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Instruction Manual

Models 7015-S and 7015-C

40-Channel Solid-State Multiplexer Cards

Contains Operating and Servicing Information

KEITHLEY

7015-901-01 Rev. A / 6-93

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Models 7015-S and 7015-C Instruction Manual

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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 7015-901-01) .....June 1993

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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 the operating information carefully before using the product.

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, 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.

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.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users 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.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

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.

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 cables 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.

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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 **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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Model 7015-C, 7015-S
40-Channel Solid State Multiplexer Cards

MULTIPLEX CONFIGURATION: Four independent 1×10 2-pole multiplex banks or two independent 1×10 4-pole multiplex banks. Adjacent banks can be connected together. Jumpers can be removed to isolate any bank from the backplane.

CONTACT CONFIGURATION: 2-pole Form A (Hi, Lo).

CONNECTOR TYPE:

7015-C: 96-pin male DIN connector.

7015-S: Screw terminal, #16AWG maximum wire size, with .092 inch O.D. 28 conductors per card maximum. #22AWG typical wire size with .062 inch O.D. 88 conductors per card maximum.

MAXIMUM SIGNAL LEVEL: 175V peak between any two pins, 34mA resistive load, 0.3VA max., 1×10^6V•Hz max.

COMMON MODE VOLTAGE: 175V peak, any pin to chassis.

CONTACT TYPE: Solid state switch.

CHANNEL RESISTANCE (per conductor): < 210Ω.

CONTACT POTENTIAL:

7015-C: <5µV per channel contact pair.

7015-S: <4µV per channel contact pair.

OFFSET CURRENT: < 1nA.

ACTUATION TIME: <500µs.

ISOLATION:

Bank: $>10^9\Omega$, <25 pF.

Channel to Channel: $>10^9\Omega$, <50 pF.

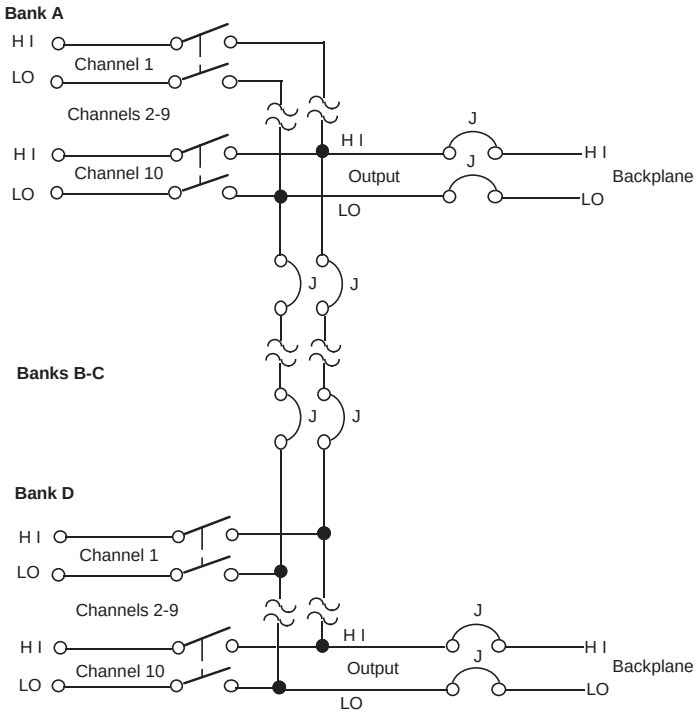
Differential: Configured as 1×10: $>10^9\Omega$, <100pF.
Configured as 1×40: $>10^9\Omega$, <200pF.

Common Mode: Configured as 1×10: $>10^9\Omega$, <375pF.
Configured as 1×40: $>10^9\Omega$, <1100pF.

INSERTION LOSS (50Ω Source, 1MΩ Load): <0.1dB below 250kHz, <3dB below 500kHz.

ENVIRONMENT: **Operating**: 0° to 50°C, up to 35°C at 80% RH.
Storage: –25°C to 65°C.

Specifications subject to change without notice.



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1 General Information

1.1 Introduction

This section contains general information about the Model 7015 40-Channel Solid-State Multiplexer Card.

There are two basic versions of this multiplexer card; the Model 7015-S and the Model 7015-C. The Model 7015-S assembly consists of a screw terminal connector card and a relay card. External test circuits are wired directly to the screw terminals of the connector card. Also available from Keithley is the Model 7015-ST, which is an extra screw terminal connector card. With an extra connector card, you can wire a second test system without disturbing the wiring configuration of the first test system.

The Model 7015-C assembly consists of a multi-pin (mass termination) connector card and the relay card. External test circuit connections to the multiplexer are made via the 96-pin male DIN connector on the connector card. Keithley offers a variety of optional accessories that can be used to make connections to the connector card (see paragraph 1.8).

The rest of Section 1 is arranged in the following manner:

1.2 Features

1.3 Warranty information

1.4 Manual addenda

1.5 Safety symbols and terms

1.6 Specifications

1.7 Unpacking and inspection

1.8 Repacking for shipment

1.9 Optional accessories

1.2 Features

The Model 7015 is a solid-state, two-pole, quad, 1×10 multiplexer card. Some of the key features include:

- Solid-state relays for fast switching, indefinite "contact" life, and quiet operation.
- Low contact potential and offset current for minimal effects on low-level signals.
- The connector board detaches from the relay board allowing easy access to the screw terminals (Model 7015-S) and jumpers.
- Easy jumper configuration of one, two, three or four multiplexer banks.
- Backplane jumpers. Cutting jumpers disconnects multiplexer bank outputs from the Model 7001 or Model 7002 analog backplane.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7015 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information.

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When returning the multiplexer 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.

1.4 Manual addenda

Any improvements or changes concerning the multiplexer card or manual will be explained in an addendum included with the card. Addenda are provided in a page replacement format. Simply replace the obsolete pages with the new pages.

1.5 Safety symbols and terms

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

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

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

1.6 Specifications

Model 7015 specifications are found at the front of this manual. These specifications are exclