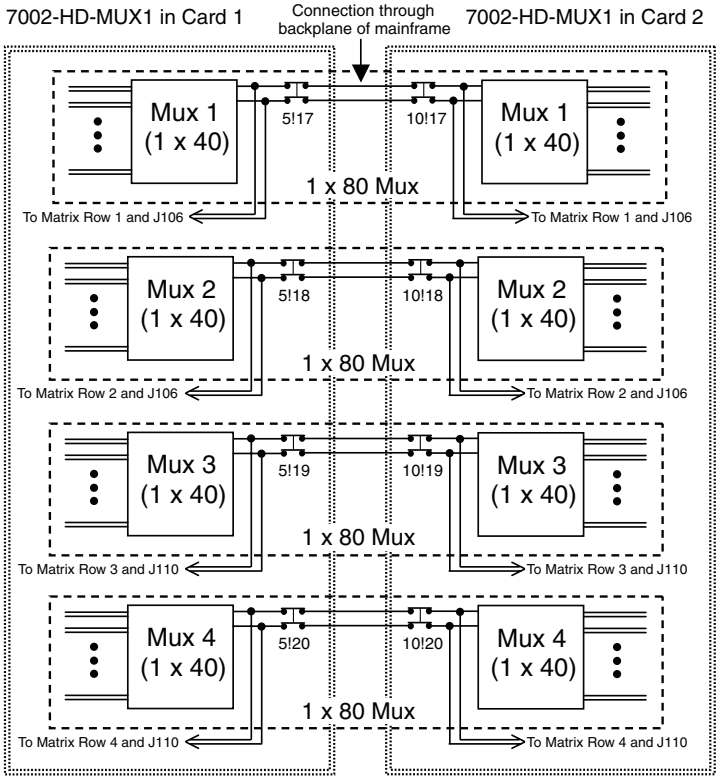
Additional expansion is possible by combining mainframes. If two 7002-HD mainframes are each loaded with two 7002-HD-MUX1 cards, and the corresponding multiplexer output terminals (i.e., Mux1 HI to Mux1 HI … Mux4 LO to Mux4 LO) from either card on one mainframe to either card on the other mainframe are manually wired together, then a 1 x 640 differential multiplexer is formed by closing all backplane relays. Further expansion using additional mainframes is also possible using this same approach.

Figure 2-11
Multiplexer expansion



Quad 1 x 80 Mux Configuration

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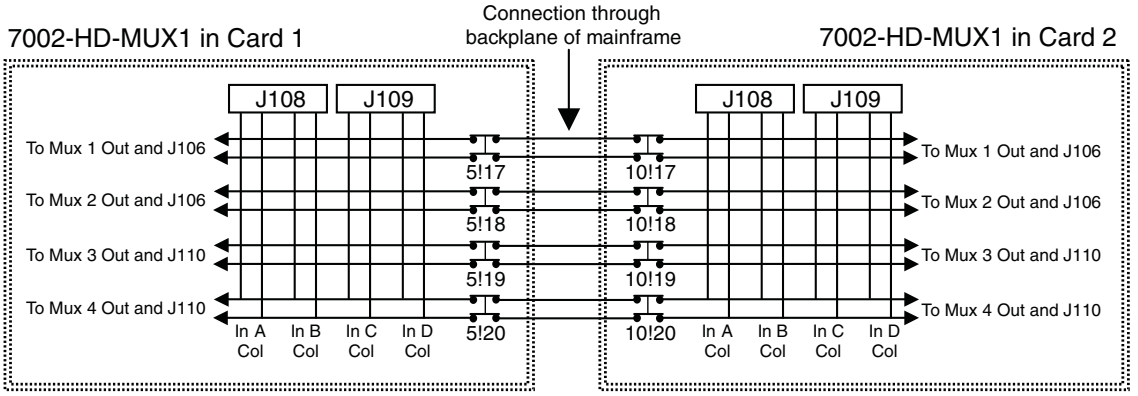
Matrix expansion

It is also possible to use a second 7002-HD-MUX1 card to expand the number of columns in the matrix from four to eight. This expansion is performed by closing the backplane relays as shown with the multiplexer expansion example. It has the side effect of coupling the multiplexers together on the two cards as well.

Figure 2-12 illustrates how closing the backplane relays on each card (5!17 through 5!20 and 10!17 through 10!20) can expand the matrix from 4 x 4 to 4 x 8. This configuration also connects together the outputs of the multiplexers on each card as shown in Figure 2-11.

Figure 2-12
Matrix expansion



4 x 8 Matrix Configuration

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Card installation and removal

The following paragraphs describe how to install and remove the Model 7002-HD-MUX1 card assembly from the Model 7002-HD mainframe.

WARNING **Installation or removal of the Model 7002-HD-MUX1 should be performed by qualified service personnel only. Failure to recognize and observe standard safety precautions could result in personal injury or death.**

NOTE To prevent performance degradation caused by contamination, handle the card only by the edges and covers.

Card installation

After connecting the input/output cables, perform the following steps, and refer to Figure 2-13 to install the card assembly in the Model 7002-HD mainframe in either the Card 1 or Card 2 location.

WARNING **Turn off power to all instrumentation (including the Model 7002-HD), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.**

1. Slide the card edges into the guide rails inside the mainframe.
2. Carefully push the card all the way forward to seat it fully in the connectors.
3. Make sure the captive screws are securely in place.

Card removal

Follow the steps below to remove the multiplexer card from the mainframe.

WARNING **Turn off power to all instrumentation (including the Model 7002-HD), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.**

1. Loosen the captive screws that secure the card.
2. Pull out on the card until it pulls free from the internal connector.
3. Carefully slide the card out of the switching mainframe.

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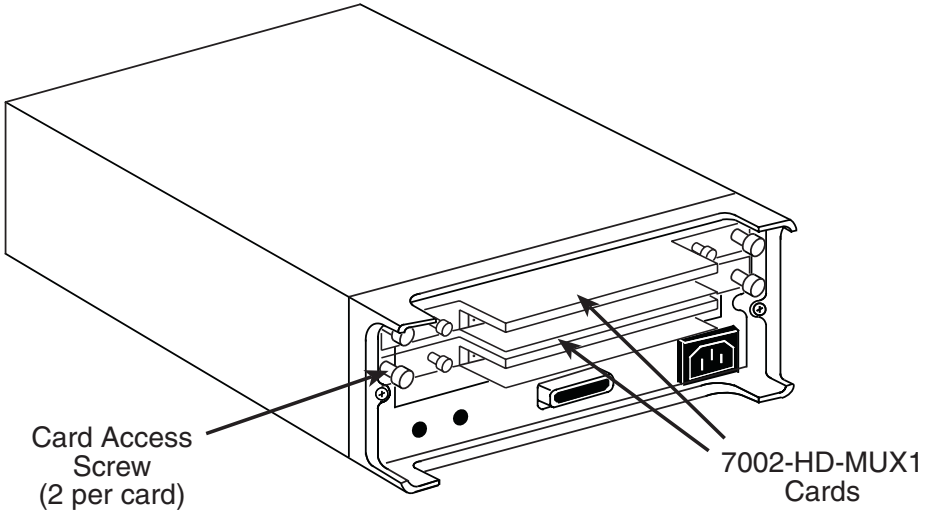
Figure 2-13
Card installation in Model 7002-HD mainframe



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3 Operation

Section 3 topics

Introduction

This section contains basic information on using the Model 7002-HD-MUX1 including signal limitations, channel mapping, front panel and IEEE-488 bus operation, switching considerations, and applications.

Signal limitations

CAUTION **To prevent damage to the Model 7002-HD-MUX1, do not exceed the maximum signal level specifications of the card.**

To prevent overheating or damage to the relays, never exceed the following maximum signal levels when using the Model 7002-HD-MUX1:

- **Maximum voltage:** 200V DC or 200V rms (283V peak for AC waveforms)
- **Maximum current:** 1A switched per channel
- **Maximum power:** 60W, 125VA maximum

Channel mapping

Channel mapping for the multiplexers and matrix is shown in the following pages. See "Front panel control" on page 3-11 and "IEEE-488 bus control" on page 3-13 for details on closing and opening channels. See Figure 2-1 on page 2-4 for a functional diagram. Mapping is as follows:

- **Multiplexers:** mapping for the four 1 x 40 multiplexers is shown in Table 3-1 (channels 1-10, Table 3-2 on page 3-4 (channels 11-20), Table 3-3 on page 3-5 (channels 21-30), and Table 3-4 on page 3-6 (channels 31-40). Close or open these channels as needed to close or open specific channels.
- **Matrix:** mapping for the 4 x 4 matrix is shown in Table 3-5 on page 3-7. Close or open these channels to close or open specific crosspoints and connect the associated multiplexer as shown.
- **Backplane:** mapping for backplane isolation is summarized in Table 3-6 on page 3-8. Close a specific channel to connect the associated multiplexer to the Model 7002-HD mainframe backplane. Open a specific channel to disconnect the multiplexer from the backplane.
- **Input selection:** mapping for input selection is shown in Table 3-7 on page 3-8. Close 5!21 to select Aux Input A Hi; open 5!21 to select Input A Hi.

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Table 3-1
Multiplexer mapping for channels 1 through 10

		Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10
Mux 1		1!1	1!2	1!3	1!4	1!5	1!6	1!7	1!8	1!9	1!10
	Relay	K101	K102	K103	K104	K105	K106	K107	K108	K109	K110
Mux 2	Close Command	2!1	2!2	2!3	2!4	2!5	2!6	2!7	2!8	2!9	2!10
	Relay	K201	K202	K203	K204	K205	K206	K207	K208	K209	K210
Mux 3		3!1	3!2	3!3	3!4	3!5	3!6	3!7	3!8	3!9	3!10
	Relay	K301	K302	K303	K304	K305	K306	K307	K308	K309	K310
Mux 4	Close Command	4!1	4!2	4!3	4!4	4!5	4!6	4!7	4!8	4!9	4!10
	Relay	K401	K402	K403	K404	K405	K406	K407	K408	K409	K410

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Table 3-2
Multiplexer mapping for channels 11 through 20

		Ch 11	Ch 12	Ch 13	Ch 14	Ch 15	Ch 16	Ch 17	Ch 18	Ch 19	Ch 20
Mux 1		1!11	1!12	1!13	1!14	1!15	1!16	1!17	1!18	1!19	1!20
	Relay	K111	K112	K113	K114	K115	K116	K117	K118	K119	K120
Mux 2	Close Command	2!1	2!12	2!13	2!14	2!15	2!16	2!17	2!18	2!19	2!20
	Relay	K211	K212	K213	K214	K215	K216	K217	K218	K219	K220
Mux 3		3!11	3!12	3!13	3!14	3!15	3!16	3!17	3!18	3!19	3!20
	Relay	K311	K312	K313	K314	K315	K316	K317	K318	K319	K320
Mux 4	Close Command	4!11	4!12	4!13	4!14	4!15	4!16	4!17	4!18	4!19	4!20
	Relay	K411	K412	K413	K414	K415	K416	K417	K418	K419	K420

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Table 3-3
Multiplexer mapping for channels 21 through 30

		Ch 21	Ch 22	Ch 23	Ch 24	Ch 25	Ch 26	Ch 27	Ch 28	Ch 29	Ch 30
Mux 1		1!21	1!22	1!23	1!24	1!25	1!26	1!27	1!28	1!29	1!30
	Relay	K121	K122	K123	K124	K125	K126	K127	K128	K129	K130
Mux 2	Close Command	2!21	2!22	2!23	2!24	2!25	2!26	2!27	2!28	2!29	2!30
	Relay	K221	K222	K223	K224	K225	K226	K227	K228	K229	K230
Mux 3		3!21	3!22	3!23	3!24	3!25	3!26	3!27	3!28	3!29	3!30
	Relay	K321	K322	K323	K324	K325	K326	K327	K328	K329	K330
Mux 4	Close Command	4!21	4!22	4!23	4!24	4!25	4!26	4!27	4!28	4!29	4!30
	Relay	K421	K422	K423	K424	K425	K426	K427	K428	K429	K430

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Table 3-4
Multiplexer mapping for channels 31 through 40

		Ch 31	Ch 32	Ch 33	Ch 34	Ch 35	Ch 36	Ch 37	Ch 38	Ch 39	Ch 40
Mux 1		1!31	1!32	1!33	1!34	1!35	1!36	1!37	1!38	1!39	1!40
	Relay	K131	K132	K133	K134	K135	K136	K137	K138	K139	K140
Mux 2	Close Command	2!31	2!32	2!33	2!34	2!35	2!36	2!37	2!38	2!39	2!40
	Relay	K231	K232	K233	K234	K235	K236	K237	K238	K239	K240
Mux 3		3!31	3!32	3!33	3!34	3!35	3!36	3!37	3!38	3!39	3!40
	Relay	K331	K332	K333	K334	K335	K336	K337	K338	K339	K340
Mux 4	Close Command	4!31	4!32	4!33	4!34	4!35	4!36	4!37	4!38	4!39	4!40
	Relay	K431	K432	K433	K434	K435	K436	K437	K438	K439	K440

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Table 3-5
Matrix channel mapping

		Input A	Input B	Input C	Input D
Mux 1		5!1	5!2	5!3	5!4
	Relay	K501	K502	K503	K504
Mux 2	Close Command	5!5	5!6	5!7	5!8
	Relay	K505	K506	K507	K508
Mux 3		5!9	5!10	5!11	5!12
	Relay	K509	K510	K511	K512
Mux 4	Close Command	5!13	5!14	5!15	5!16
	Relay	K513	K514	K515	K516

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Table 3-6
Backplane isolation channel mapping

		Backplane isolation
Mux 1		5!17
	Relay	K517
Mux 2	Close Command	5!18
	Relay	K518
Mux 3		5!19
	Relay	K519
Mux 4	Close Command	5!20
	Relay	K520

Note: Slot numbers assume Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation. See "Backplane connections" on page 3-9 for additional information.

Table 3-7
Input selection channel mapping

		Aux Input HI	Input A HI
Column 1 HI Selection	Close Command	Close 5!21	Open 5!21
	Relay	K521	K521

Note: Slot number assumes Model 7002-HD-MUX1 is installed in Card 1. Add five to slot numbers for Card 2 operation.

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Backplane connections

The Model 7002-HD mainframe backplane connects signals from the Card 1 and Card 2 positions inserted in the mainframe in a one-to-one fashion. Therefore, pin 1 on J107 on the Card 1 card is connected to pin 1 on J107 on the Card 2 card through the backplane. The other J107 pins are connected similarly in this one-to-one manner. When both cards are of the same type, the connections through the backplane from one card to the other connect the same signals due to the symmetry of the cards. Table 3-8 can be used to interconnect two different card types through the 7002-HD backplane by closing the appropriate backplane relays on each card. (In this case, a Model 7002-HD-MUX1 is used with a Model 7002-HD-MTX1 6 x 32 Matrix Card.) The backplane signals are not externally accessible to the end user. All pins not specified are unused.

Table 3-8
Backplane connections between 7002-HD-MUX1 and 7002-HD-MTX1 cards

J107 pin number	7002-HD-MUX1 card use		7002-HD-MTX1 card use	
	Signal	Polarity	Signal	Polarity
11	None	N/A	Row 6	HI
12	None	N/A	Row 5	HI
13	Mux 4 Out	HI	Row 4	HI
14	Mux 3 Out	HI	Row 3	HI
15	Mux 2 Out	HI	Row 2	HI
16	Mux 1 Out	HI	Row 1	HI
43	None	N/A	Row 6	LO
44	None	N/A	Row 5	LO
45	Mux 4 Out	LO	Row 4	LO
46	Mux 3 Out	LO	Row 3	LO
47	Mux 2 Out	LO	Row 2	LO
48	Mux 1 Out	LO	Row 1	LO

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Channel control considerations

Card 1

When a Model 7002-HD-MUX1 is used in the Card 1 position of the Model 7002-HD, channels will be controlled using slots 1 through 5 as shown in the channel mapping tables.

Card 2

When a Model 7002-HD-MUX1 is used in the Card 2 position of the Model 7002-HD, the card will be controlled using slots 6 through 10. When using the tables, add five to the slot number programming. For example: mux 1 / channel 1 would be addressed as 6!1.

Slot numbers

Table 3-9 summarizes slot and channel numbers for both the Card 1 and Card 2 locations.

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Table 3-9
Slot/channel assignments for Card 1 and Card 2 locations

	Card 1 slot/channel	Card 2 slot/channel
Mux 1 channel inputs	1!1 to 1!40	6!1 to 6!40
Mux 2 channel inputs	2!1 to 2!40	7!1 to 7!40
Mux 3 channel inputs	3!1 to 3!40	8!1 to 8!40
Mux 4 channel inputs	4!1 to 4!40	9!1 to 9!40
Matrix connections	5!1 to 5!16	10!1 to 10!16
Mux 1 backplane connection	5!17	10!17
Mux 2 backplane connection	5!18	10!18
Mux 3 backplane connection	5!19	10!19
Mux 4 backplane connection	5!20	10!20
Input A/ Input Aux A switching	5!21	10!21

Front panel control

Closing and opening channels

To close a Model 7002-HD-MUX1 multiplexer, matrix, backplane, or input channel, key in the CHANNEL assignment from the tables on the preceding pages, and then press the Model 7002-HD CLOSE key. For example, to close channel 10, multiplexer 1 of Card 1, key in the following channel list, and press CLOSE:

```
SELECT CHANNELS 1!10
```

To open a closed channel, press OPEN or OPEN ALL.

You can also simultaneously close more than one channel at a time by including the desired channels in the channel list. For example, to close Card 1, channel 1, mux 1 and channel 9, mux 3, and connect mux 1 and mux 3 to the backplane, enter the following channel list:

```
SELECT CHANNELS 1!1,3!9,5!17,5!19
```

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Channels are separated by a comma, which can be inserted by pressing either the ENTER or right cursor key. Again, you can open closed channels with the OPEN or OPEN ALL key. OPEN opens only channels in the channel list, and OPEN ALL opens all channels.

WARNING **Multiple channel operation should only be performed by experienced test engineers who recognize the dangers associated with multiple channel closures.**

CAUTION **When closing multiple channels, it is possible to connect incompatible test equipment and/or DUTs causing high currents to flow. This situation can cause serious damage to test equipment and DUTs.**

Scanning channels

To scan through channels, first configure a scan list, and then program the Model 7002-HD to perform a scan sequence. You can create a scan list in the same manner as you would a channel list. First, however, press the SCAN LIST key to select the SCAN CHANNEL mode, and then enter the desired channels to be included in the scan list. For example, the following list scans all 40 channels of multiplexer 4 located in Card 1:

```
SCAN CHANNELS 4!1-4!40
```

Channels are scanned in the order they appear in the scan list.

To perform a manual scan, select the RESET default conditions in the SAVESETUP menu of the main MENU. Press STEP to take the mainframe out of the idle state, and then manually scan through channels by pressing the STEP key.

For information on more complex scan sequences, refer to the Model 7002-HD User's Manual.

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IEEE-488 bus control

Closing and opening channels

Use the following SCPI commands to close and open channels:

```
:CLOS <list>
:OPEN <list> | ALL
```

For example, the following command will close channel 21 of mux 2 and channel 35 of mux 3 in Card 1:

```
:CLOS (@ 2!21,3!35)
```

Conversely, either of the commands below will open previously closed mux 2, channel 21 and mux 3, channel 35 in Card 1:

```
:OPEN (@ 2!21,3!35)
:OPEN ALL
```

WARNING **Multiple channel operation should only be performed by experienced test engineers who recognize the dangers associated with multiple channel closures.**

CAUTION **When closing multiple channels, it is possible to connect incompatible test equipment and/or DUTs causing high currents to flow. This situation can cause serious damage to test equipment and DUTs.**

Scanning channels

You can perform a simple scan using the following four commands:

```
*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN <list>
:INIT
```

The *RST command selects the default scan configuration, while the second command automatically sets the channel count to the number of channels in the scan list. The :ROUT:SCAN command programs the scan list, and the :INIT command takes the mainframe out of the idle state.

For example, send the following commands to scan through the first 20 channels of mux 3 located in Card 1:

```
*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN (@ 3!1:3!20)
:INIT
```

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Measurement considerations

Signals passing through the Model 7002-HD-MUX1 Multiplexer Card are subject to various effects that can influence their characteristics. The following paragraphs discuss some of these effects and ways to minimize them.

Connectors

Connector housing materials will affect the performance of the Model 7002-HD-MUX1. In order to achieve the Model 7002-HD-MUX1 specifications, follow the list of recommended connectors.

Cables

Cable leakage and capacitance affect Model 7002-HD-MUX1 performance. In order to achieve the Model 7002-HD-MUX1 specifications, follow the list of recommended cables.

Path isolation resistance

The path isolation resistance is the equivalent resistance between two given connecting points on the card and is of importance primarily for DC and low-frequency AC signals switched by the card. The effects of this characteristic depend on the particular isolation specification. Channel-to-channel isolation resistance may result in leakage currents generated in one channel caused by a voltage source connected to another channel.

To maintain maximum path isolation resistance, operate the Model 7002-HD-MUX1 in a clean environment to avoid contamination. Also be careful not to touch connectors and board surfaces during wiring and installation. If the board becomes contaminated, it should be cleaned using the procedure described in "Handling and cleaning precautions" on page 4-2.

Magnetic fields and RFI

Magnetic fields and RFI (Radio Frequency Interference) can induce small currents or other noise signals in connecting cables and wiring. To reduce the effects of these unwanted signals in a test system: (1) keep cable lengths to a minimum, and (2) minimize the exposed circuit area. Magnetic or RFI shielding may be necessary for satisfactory results. Measurement instrument offset nulling or filtering may be also be needed to minimize these negative effects on measurement integrity.

Ground loops

Ground loops that induce a noise signal at the power line frequency or its harmonics can result when two or more measurement instruments are connected to power line or earth ground simultaneously. To eliminate ground loop noise, connect only one instrument in the test system to power line or earth ground.

WARNING **When making instrument connections, be careful to observe all necessary safety ground precautions for operator safety.**

Applications

The following paragraphs discuss typical applications for the Model 7002-HD-MUX1 including bias measurements and low-resistance measurements.

Momentary bias measurements

This application tests 80 DUTs while applying a momentary bias to each. As Figure 3-1 shows, the application connects each DUT to its own series resistor to limit current and measurably drop the applied voltage across it. Each input of Mux 1 should be connected across the resistor and DUT pair as illustrated in the diagram. The Mux 2 high and low input terminals are connected directly across each of 40 DUTs as shown. To configure the other 40 DUTs, repeat these connections with Mux 3 taking the place of Mux 1 and Mux 4 taking the place of Mux 2. If all DUTs are the same, a single current-limiting resistor can be used instead and placed in series with the voltage source.

To perform the test measurement, connect a DMM (for example, a Keithley Model 2000) and a voltage supply to the input nodes that feed the matrix on the card. One way this could be done is to connect the 2-wires of the DMM to Input A HI and LO respectively and the voltage supply to the high and low inputs for Input B. To start the test, route the voltage supply through Mux 1 or Mux 3 to the resistor and DUT. This requires the closure of the corresponding matrix relay and the multiplexer channel relay only for the specific device under test. Then connect the DMM by closing the corresponding matrix relay and the Mux 2 (or Mux 4) channel relay to take a voltage measurement on the same DUT. This configuration will temporarily bias devices and allow for the detection of failures caused by internal shorting or opening.

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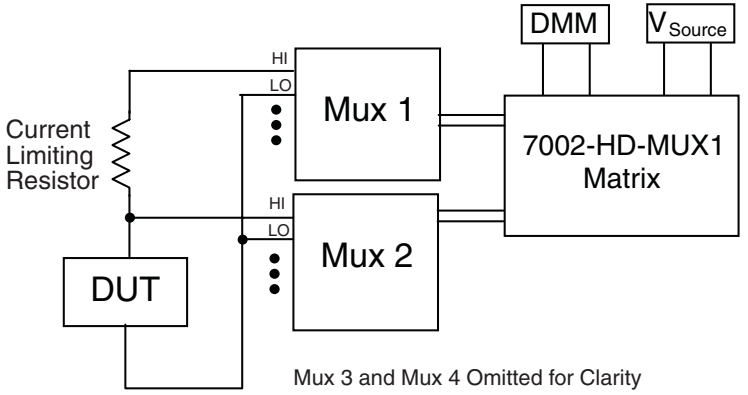
Figure 3-1
Connections for bias measurements



Continuous bias measurements

For continuous bias measurements, repeat the test setup described for momentary bias measurements with the following difference. Instead of biasing one device at a time, close all of the channel relays in Mux 1 and Mux 3 so the voltage source is supplied to all devices under test in parallel. While leaving the voltage applied continually, close one channel at a time on Mux 2 or Mux 4 to take a voltage measurement for each of the devices sequentially. Using this configuration, devices can be tested for failures during a burn-in voltage stress period.

Low-resistance measurements

The Model 7002-HD-MUX1 can be used in conjunction with a Keithley Model 2400 SourceMeter to perform low-resistance measurements. Typically, such measurements are made using 4-wire connections to DUTs to minimize the effects of wire and contact resistance.

Figure 3-2 shows the connections for making low-resistance measurements. The SourceMeter applies current to the DUT via the Output terminals, matrix, and Mux 1. The voltage across the DUT is measured through the Sense terminals, matrix, and Mux 2. DUT resistance is calculated from the sourced current and measured voltage.

Switch connections are made by closing the appropriate channels. For example, 1!1, 2!1, 5!1, and 5!7 would be closed to test DUT 1. Using this configuration, a total of 40 DUTs can be tested, but the test can be expanded to 80 DUTs using a single card by using the other two multiplexers and appropriate switching.

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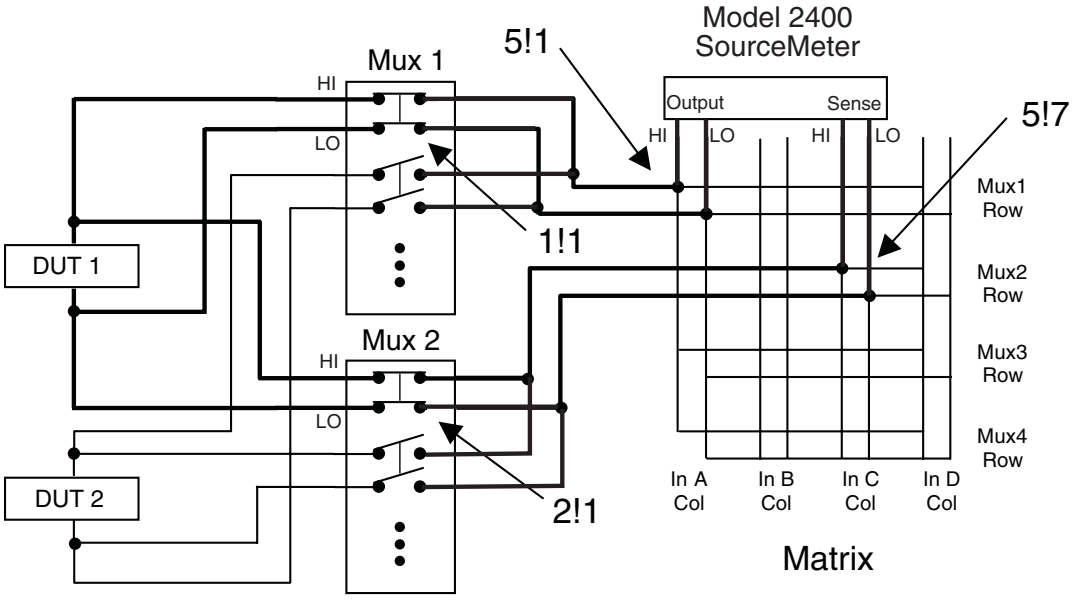
Figure 3-2
Connections for low-resistance measurements



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4 Servicing

Section 4 topics

Introduction

This section contains information necessary to service the Model 7002-HD-MUX1 and includes information on handling and cleaning, performance verification, as well as principles of operation and troubleshooting.

WARNING **The information in this section is intended only for qualified service personnel. Some of the procedures may expose you to hazardous voltages that could result in personal injury or death. Do not attempt to perform these procedures unless you are qualified to do so.**

Handling and cleaning precautions

Because of the high-impedance areas on the Model 7002-HD-MUX1, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be observed when servicing the card.

Handling precautions

Observe the following precautions when handling the multiplexer card:

- Handle the card only by the edges and shields.
- Do not touch connector insulators.
- Do not touch any board surfaces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- When servicing the card, wear clean cotton gloves.
- Do not store or operate the card in an environment where dust could settle on the circuit board.
- Use dry nitrogen gas to clean dust off of the board if necessary.

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Soldering considerations

Should it become necessary to use solder on the circuit board, observe the following precautions:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean cotton swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab only the repaired area with methanol, and then blow-dry the board with dry nitrogen gas.
- After cleaning, allow the card to dry in a 50°C low humidity environment for several hours before use.

Special handling of static-sensitive devices

CMOS and other high-impedance devices are subject to possible static discharge damage because of the high-impedance levels involved. When handling such devices, observe the following precautions.

- To prevent damage, assume all parts are static-sensitive.
- Such devices should be transported and handled only in containers specially designed to prevent or dissipate static build-up. Typically, these devices will be received in anti-static containers made of plastic or foam.
- Keep these parts in their original containers until ready for installation or use.
- Remove the devices from their protective containers only at a properly grounded workstation. Also, ground yourself with an appropriate wrist strap while working with these devices.
- Handle the devices only by the body; do not touch the pins or terminals.
- Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.
- Use only anti-static type de-soldering tools and grounded-tip soldering irons.

Specifications

The performance verification procedures in this section refer to the Model 7002-HD-MUX1 specifications for various tests. Refer to "Specifications" on page A-2 for information when performing these tests.

Performance verification

The following paragraphs discuss performance verification procedures for the Model 7002-HD-MUX1, including path resistance, offset current, contact potential, and path isolation.

The verification procedures are located on the following pages:

"Channel resistance tests" on page 4-7

"Offset current tests" on page 4-16

"Contact potential tests" on page 4-23

"Path isolation tests" on page 4-29

Except where otherwise indicated, the performance verification procedures must be performed with only one Model 7002-HD-MUX1 (the one being checked) installed in the Model 7002-HD. These conditions do not apply if there are signals present in the backplane of the Model 7002-HD.

WARNING **The following information is intended for qualified service personnel. Do not perform these tests unless you are qualified to do so.**

To prevent electric shock that could result in serious injury or death, adhere to following safety precautions:

- **Before removing or installing a Model 7002-HD-MUX1 in the mainframe, make sure the mainframe is turned off and disconnected from line power.**
- **Before making or breaking connections, make sure power is removed from all external circuitry.**
- **Do not connect signals that may exceed the maximum specifications of the Model 7002-HD-MUX1 or external wiring. Specifications for the Model 7002-HD-MUX1 are provided at the end of this manual.**

CAUTION **The maximum signal level, any channel to any channel, is: 200V DC or 200V rms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum. Exceeding these signal levels may result in card damage, possibly voiding the warranty.**

NOTE Failure of any performance verification test may indicate that the Model 7002-HD-MUX1 is contaminated. See "Handling and cleaning precautions" on page 4-2 to clean the Model 7002-HD-MUX1.

Environmental conditions

All verification measurements should be made at an ambient temperature between 18°C and 28°C, and at a relative humidity of less than 50%.

Recommended equipment

Table 4-1 summarizes the equipment necessary for performance verification, along with an application for each unit.

Table 4-1
Verification equipment

Description	Keithley Model	Specifications	Applications
DMM	2750	100Ω; 0.01%	Path resistance
Electrometer with voltage source	6517A	20pA; 1% 20nA, 200nA; 0.2% 100V source; 0.15%	Offset current, isolation
Sensitive DMM	2182A	10mV; 0.006%	Contact potential
Triax cable	237	NA	Offset current, isolation
Low thermal cable	2107	NA	Contact potential
Low thermal short	2188	NA	Contact potential

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Card connections

The following information summarizes methods that can be used to connect test instrumentation to the matrix. Refer to "Cables and wiring" on page 2-14 for detailed information.

Multiplexer inputs

Two 40-pin IDC ribbon cable headers act as the input connection to each of the multiplexers. One method to make instrumentation or device connections to a multiplexer is to hard-wire a 40-pin socket connector and then mate it to the multiplexer input connector. Channel shorting connections can also be done at the connector. Multiplexer input connectors are summarized in Table 2-1 on page 2-10 and input terminals are listed in Table 2-2 on page 2-11 and Table 2-3 on page 2-12.

Before pre-wiring any connector plugs, study the following test procedures to fully understand the connection requirements.

Multiplexer outputs

The multiplexer output signals are accessible at screw terminals and form the rows of the matrix. Instrumentation can be hard-wired directly to the screw terminals. Keep jumper wires as short as possible. Multiplexer output terminals are shown in Table 2-4 on page 2-13.

Matrix column inputs

The matrix column inputs are accessible at screw terminals. Just like the multiplexer outputs, instrumentation can be hard-wired directly to the screw terminal and jumper wires should be kept as short as possible. Matrix connector terminals are listed in Table 2-4 on page 2-13.

Channel mapping

The tests in this section identify certain channels to close for a specific test path. In order to test alternate paths, it will be necessary to close different channels. See the following for information on channels to close:

- Multiplexer channels: Table 3-1 on page 3-3 through Table 3-4 on page 3-6
- Matrix channels: Table 3-5 on page 3-7
- Backplane isolation channels: Table 3-6 on page 3-8

Channel resistance tests

These tests will verify that each relay is closing properly and that the channel resistance is within specifications for various configurations. All of the multiplexer HI IDC connector pins should be connected together to form a single common bus while all of the LO connector pins should also be connected to each other. Refer to the multiplexer input pin assignments in Table 2-2 on page 2-11 and Table 2-3 on page 2-12 when making these connections. The matrix column screw terminals should similarly have the HI and LO signals connected to form two respective common buses. Figure 4-1 illustrates this necessary setup in addition to specific instrument connection nodes for a specific test case.

Each of the verification procedures is single-ended (non-differential) except that for the input selector. The first tests verify the HI path resistance while the second verifies LO path resistance. Figure 4-1 depicts the connection nodes for the initial Model 2750 connections. For each, the input HI and sense HI connections should be positioned where the appropriate connection node is illustrated on opposite ends of the common bus to maximize lead separation. This is important to avoid measuring resistance not in the analyzed signal path. The same applies for the input LO and sense LO connections as well.

A Model 2750 Multimeter will be used to perform this verification test. Both the HI and LO differential paths will be verified on the card using a similar procedure. In terms of this testing, there is no relationship between HI and LO on the Model 2750 and the HI and LO differential paths on the Model 7002-HD-MUX1. The INPUT HI and SENSE HI leads of the Model 2750 will always be connected to a multiplexer input (which can be either the HI or LO path), and the INPUT LO and SENSE LO will be connected to the HI or LO multiplexer output or matrix columns depending on the test.

Configuration 1: Auxiliary Input path resistance

1. Remove power from the Model 7002-HD.
2. Set up for the resistance tests:
   - Connect both INPUT HI and SENSE HI to the HI of Mux1's output screw terminal (J106 Pin 4).
   - Connect both INPUT LO and SENSE LO to the Input A Auxiliary HI matrix column input screw terminal (J108 Pin 5).
3. Check resistance for the Auxiliary HI path:
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - Turn on the Model 7002-HD, and program it to close channel 5!1 (Matrix Row 1 Column 1) and 5!21 (Input Selector Relay). Verify that the resistance of this path is less than the Quad 1 x 40 channel resistance specification (page A-2).

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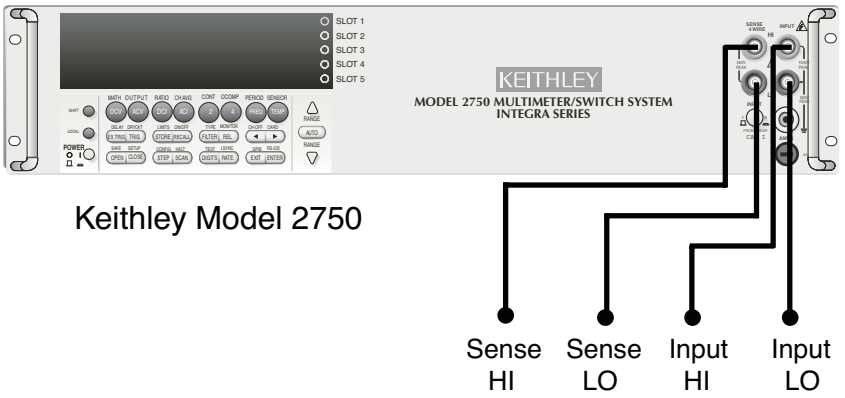
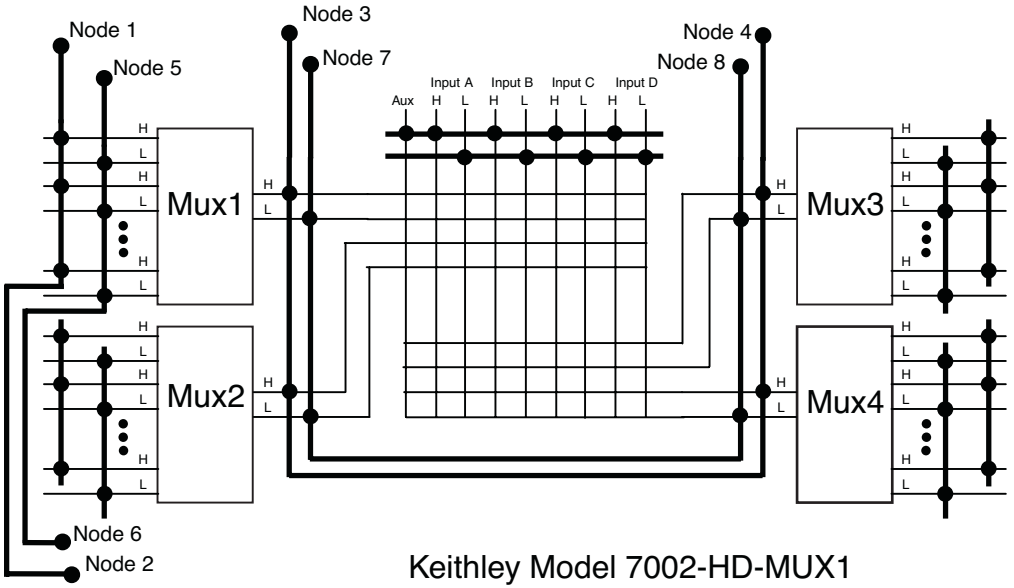
4. Check resistance for the Input A HI path:
   - Remove power from the 7002-HD and change the connection of the Model 2750 so the INPUT LO and SENSE LO signals are connected to the Input A HI matrix column screw terminal (J108 Pin 4).
   - Turn on the Model 7002-HD, and program it to close channel 5!1 (Matrix Row 1 Column 1). Verify that the resistance of this path is less than the Quad 1 x 40 channel resistance specification.

Figure 4-1
Connections to verify 1 x 40 multiplexer channel resistance





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Configuration 2: Quad 1 x 40 multiplexer path resistance

1. Remove power from the Model 7002-HD.
2. Set up for the resistance tests:
   - As shown in Figure 4-1, connect all HI multiplexer input pins together to form one common bus for each multiplexer.
   - Also connect all LO multiplexer input pins together to form another common bus for each multiplexer.
   - Similarly connect together all of the multiplexer outputs HI and LO signals to form two respective common buses as shown in Figure 4-1.
   - Check that the FRONT/REAR switch of the Model 2750 is set to FRONT.
   - Set the Model 2750 to the 4-Wire 100Ω range, and connect four test leads to the INPUT and SENSE inputs.
   - Short the four test leads together and REL the Model 2750. Leave REL enabled for the entire test.
   - Connect INPUT HI and SENSE HI of the Model 2750 to the common Mux 1 bus NODE 1 and NODE 2 respectively as labeled on Figure 4-1. It is recommended that the physical connections be made at the two opposite ends of the common bus as shown in the illustration.
   - Connect INPUT LO and SENSE LO to the other common bus NODE 3 and NODE 4 as shown on Figure 4-1. It is again recommended to make the connections at the two opposite ends of the common bus as shown.
3. Check the resistance for the Mux 1 HI differential path:
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - Turn on the Model 7002-HD, and program it to close channel 1!1 (Mux 1 channel 1). Verify that the resistance of this channel is less than the Quad 1 x 40 channel resistance specification (page A-2).
   - Open channel 1!1 and close 1!2. Verify that this channel measures less than the Quad 1 x 40 channel resistance specification.
   - Open channel 1!2 and close 1!3. Verify that this channel measures less than the Quad 1 x 40 channel resistance specification.
   - Repeat this basic procedure of opening and closing channels to check the resistance of all channels of Mux 1 (for example, 1!1 through 1!40). See Table 3-1 on page 3-3 through Table 3-4 on page 3-6.
4. Check the resistance of Muxes 2-4:
   - Remove power from the Model 7002-HD, and change the connection of the Model 2750 so the INPUT HI and SENSE HI leads are similarly connected to the common bus of the next multiplexer to test.
   - Repeat this procedure described in step 3 and 4 for Mux 2 (2!1 through 2!40), Mux 3 (3!1 through 3!40), and Mux 4 (4!1 through 4!40) to verify their path resistance.

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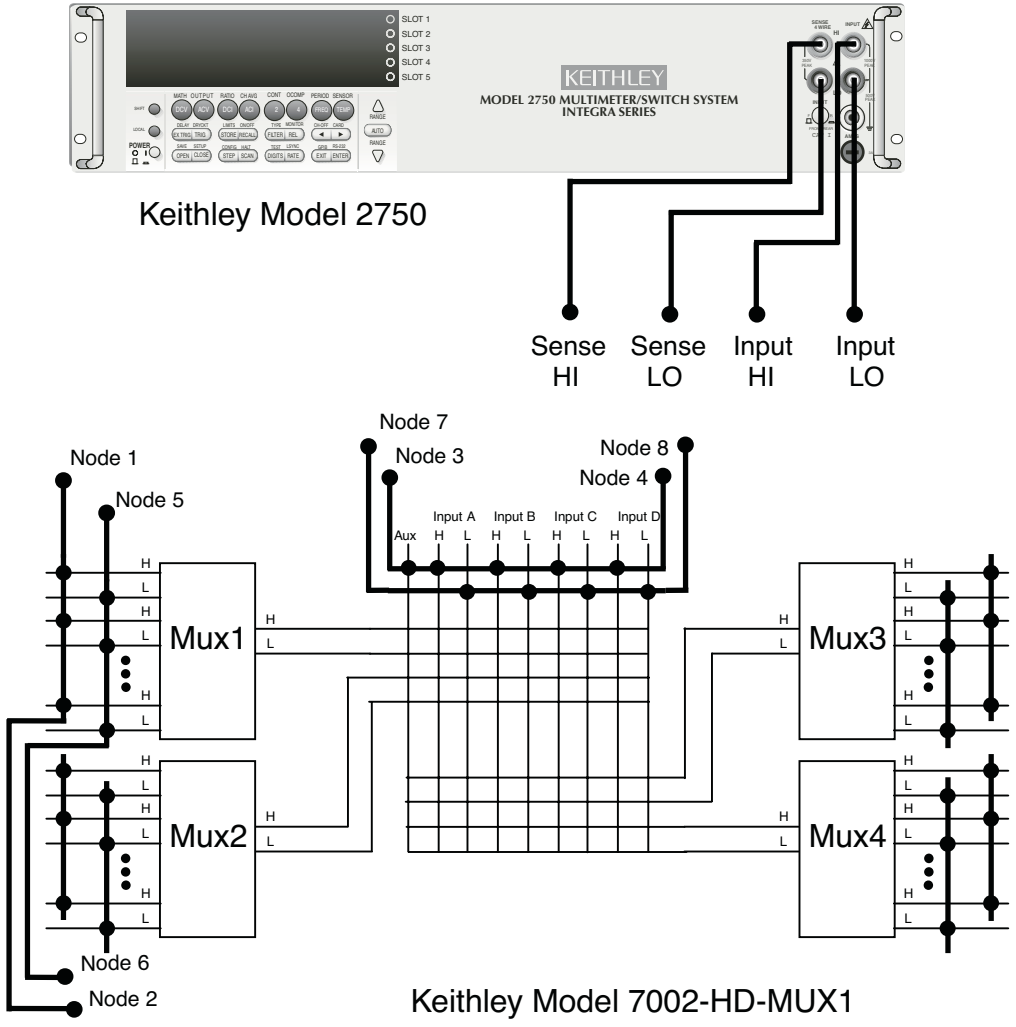
5. Check the resistance of the LO differential path for all multiplexers:
   - Remove power from the Model 7002-HD, and change the connection of the Model 2750 so that INPUT HI is connected to NODE 5 and SENSE HI to NODE 6 as shown in Figure 4-1. Additionally connect INPUT LO to NODE 7 and SENSE LO to NODE 8. It is recommended to separate the sense and input leads on opposite ends of the common buses as shown.
   - Repeat steps 3 and 4 to test the LO differential path resistance.

Figure 4-2
Connections to verify multiplexer signal channel resistance through the matrix



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Configuration 3: 1 x 160 multiplexer path resistance

1. Remove power from the Model 7002-HD.
2. Setup for the resistance tests:
   - As shown in Figure 4-2, connect all HI multiplexer input pins together to form one common bus for each multiplexer.
   - Also connect all LO multiplexer input pins together to form another common bus for each multiplexer.
   - Similarly connect together all of the matrix column HI and LO signals to form two respective common buses as shown in Figure 4-2.
   - Check that the FRONT/REAR switch of the Model 2750 is set to FRONT.
   - Set the Model 2750 to the 4-Wire 100Ω range, and connect four test leads to the INPUT and SENSE input.
   - Short the four test leads together, and REL the Model 2750. Leave REL enabled for the entire test.
   - Connect INPUT HI and SENSE HI of the Model 2750 to the common Mux 1 bus NODE 1 and NODE 2 respectively as labeled on Figure 4-2. It is recommended that the physical connections be made at the two opposite ends of the common bus as shown in the illustration.
   - Connect INPUT LO and SENSE LO to the other common bus's NODE 3 and NODE 4 as shown on Figure 4-2. It is again recommended to make the connections at the two opposite ends of the common bus as shown.
3. Check resistance from the Mux 1 HI differential path through the first column of the matrix:
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - Turn on the Model 7002-HD, and program it to close channel 1!1 (Mux 1 channel 1) and 5!1 (Matrix Row 1 Column 1). Verify that the resistance of this path is less than the 1 x 160 channel resistance specification (page A-2).
   - Open channel 1!1 and close 1!2. Leave channel 5!1 closed. Verify that this path resistance is less than the 1 x 160 channel resistance specification.
   - Open channel 1!2 and close 1!3. Verify that this path resistance is less than the 1 x 160 channel resistance specification.
   - Repeat this basic procedure of opening and closing channels to check the resistance of all HI channels of Mux 1 (for example, 1!1 through 1!40).

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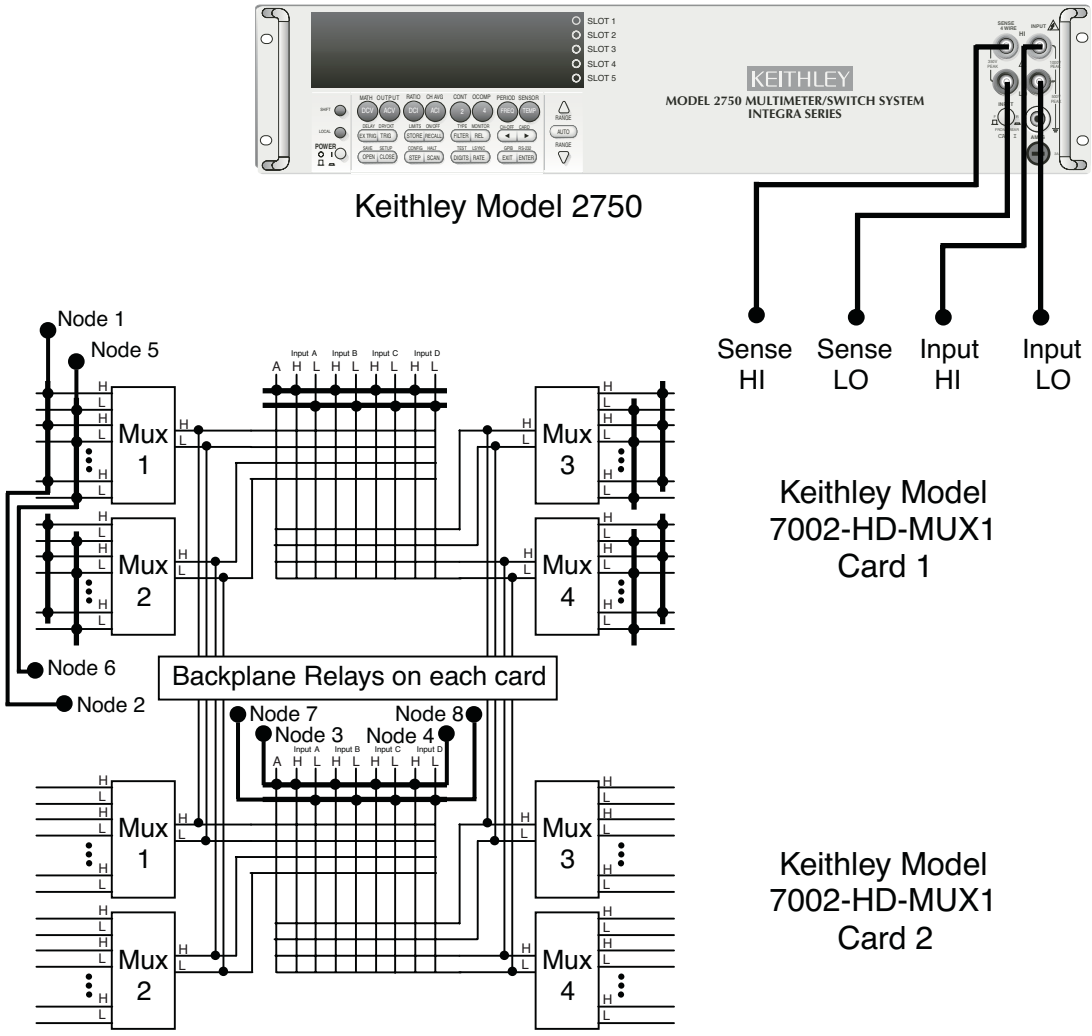
4. Check resistance from the Mux 1 HI path through the other columns of the matrix:
   - Open all matrix relays, and then close the Input B column relay for the active mux (for example, 5!2 for Mux 1, 5!6 for Mux 2, etc.). Refer to Table 3-5 on page 3-7 for matrix relay mappings. Repeat step 3 for each of the matrix column inputs B-D.
5. Check the resistance of Muxes 2-4:
   - Turn off the Model 7002-HD, and change the connection of the Model 2750 so the INPUT HI and SENSE HI leads are connected to the common bus of the next multiplexer to test.
   - Repeat this procedure described in Step 3 and 4 for Mux 2 (channels 2!1 through 2!40), Mux 3 (3!1 through 3!40), and Mux 4 (4!1 through 4!40) to verify their path resistance. See Table 3-1 on page 3-3 through Table 3-4 on page 3-6.
6. Repeat testing to verify the resistance of the LO path:
   - Remove power from the Model 7002-HD, and change the connection of the Model 2750 so that INPUT HI is connected to NODE 5 and SENSE HI to NODE 6 as shown in Figure 4-2. Additionally connect INPUT LO to NODE 7 and SENSE LO to NODE 8. It is recommended to separate the sense and input leads on opposite ends of the common buses as shown.
   - Repeat steps 3 through 5 to check the LO path resistance.

Figure 4-3
Connections to verify multiplexer signal channel resistance through the matrix and backplane



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Configuration 4: 1 x 320 multiplexer path resistance

1. Remove power from the Model 7002-HD.
2. Set up for the resistance tests using two Model 7002-HD-MUX1 cards:
   - Connect all HI multiplexer input pins together to form one common bus for each multiplexer on Card 1 as shown in Figure 4-3.
   - Also connect all LO multiplexer input pins together to form another common bus for each multiplexer on Card 1.
   - On the second card, connect together all of the matrix column HI and LO signals to form two respective common buses as shown in Figure 4-3.
   - Check that the FRONT/REAR switch of the Model 2750 is set to FRONT.
   - Set the Model 2750 to the 4-Wire 100Ω range, and connect four test leads to the INPUT and SENSE input.
   - Short the four test leads together and REL the Model 2750. Leave REL enabled for the entire test.
   - Connect INPUT HI and SENSE HI of the Model 2750 to the Card 1 common Mux 1 bus NODE 1 and NODE 2 respectively as labeled on Figure 4-3. It is recommended that the physical connections be made at the two opposite ends of the common bus as shown in the illustration.
   - Connect INPUT LO and SENSE LO to the Card 2 common bus's NODE 3 and NODE 4 as shown on Figure 4-3. It is again recommended to make the connections at the two opposite ends of the common bus as shown.
3. Check resistance from the Mux 1 HI path through the backplane and the first column of the matrix:
   - Install the first Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - Install the second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD.
   - Turn on the Model 7002-HD.
   - Close the backplane relay on each of the cards to connect the multiplexer under test (for example, 5!17 and 10!17 for Mux 1). See Table 3-6 on page 3-8 for backplane relay mappings.
   - Program the Model 7002-HD to close channel 1!1 (Card 1 Mux 1 channel 1) and 10!1 (Card 2 Matrix Row 1 Column 1). Verify that the resistance of this path is less than the 1 x 320 channel resistance specification (page A-2).
   - Open channel 1!1 and close 1!2. Leave the Card 2 matrix channel 10!1 closed and the applicable backplane relays closed. Verify that this path measures less than the 1 x 320 channel resistance specification.
   - Open channel 1!2 and close 1!3. Verify that this path measures less than the 1 x 320 channel resistance specification.

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- Repeat this basic procedure of opening and closing channels to check the resistance of all HI channels of Mux1 (for example, 1!1 through 1!40).

4. Check resistance from the Mux1 HI path through the other columns of the matrix:
   - Open all matrix relays, and then close the Input B column relay on Card 2 for the active mux (for example, 10!2 for Mux 1, 10!6 for Mux 2, etc.). Refer to Table 3-5 on page 3-7 for matrix relay mappings while noting that logical slot 5 becomes logical slot 10 since the card is in the second mainframe slot (see Table 3-9 on page 3-11). Repeat step 3 for each of the matrix column inputs B-D.
5. Check the resistance of Muxes 2-4:
   - Turn off the 7002-HD, and change the connection of the 2750 on Card 1 so the INPUT HI and SENSE HI leads are connected to the common bus of the next multiplexer to test.
   - Repeat this procedure described in step 3 and 4 for Mux 2 (channels 2!1 through 2!40), Mux 3 (3!1 through 3!40), and Mux 4 (4!1 through 4!40) to verify their path resistance.
6. Repeat testing to verify the resistance of the LO differential path:
   - Remove power from the Model 7002-HD, and change the connection of the Model 2750 to Card 1 so INPUT HI is connected to NODE 5 and SENSE HI to NODE 6 as shown in Figure 4-3. Additionally, connect INPUT LO to NODE 7 and SENSE LO to NODE 8 on Card 2. It is recommended to separate the sense and input leads on opposite ends of the common buses as shown.
   - Repeat steps 3 through 5 to check the LO differential path resistance.

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Offset current tests

These tests check leakage current from channel-to-channel and from channel-to-chassis for each pathway. In general, these tests are performed by measuring the leakage current with an electrometer. In the following procedure, the Model 6517A is used to measure leakage current.

Differential channel offset current

Configuration 1: Quad 1 x 40 differential channel offset current

1. Remove power from the Model 7002-HD.
2. Set up for the offset current test as follows:
   - Connect the Model 6517A HI lead to Mux 1 Output HI (shown as Node 1 in Figure 4-4). Connect the LO lead from the Model 6517A to Mux 1 Output LO (shown as Node 2 in Figure 4-4).
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - On the Model 6517A, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure unless otherwise specified.
3. Check multiplexer differential HI pathway leakage current:
   - Turn on the Model 7002-HD.
   - Program the Model 7002-HD to close the first channel of the multiplexer (for example 1!1 for Mux 1).
   - On the Model 6517A, disable zero check, and verify that the leakage current of the pathway is less than the 1 x 40 configuration specification (page A-2).
   - On the Model 6517A, enable zero check.
   - Open the closed channel on the Model 7002-HD-MUX1.
   - Repeat this procedure until all channels are tested for the multiplexer (for example 1!1 through 1!40).
4. Repeat to verify leakage currents of multiplexer 2, 3, and 4:
   - Remove power from the 7002-HD and change the 6517A HI lead to connect to the next multiplexer and the LO lead to connect to the respective Output LO.
   - Repeat step 3 to verify the leakage current.
5. Turn off the Model 7002-HD and disable zero correct on the Model 6517A.

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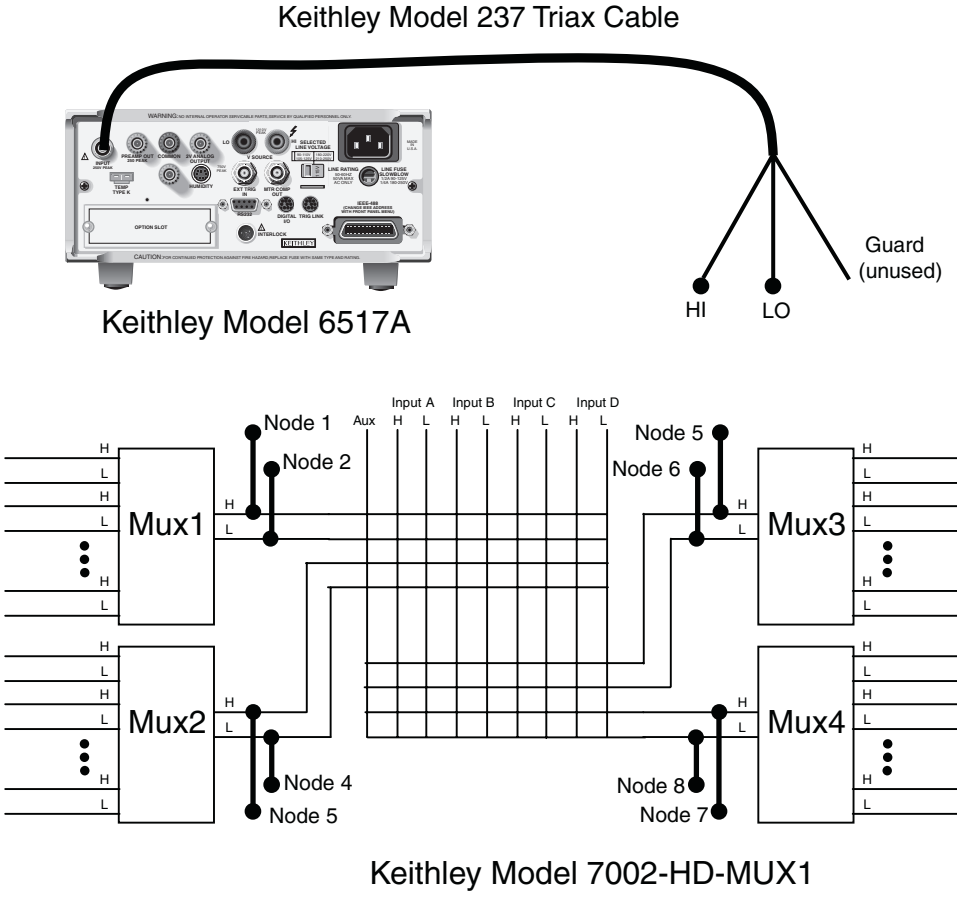
Configuration 2: 1 x 160 channel-to-channel offset current

1. Remove power from the 7002-HD.
2. Set up for the offset current test:
   - Connect the Model 6517A HI lead to Mux 1 Output HI (shown as Node 1 in Figure 4-4). Connect the LO lead from the 6517A to Mux 1 Output LO (shown as Node 2 in Figure 4-4).
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - On the Model 6517A, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure unless otherwise specified.
   - Turn on the Model 7002-HD.

Figure 4-4
Connections to verify 1 x 40 and 1 x 160 multiplexer offset current



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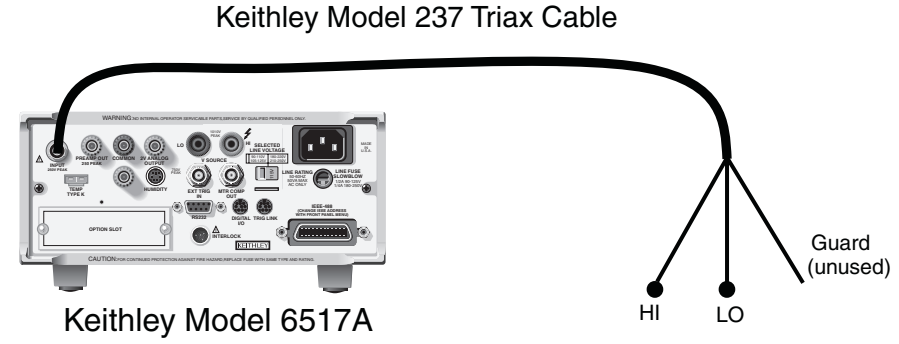
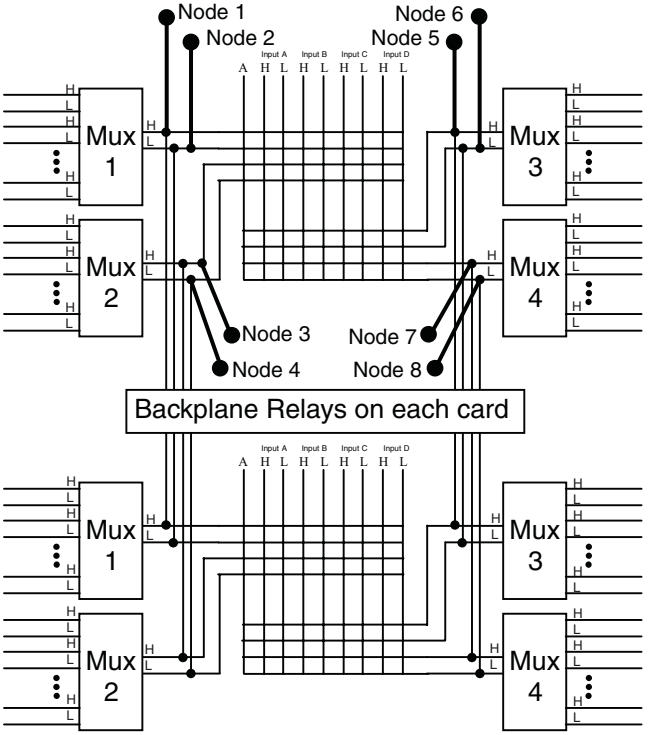
3. Check multiplexer differential HI pathway leakage current:
   - Program the Model 7002-HD to close the first channel of the multiplexer (for example, 1!1 for Mux 1) and all Input A column relays (5!1, 5!5, 5!9, and 5!13). See Table 3-5 on page 3-7 for matrix channel mapping information.
   - On the Model 6517A, disable zero check, and verify that the leakage current of the pathway is less than the 1 x 160 configuration specification (page A-2).
   - On the Model 6517A, enable zero check.
   - Open the closed multiplexer channel on the Model 7002-HD-MUX1.
   - Repeat this procedure until all 40 channels are tested through the given matrix relay for the multiplexer (for example, 1!1 through 1!40).
4. Verify leakage currents on the other matrix columns.
   - Open any closed matrix relays.
   - Repeat step 3 for the other matrix column inputs B, C, and D by closing all their corresponding column relays instead as indicated.
5. Continue on to verify the leakage currents for multiplexer 2, 3, and 4:
   - Remove power from the 7002-HD, and change the 6517A HI lead to connect to the next multiplexer Output HI and the LO lead to connect to the respective Output LO.
   - Turn on the Model 7002-HD, and repeat steps 4 and 5 to verify the leakage currents.
6. Turn off the Model 7002-HD, and disable zero correct on the Model 6517A.

Configuration 3: 1 x 320 channel-to-channel offset current

1. To check the channel-to-channel offset current, install a second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD.
2. Follow the procedure described in the Configuration 2 offset current test, using Figure 4-5 as a reference for connections. When testing, make sure to close the appropriate backplane relays on each of the Model 7002-HD-MUX1 cards (5!17 and 10!17 for Mux 1, 5!18 and 10!18 for Mux 2, 5!19 and 10!19 for Mux 3, and 5!20 and 10!20 for Mux 4).
3. For each step, verify the leakage current is less than the 1 x 320 configuration specification (page A-2).

Figure 4-5
Connections to verify 1 x 320 multiplexer offset current





Keithley Model 7002-HD-MUX1 Card 1

Keithley Model 7002-HD-MUX1 Card 2

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Common mode offset current

Configuration 4: Quad 1 x 40 channel-to-chassis offset current

1. Remove power from the 7002-HD.
2. Setup for the offset current test:
   - Connect the Model 6517A HI lead to Mux 1 Output HI and LO (shown as Node 1 and 2 in Figure 4-4). Connect the LO lead from the 6517A to chassis ground, which is accessible at any metal contact on the rear panel of the 7002-HD.
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - On the Model 6517A, select the 200pA range and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure unless otherwise specified.
3. Check multiplexer pathway leakage current:
   - Turn on the Model 7002-HD.
   - Program the Model 7002-HD to close the first channel of the multiplexer (for example, 1!1 for Mux 1).
   - On the Model 6517A, disable zero check and verify that the leakage current of the pathway is less than the 1 x 40 configuration specification (page A-2).
   - On the Model 6517A, enable zero check.
   - Open the closed channel on the Model 7002-HD-MUX1.
   - Repeat this procedure until all channels are tested for the multiplexer (for example, 1!1 through 1!40).
4. Repeat to verify leakage currents of multiplexer 2, 3, and 4:
   - Remove power from the 7002-HD and change the 6517A HI lead to connect to the next multiplexer Output HI and LO (for example, Node 3 and 4 in Figure 4-4 for Mux 2, Node 5 and 6 for Mux 3, and Node 7 and 8 for Mux 4).
   - Repeat step 3 to verify the leakage current.
5. Turn off the Model 7002-HD and disable zero correct on the Model 6517A.

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Configuration 5: 1 x 160 channel-to-chassis offset current

1. Remove power from the Model 7002-HD.
2. Set up for the offset current test:
   - Connect the Model 6517A HI lead to Mux 1 Output HI and LO (shown as Node 1 and 2 in Figure 4-4). Connect the LO lead from the Model 6517A to chassis ground, which is accessible at any metal contact on the rear panel of the Model 7002-HD.
   - Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
   - On the Model 6517A, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure unless otherwise specified.
   - Turn on the Model 7002-HD.
3. Check multiplexer pathway leakage current:
   - Program the Model 7002-HD to close the first channel of the multiplexer (for example, 1!1 for Mux1) and all Input A column relays (5!1, 5!5, 5!9, and 5!13). See Table 3-5 on page 3-7 for matrix channel mapping information.
   - On the Model 6517A, disable zero check, and verify that the leakage current of the pathway is less than the 1 x 160 configuration specification (page A-2).
   - On the Model 6517A, enable zero check.
   - Open the closed multiplexer channel on the Model 7002-HD-MUX1.
   - Repeat this procedure until all 40 channels are tested through the given matrix relay for the multiplexer (for example, 1!1 through 1!40).
4. Verify leakage currents on the other matrix columns:
   - Open any closed matrix relays.
   - Repeat step 3 for the other matrix column inputs B, C, and D by closing all of the their corresponding column relays instead as shown.
5. Continue on to verify the leakage currents for multiplexer 2, 3, and 4:
   - Remove power from the 7002-HD, and change the 6517A HI lead to the next multiplexer Output HI and LO (for example, Node 3 and 4 in Figure 4-4 for Mux 2, Node 5 and 6 for Mux 3, and Node 7 and 8 for Mux 4).
   - Turn on the Model 7002-HD.
   - Repeat step 4 and 5 to verify the leakage currents.
6. Turn off the Model 7002-HD, and disable zero correct on the Model 6517A.

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Configuration 6: 1 x 320 channel-to-chassis offset current

1. To check the channel-to-chassis offset current, install a second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD.
2. Follow the procedure described in the Configuration 5 offset current test, using Figure 4-5 as a reference for connections. When testing, make sure to close the appropriate backplane relays on each of the Model 7002-HD-MUX1 cards (5!17 and 10!17 for Mux 1, 5!18 and 10!18 for Mux 2, 5!19 and 10!19 for Mux 3, and 5!20 and 10!20 for Mux 4).
3. For each step, verify the leakage current is less than the 1 x 320 configuration specification (page A-2).

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Contact potential tests

These tests check the EMF generated by each relay contact for each pathway. The tests consist of using a sensitive digital voltmeter (Model 2182A) to measure the contact potential.

Configuration 1: Quad 1 x 40 multiplexer contact potential

1. Remove power from the Model 7002-HD.
2. Set up the Model 7002-HD-MUX1:
   - As shown in Figure 4-6, connect all HI and LO multiplexer input pins together.
   - Connect together Mux 1, Mux 2, Mux 3, and Mux 4 Output HI together, and connect all four Mux Output LO terminals together similarly as shown in Figure 4-6.
3. Connect the Model 2182A HI lead to Mux 1 Output HI (Node 1 in Figure 4-6) and the LO lead to Mux 1 Output LO (Node 2 in Figure 4-6).
4. Connect a low thermal short between the HI and LO lead terminations of the Model 2182A within the Model 7002-HD-MUX1 card.
5. Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD, and turn the Model 7002-HD on.
6. Allow the Model 2182A, Model 7002-HD, and Model 7002-HD-MUX1 to warm up for two hours.
7. Set up the Model 2182A:
   - Select the 10mV range.
   - Press REL to null out internal offsets.
   - Leave REL enabled for the entire procedure.
8. Remove low thermal short:
   - Turn off the Model 7002-HD.
   - Remove the Model 7002-HD-MUX1 from the Card 1 opening.
   - Cut the low thermal short between HI and LO of the Model 2182A.
   - Re-install the 7002-HD-MUX1 into the Card 1 opening.
9. Turn on the Model 7002-HD, and program it to close the first channel of the multiplexer (1!1 for Mux 1).
10. After settling (less than 5 minutes), verify that the reading on the Model 2182A is less than the 1 x 40 specification (page A-2). This measurement represents the contact potential of the pathway.
11. On the Model 7002-HD, open channel 1!1, close the next channel (1!2) of the multiplexer, and verify its path contact potential. Continue this process until all 40 channels of the multiplexer have been tested.
12. Repeat steps 9 through 11 for each multiplexer.

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Figure 4-6
Connections to verify quad 1 x 40 multiplexer contact potential

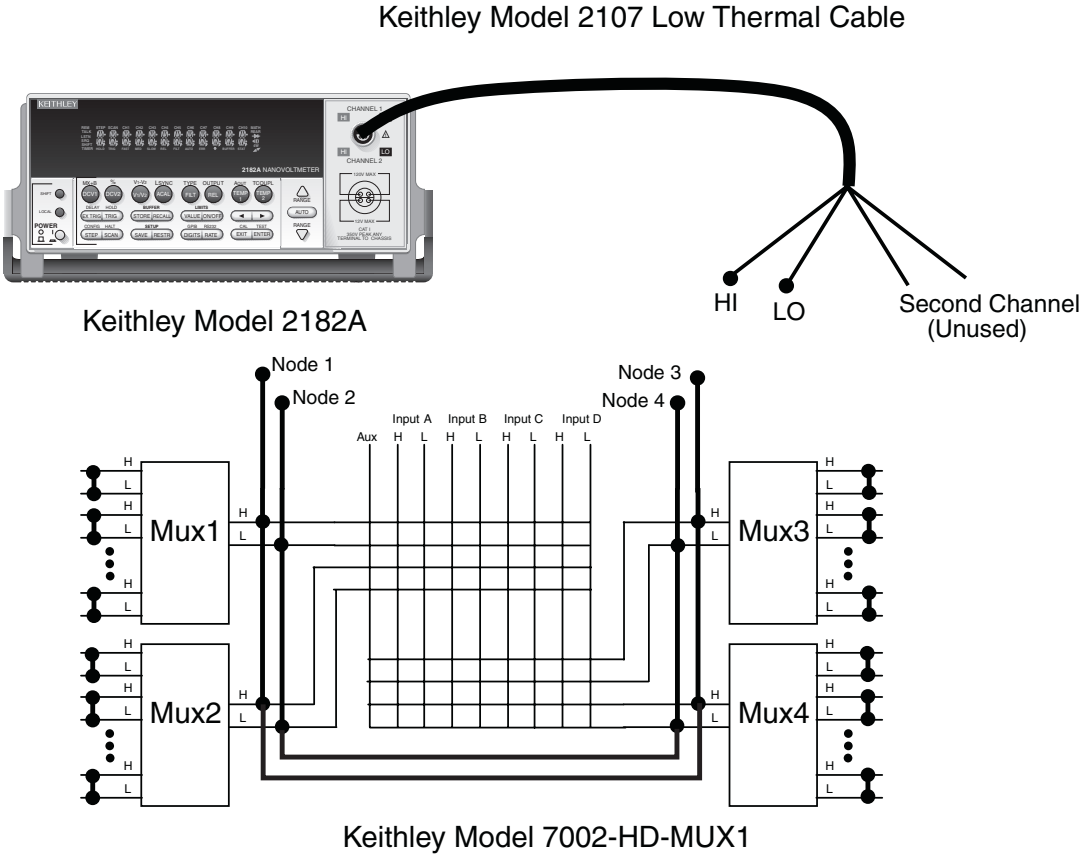

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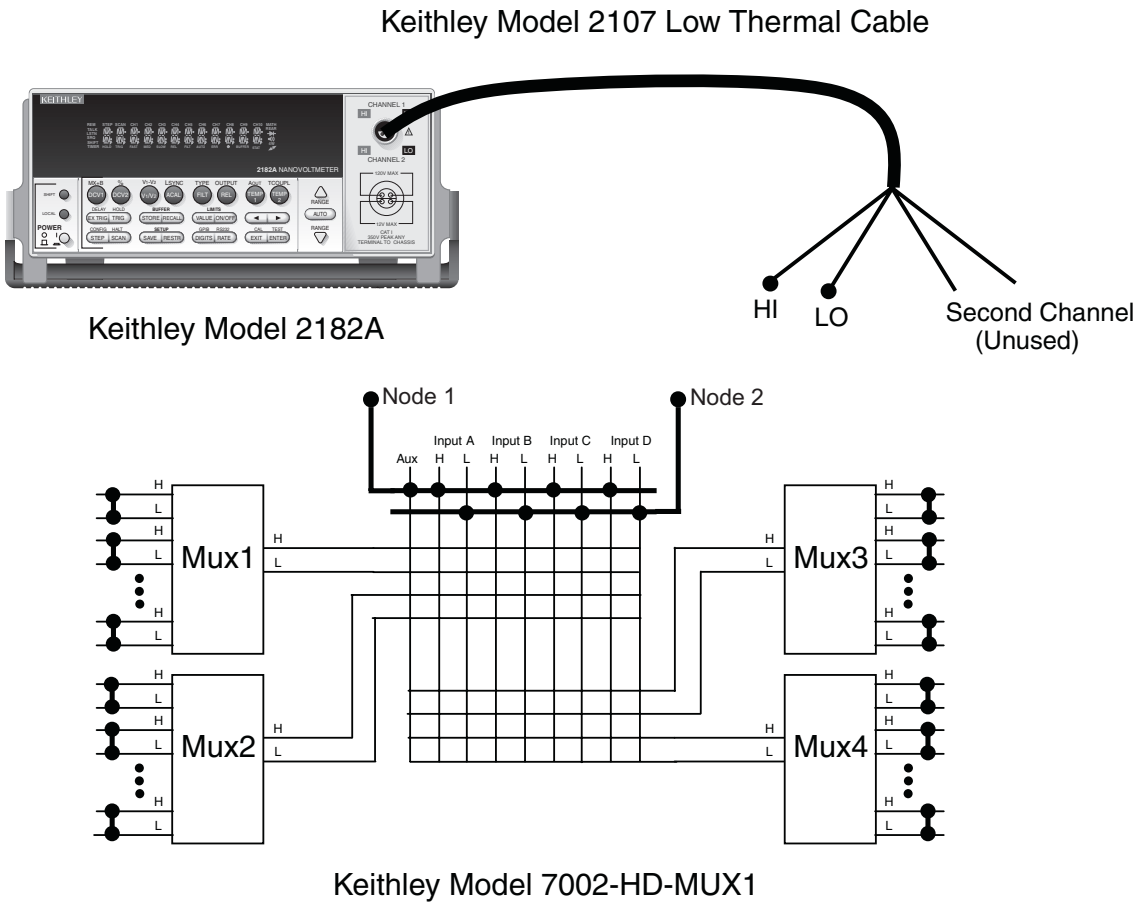
Figure 4-7
Connections to verify 1 x 160 multiplexer contact potential



Configuration 2: 1 x 160 multiplexer contact potential

1. Remove power from the Model 7002-HD, and disable REL on the Model 2182A.
2. Set up the Model 7002-HD-MUX1:
   - As shown in Figure 4-7, connect all HI and LO multiplexer input pins together.
   - Connect together the matrix HI column signals to form one common bus, and connect all of the matrix LO column signals to form a second common bus as shown in Figure 4-7.

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3. Connect a low thermal short between HI and LO of the Model 2182A within the Model 7002-HD-MUX1 card.
4. Connect the Model 2182A HI lead to the columns HI common bus (Node 1 in Figure 4-7) and the LO lead to the columns LO common bus HI (Node 2 in Figure 4-7).
5. Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD, and turn the model 7002-HD on.
6. Allow the Model 2182A, Model 7002-HD, and Model 7002-HD-MUX1 to warm up for two hours.
7. Set up the Model 2182A:
   - Select the 10mV range.
   - Press REL to null out internal offsets.
   - Leave REL enabled for the entire procedure.
8. Remove low thermal short:
   - Turn off the Model 7002-HD.
   - Remove the Model 7002-HD-MUX1 from the Card 1 opening.
   - Cut the low thermal short between HI and LO of the Model 2182A.
   - Re-install the 7002-HD-MUX1 into the Card 1 opening.
   - Turn on the Model 7002-HD.
9. Program the Model 7002-HD to close the first channel of the multiplexer (1!1 for Mux 1) and the appropriate matrix interconnect (5!1). Refer to Table 3-5 on page 3-7 for matrix channel mapping information.
10. After settling (less than 5 minutes), verify that the reading on the Model 2182A is less than the 1 x 160 configuration specification (page A-2). This measurement represents the contact potential of the pathway.
11. On the Model 7002-HD, open the channel 1!1, close the next channel (1!2) of the multiplexer, and verify its path contact potential while leaving the same matrix relay closed. Continue this process until all 40 channels of the multiplexer have been tested.
12. Verify the contact potential of the other matrix columns for the given multiplexer:
    - Open all matrix relays.
    - Close the matrix relay associated with the multiplexer under test and the next HI column to test Inputs B through D. Repeat steps 9 through 11 until each column is tested.
13. Verify the contact potential of the other multiplexers by repeating steps 9 through 12 for each.

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Configuration 3: 1 x 320 multiplexer contact potential

1. Install a second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD.
2. Follow the procedure described in the Configuration 2 contact potential test. When testing, make sure to close the appropriate backplane relays on each of the Model 7002-HD-MUX1 cards (5!17 and 10!17 for Mux 1, 5!18 and 10!18 for Mux 2, 5!19 and 10!19 for Mux 3, and 5!20 and 10!20 for Mux 4). Make the multiplexer input connections on Card 1 and the matrix column connections on Card 2 as shown in Figure 4-8.
3. For each step, verify the contact potential is less than the 1 x 320 configuration specification (page A-2).

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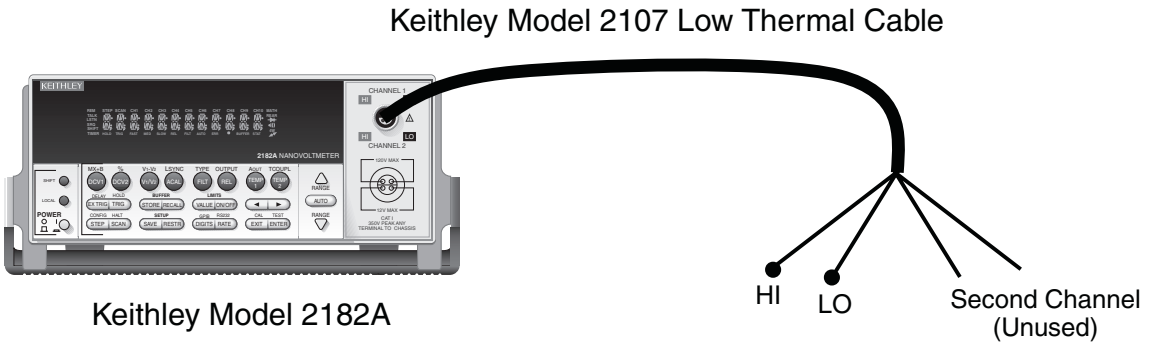
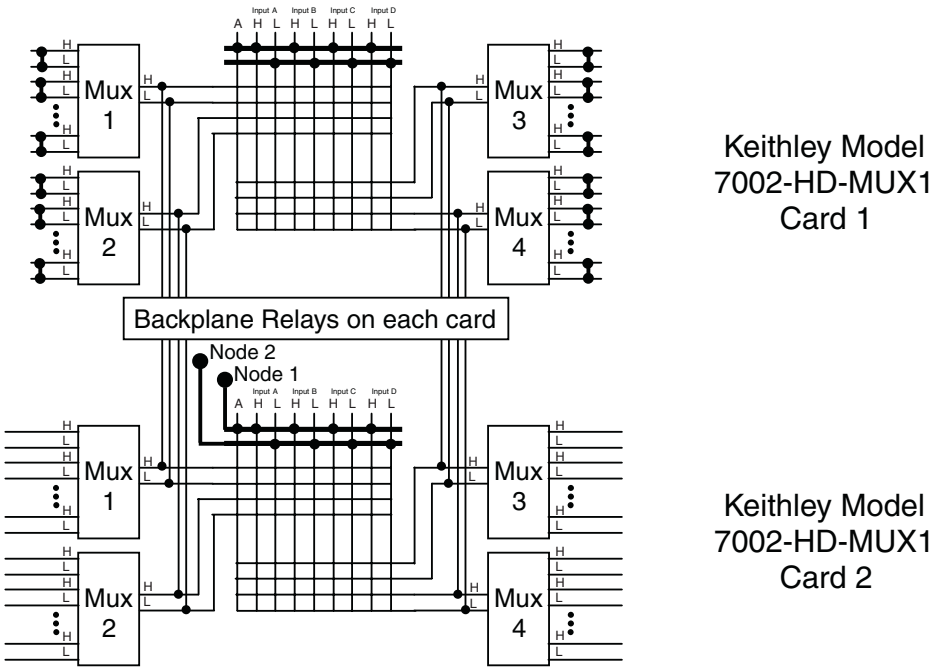
Figure 4-8
Connections to verify 1 x 320 multiplexer contact potential





Keithley Model 7002-HD-MUX1 Card 1

Keithley Model 7002-HD-MUX1 Card 2

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Path isolation tests

Differential channel isolation

WARNING The following steps use high voltage (up to 100V). Be sure to remove power from the circuit before making connection changes.

The isolation tests check the channel-to channel leakage resistance (isolation) between adjacent paths and the channel-to-chassis isolation. A path is defined as the contact from a multiplexer input to a multiplexer output or matrix column output. In general, the test is performed by applying a voltage (+100V) across two adjacent paths and then measuring the leakage current across the paths. The isolation resistance is then calculated as R = V / I. In the following procedure, the Model 6517A functions as both a voltage source and an ammeter. In the R function, the Model 6517A internally calculates the resistance from the known voltage and current levels and displays the resistance value.

Configuration 1: Quad 1 x 40 multiplexer differential isolation test

1. Remove power from the Model 7002-HD. Make sure the voltage source OPERATE is disabled on the Model 6517A and there are no other connections to the Model 7002-HD-MUX1.
2. Connect the ammeter HI (A-HI in Figure 4-9) of the Model 6517A to the HI output path of Mux1 (NODE 1) and the voltage source HI (VS-HI in Figure 4-9) to the LO output path (NODE 2).
3. Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
4. On the Model 6517A:
   - Enable the voltage source LO (VS-LO) and ammeter input LO (A-LO) internal connection by setting the METER-CONNECT in the CONFIGURE V-SOURCE menu.
   - Remove any physical ground link connecting the rear panel common and chassis ground on the Model 6517A if present.
   - Place the Model 6517A in the R measurement function.
   - Select the 20pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
   - Release zero check.
   - Press REL to cancel offset current, and then enable zero check.
   - Set the voltage source for +100V, and select the 200nA current range. Make sure that the voltage source OPERATE is not enabled.

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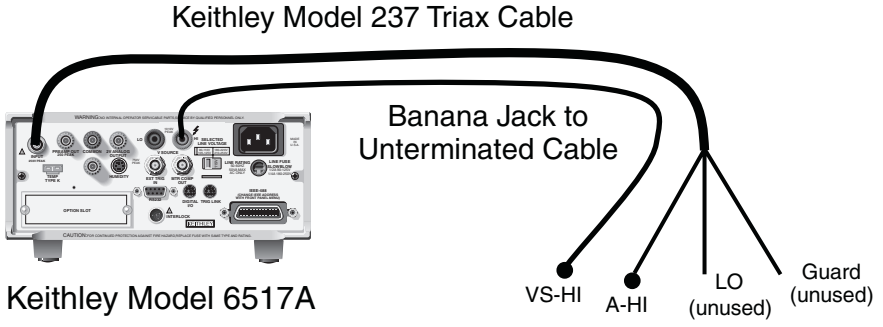
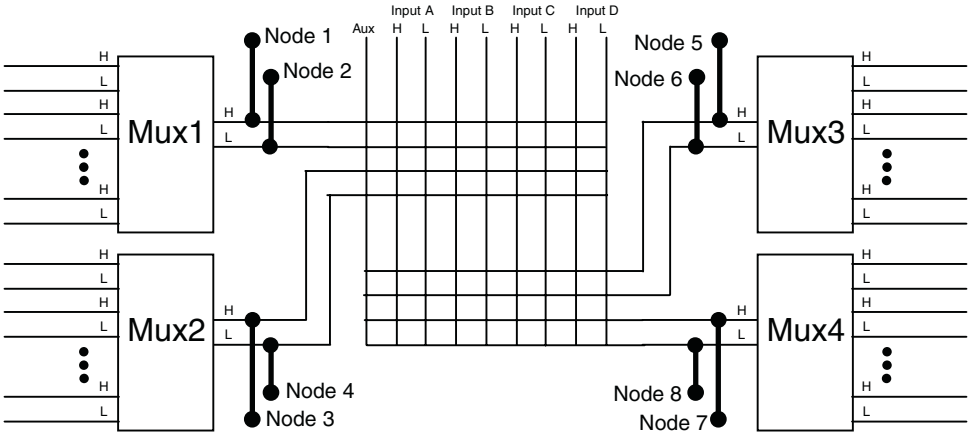
Figure 4-9
Connections to verify quad 1 x 40 and 1 x 160 multiplexer isolation





Model 7002-HD-MUX1

5. Turn on the Model 7002-HD, and program it to close the first channel of Mux 1 (1!1).
6. On the Model 6517A, disable zero check, and press OPERATE to source +100V.
7. After allowing the reading on the Model 6517A to settle, verify that it is greater than the specification for the 1 x 40 configuration (page A-2). This measurement is the leakage resistance (isolation) between differential pathways.
8. Turn the Model 6517A +100V source off, and enable zero check.
9. Program the 7002-HD to open channel 1!1, and close the next multiplexer channel 1!2.

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10. Continue to verify the isolation of all 40 multiplexer channels by repeating steps 5 through 9.
11. Verify the differential channel isolation of the other multiplexers:
    - Remove power from the 7002-HD, and ensure that the 6517A source has been disabled.
    - Change the 6517A connections so that A-HI is connected to Mux 2 Output HI (A-HI to NODE 3 in Figure 4-9), and VS-HI is connected to Mux 2 Output LO (VS-HI to NODE 4 in Figure 4-9).
    - Repeat steps 5 through 11 to test the isolation of Mux 2, Mux 3, and Mux 4.
12. Turn the Model 6517A +100V source off, disable REL, and enable zero check when testing is complete.

Configuration 2: 1 x 160 multiplexer differential isolation test

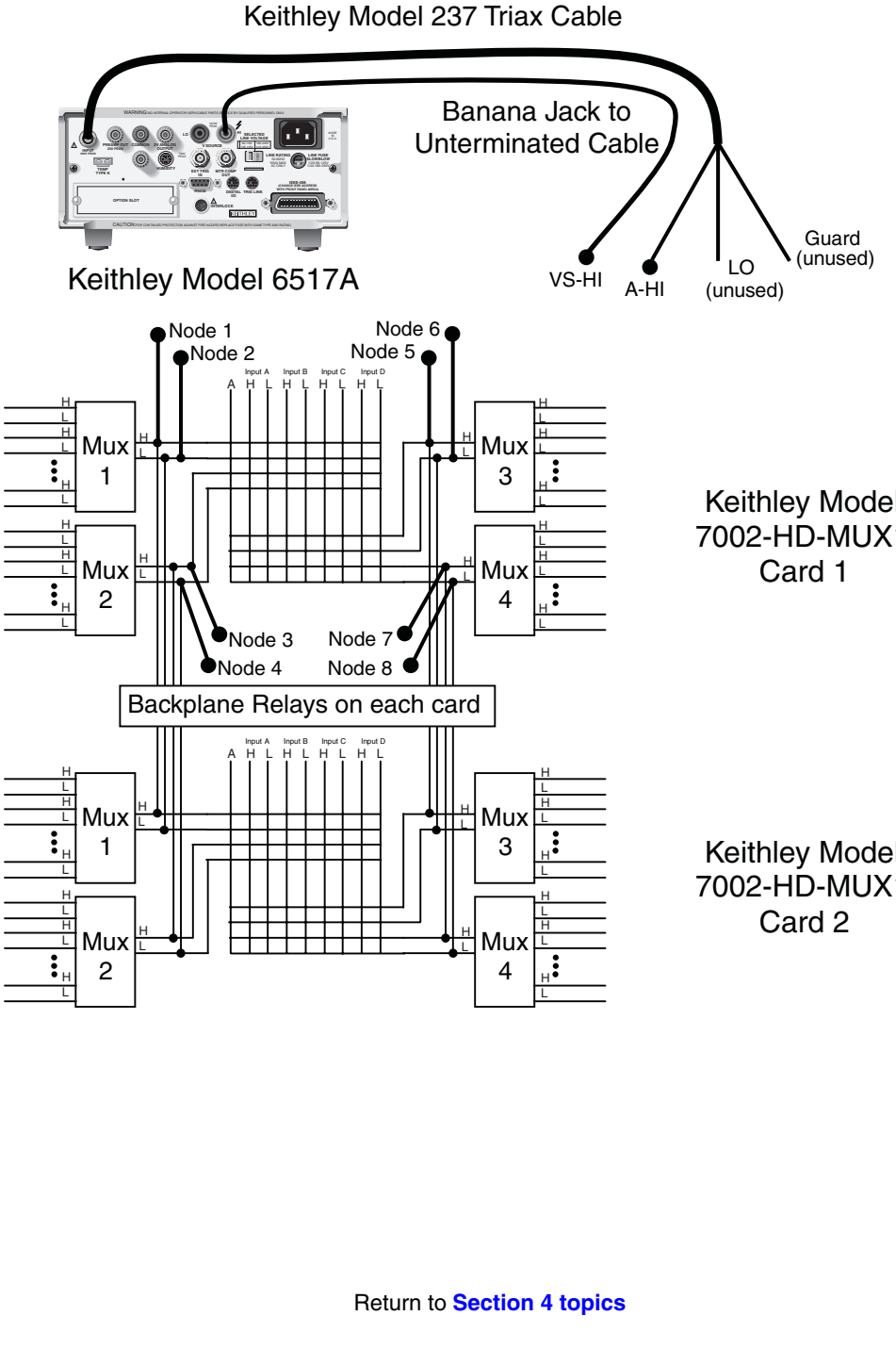
1. Perform the same steps 1 through 4 from Isolation Test Configuration 1.
2. Turn on the Model 7002-HD, and program it to close the first channel of Mux 1 (1!1) and all matrix crosspoints that connect to Input A (5!1, 5!5, 5!9, and 5!13).
3. On the Model 6517A, disable zero check, and press OPERATE to source +100V.
4. After allowing the reading on the Model 6517A to settle, verify that it is greater than the specification for the 1 x 160 configuration (page A-2). This measurement is the leakage resistance (isolation) between differential pathways.
5. Turn the Model 6517A +100V source off, and enable zero check.
6. Program the Model 7002-HD to open the multiplexer channel 1!1. Close the next multiplexer channel 1!2 while leaving the same relay crosspoint relay closed.
7. Continue to verify the isolation of all 40 multiplexer channels by repeating steps 2 through 6.
8. Verify the differential channel isolation of the other matrix columns:
    - Open all closed matrix relays, and close the relay associated with the multiplexer under test and all relays in the next input column (for example, 5!2, 5!6, 5!10, and 5!14 for Input B). Repeat steps 2-8 until column inputs B, C, and D have been tested.

9. Verify the differential channel isolation of the other multiplexers:
   - Remove power from the Model 7002-HD, and ensure that the Model 6517A source has been disabled.
   - Change the Model 6517A connections so that A-HI is connected to Mux 2 Output HI (A-HI to NODE 3 in Figure 4-9), and VS-HI is connected to Mux 2 Output LO (VS-HI to NODE 4 in Figure 4-9).
   - Repeat steps 2 through 9 to test the isolation of Mux 2, Mux 3, and Mux 4.
10. Turn the Model 6517A +100V source off, disable REL, and enable zero check when testing is complete.

Configuration 3: 1 x 320 Multiplexer differential isolation test

1. To check the 1 x 320 differential channel isolation, install a second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD (see Figure 4-10).
2. Follow the procedure described in the Configuration 2 Isolation Test. When testing, make sure to close the appropriate backplane relays on each of the Model 7002-HD-MUX1 cards (5!17 and 10!17 for Mux 1, 5!18 and 10!18 for Mux 2, 5!19 and 10!19 for Mux 3, and 5!20 and 10!20 for Mux 4).
3. For each step, verify the isolation resistance is greater than the specification for the 1 x 320 configuration (page A-2).

Figure 4-10
Connections to verify 1 x 320 multiplexer isolation



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Common mode chassis isolation

Configuration 4: Quad 1 x 40 multiplexer common mode isolation test

1. Remove power from the Model 7002-HD. Make sure that the voltage source OPERATE is disabled on the 6517A and that there are no other connections to the Model 7002-HD-MUX1.
2. Connect the ammeter HI (A-HI in Figure 4-9) of the Model 6517A to chassis ground, which is accessible at any metal contact on the rear panel of the Model 7002-HD. Connect the Model 6517A voltage source HI lead (VS-HI in Figure 4-9) to the Mux 1 output (NODE 1 and 2).
3. Install the Model 7002-HD-MUX1 in Card 1 of the Model 7002-HD.
4. On the Model 6517A:
   - Enable the voltage source LO and ammeter input LO internal connection by setting the METER-CONNECT in the CONFIGURE V-SOURCE menu.
   - Remove any physical ground link connecting the rear panel common and chassis ground on the Model 6517A if present.
   - Place the Model 6517A in the R measurement function
   - Select the 20pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
   - Release zero check.
   - Press REL to cancel offset current, and then enable zero check.
   - Set the voltage source for +100V, and select the 200nA current range. Make sure that the voltage source OPERATE is not enabled.
5. Turn on the Model 7002-HD, and program it to close the first channel of Mux 1 (1!1).
6. On the Model 6517A, disable zero check, and press OPERATE to source +100V.
7. After allowing the reading on the Model 6517A to settle, verify that it is greater than the specification for the 1 x 40 configuration (page A-2). This measurement is the leakage resistance (isolation) between the signal pathway and chassis.
8. Turn the Model 6517A +100V source off, and enable zero check.
9. Program the Model 7002-HD to open channel 1!1 and close the next multiplexer channel 1!2.
10. Continue to verify the isolation of all 40 multiplexer channels by repeating steps 5 through 9.
11. Verify the channel isolation of the other multiplexers:
    - Remove power from the Model 7002-HD, and ensure that the Model 6517A voltage source has been disabled.

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- Change the Model 6517A connections so that the voltage source HI lead is connected to Mux 2 Output HI (A-HI to NODE 3 and 4 in Figure 4-9). Leave the ammeter HI (A-HI in Figure 4-9) of the Model 6517A connected to chassis ground, which is accessible at any metal contact on the rear panel of the 7002-HD.
- Repeat steps 5 through 11 to test the isolation of Mux 2, Mux 3, and Mux 4.

12. Turn the Model 6517A +100V source off, disable REL, and enable zero check when testing is complete.

Configuration 5: 1 x 160 multiplexer common mode isolation test

1. Perform the same steps 1 through 4 from Configuration 4 Isolation Test.
2. Turn on the Model 7002-HD, and program it to close the first channel of Mux 1 (1!1) and the all matrix crosspoints that connect to Input A (5!1, 5!5, 5!9, and 5!13).
3. On the Model 6517A, disable zero check, and press OPERATE to source +100V.
4. After allowing the reading on the Model 6517A to settle, verify that it is greater than the specification for the 1 x 160 configuration (page A-2). This measurement is the leakage resistance (isolation) between the signal pathway and chassis.
5. Turn the Model 6517A +100V source off, and enable zero check.
6. Program the Model 7002-HD to open the multiplexer channel 1!1. Close the next multiplexer channel 1!2 while leaving the same relay crosspoint relay closed.
7. Continue to verify the isolation of all 40 multiplexer channels by repeating steps 2 through 6.
8. Verify the common mode channel isolation of the other matrix columns:
   - Open all closed matrix relays, and close the relay associated with the multiplexer under test and all relays in the next input column (for example, 5!2, 5!6, 5!10, and 5!14 for Input B). Repeat steps 2-8 until column inputs B, C, and D have been tested.
9. Verify the channel isolation of the other multiplexers:
   - Remove power from the Model 7002-HD, and ensure that the Model 6517A source has been disabled.
   - Change the Model 6517A connections so that the voltage source HI lead is connected to Mux 2 Output HI (A-HI to NODE 3 and 4 in Figure 4-9). Leave the ammeter HI (A-HI in Figure 4-9) of the Model 6517A connected to chassis ground, which is accessible at any metal contact on the rear panel of the Model 7002-HD.
   - Repeat steps 2 through 9 to test the isolation of Mux 2, Mux 3, and Mux 4.
10. Turn the Model 6517A +100V source off, disable REL, and enable zero check when testing is complete.

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Configuration 6: 1 x 320 multiplexer common mode isolation test

1. To check the 1 x 320 differential channel isolation, install a second Model 7002-HD-MUX1 in Card 2 of the Model 7002-HD (see Figure 4-10).
2. Follow the procedure described in the Configuration 5 Isolation Test. When testing, make sure to close the appropriate backplane relays on each of the Model 7002-HD-MUX1 cards (5!17 and 10!17 for Mux 1, 5!18 and 10!18 for Mux 2, 5!19 and 10!19 for Mux 3, and 5!20 and 10!20 for Mux 4).
3. For each step, verify the isolation resistance is greater than the specification for the 1 x 320 configuration (page A-2).

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Replaceable parts

This section contains replacement parts information and the component layout drawing for the Model 7002-HD-MUX1 card.

Parts list

Replaceable parts for the Model 7002-HD-MUX1 are listed in Table 4-2 and Table 4-3.

Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see inside front cover for addresses). When ordering parts, be sure to include the following information:

- Card model number (Model 7002-HD-MUX1)
- Card serial number
- Part description
- Component designation (if applicable)
- Keithley part number

Factory service

If the Model 7002-HD-MUX1 is to be returned to Keithley Instruments for repair, perform the following:

- Call the Repair Department at 1-888-KEITHLEY for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual, and include it with the Model 7002-HD-MUX1.
- Carefully pack the Model 7002-HD-MUX1 in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

Component layout

The parts are listed in Table 4-2 and Table 4-3. A component layout for Model 7002-HD-MUX1 is provided in Figure 4-11 on page 4-40.

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Table 4-2
Model 7002-HD-MUX1 electronic parts list

Circuit designation	Description	Keithley part no.
C1-C6, C81-C83	CAP,.47P,10%,100V,CERAMIC	C-451-47P
C7-C11, C15-C20, C23-C26, C30-C35, C38-C41, C45-C50, C53-C56, C60-C64, C68-C71, C75-C80, C109, C202, C212	CAP,.1U,20%,50V,CERAMIC	C-418-.1
C12-C14, C21, C22, C27-C29, C36, C37, C42-C44, C51, C52, C57-C59, C66, C67, C72-C74	CAP,47P,5%,100V,CERAMIC	C-465-47P
C103, C213	CAP,470U,20%,25V,ALUM ELEC	C-622-470
C109, C202, C212	CAP,10U,20%,25V,TANTALUM	C-440-10
CR101-CR140, CR201-CR240, CR301-CR340, CR401-CR440, CR501-CR521	SWITCHING DIODE	RF112
CR525, CR526	SCHOTTKY RECTIFIER	RF115
J100	CONN,RT ANGLE TRIPLE ROW,DIN	CS-1065-2
J101-J103, J111-J113	CONN,HEADER,40 PINS	CS-1198-40
J104-J105	CONN,RT ANGLE,HEADER,40 PIN	CS-1066-6
J107	CONN,RT ANGLE DUAL ROW,DIN	CS-1065-1
J108	5 PIN TERMINAL BLOCK	CS-521-8
K1-140, K201-K240, K301-K340, K401-K440, K501-K521	EMR NON-LATCHING RELAY	RL-243
R1-R28	RES,1K,1%,1W, THICK FILM	R-418-1K
R101-R140, R201-R240, R301-R340, R401-R440, R501-R521		
RV101, RV102	TRANSIENT VOLTAGE SUPPRESSOR	VR-15
TP100-TP103, TP105	CONN, TEST POINT	CS-1026
U1-U5	2-WIRE SERIAL EEPROMs	IC-1462
U6-U28	8 BIT INPUT LATCH DRIVE	IC-857

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Table 4-3
Model 7002-HD-MUX1 mechanical parts

Description	Keithley part no.
PHILLIPS FLAT HD UNDERCUT	4-40X1/4PFHUC
PHILLIPS PAN HEAD	4-40X1/4PPH
PHILLIPS HEAD PAN HEAD	2-56X3/8PPH
NUT	2-56NUT
TIE WRAP	CC-38-2
INSULATOR	S40-SQ00-340A
TOP COVER	S40-SQ00-337A
BOTTOM COVER	S40-SQ00-338A

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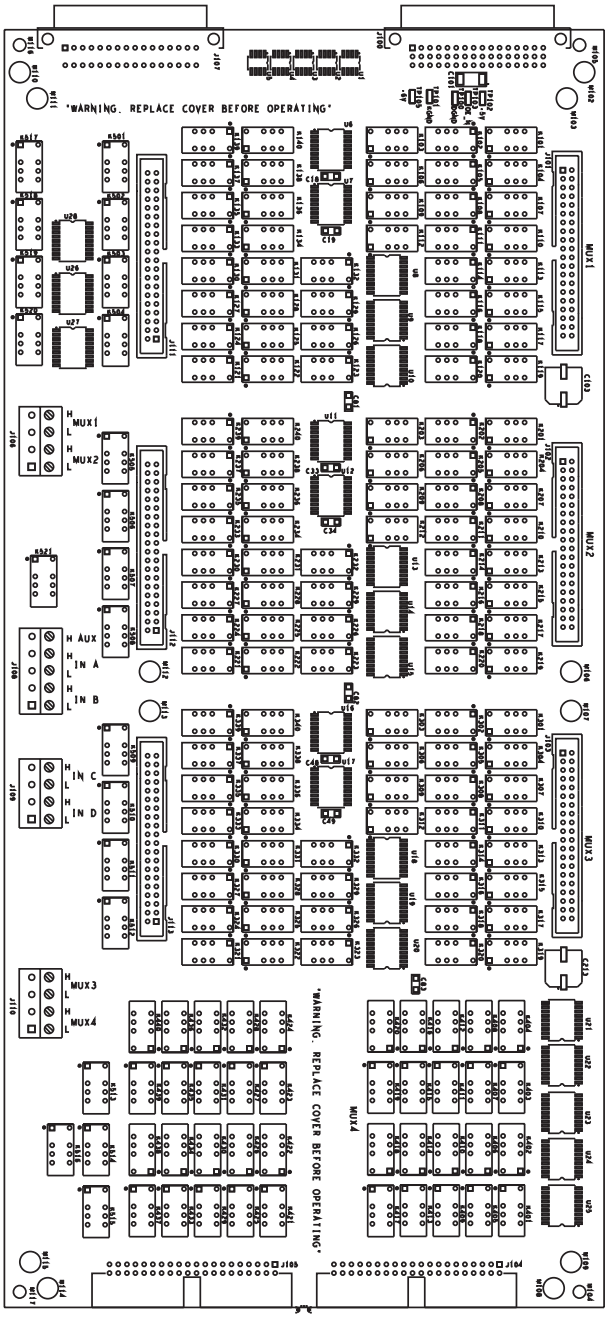
Figure 4-11
Model 7002-HD-MUX1 component layout (Top side)



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A
Specifications

7002-HD-MUX1 Differential Quad 1x40 Multiplexer Card

GENERAL

RELAY SWITCH CONFIGURATION: Differential Quad 1x40 multiplexers with programmable multiplex expansion and matrix input switching.

RELAY TYPE: Double pole form A (DPST) electromechanical relays.

RELAY DRIVE CURRENT: <35mA per channel.

RELAY ACTUATION TIME: <3ms.

FIRMWARE: Specified for Model 7002-HD.

EMC: Conforms to European Union Directive 89/336/EEC, EN61326-1.

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1.

INPUTS

MAXIMUM SIGNAL LEVEL: 200VDC or 200Vrms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum.

COMMON MODE VOLTAGE: 200VDC or 200Vrms (283V peak for AC waveforms) between any terminal and chassis.

CONNECTOR TYPE:

Matrix Inputs: 5mm removable screw terminals (supports 18-22AWG wire).
- Supplied with removable screw terminals.

Multiplexer Outputs: 5mm removable screw terminals (supports 18-22AWG wire).
- Supplied with removable screw terminals.

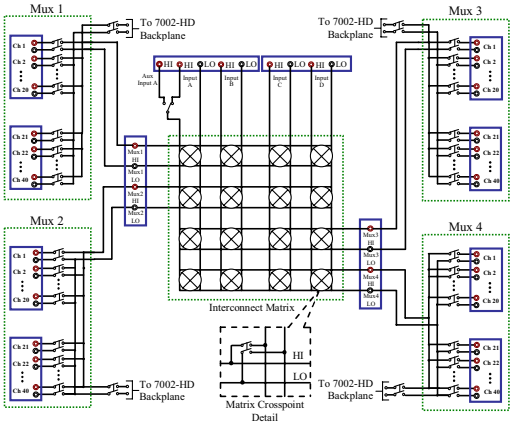
Multiplexer Inputs: 40-pin male IDC compatible headers.

CONTACT LIFE:

$>10^8$ operations at no load.
$>10^5$ operations at rated load (resistive load).

MULTIPLEXER CONFIGURATION

	Quad 1x40	Single 1x160 [5]	Single 1x320 [6]
CHANNEL RESISTANCE[4]	<1Ω	<1Ω	<2Ω
CONTACT POTENTIAL[7]	<4.5µV per contact pair	<9µV per contact pair	<9µV per contact pair
OFFSET CURRENT	<100pA	<100pA	<200pA
ISOLATION			
Between any two terminals	$>10^9$Ω <150pF	$>10^9$Ω <550pF	$>10^9$Ω <1100pF
Between any terminal and earth	$>10^9$Ω <250pF	$>10^9$Ω <700pF	$>10^9$Ω <1450pF
CROSSTALK (50Ω Load)[1]	<-50dB below 1MHz <-30B below 10MHz	<-50dB below 1MHz <-25dB below 10 MHz	<-50dB below 1MHz <-25dB below 10MHz
INSERTION LOSS (50Ω Source, 50Ω Load)[1]	<0.35dB below 1MHz <3dB below 25MHz	<0.5dB below 1MHz <3dB below 10MHz	<0.7dB below 1MHz <3dB below 2MHz



ENVIRONMENTAL[2]

OPERATING ENVIRONMENT:
Specified for 0ºC to 50ºC.
Specified to 50% RH at 35ºC.

STORAGE ENVIRONMENT: -25ºC to 65ºC.

WEIGHT: <1.9kg (4.2lb).

ALTITUDE: Maximum 2000m above sea level.

RECOMMENDED CONNECTOR/CABLE[3]

4-pin removable screw terminal	RIA Part # 31007104.
5-pin removable screw terminal	RIA Part # 31007105.
40-pin female IDC socket	
- without strain relief (for Mux 1-3)	3M Part # 89140-0101.
- with strain relief (for Mux 4)	3M Part # 89140-0100.
Long snap in latch arms (for Mux 4)	3M Part # 3505-33.
40-conductor shielded/jacketed ribbon cable	3M Part # 3517/40.

7002-HD-MUX1 Notes:
[1] Includes end of life.
[2] For indoor use only.
[3] Refer to User's Guide for measurement considerations.
[4] At end of life, add an additional 1Ω for a single card and 2Ω for two cards.
[5] For signals routed through a multiplexer and the interconnect matrix.
[6] Two cards installed in mainframe using analog backplane for expansion.
[7] For configurations using Mux 4, add 8uV to specification.

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Service Form

Model No. _____ **Serial No.** _____ **Date**_____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent ❑ Analog output follows display ❑ Particular range or function bad; specify

_____

❑ IEEE failure ❑ Obvious problem on power-up ❑ Batteries and fuses are OK

❑ Front panel operational ❑ All ranges or functions are bad ❑ Checked all cables

Display or output (check one)

❑ Drifts ❑ Unable to zero ❑ Unstable

❑ Overload ❑ Will not read applied input

❑ Calibration only ❑ Certificate of calibration required ❑ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

KEITHLEY

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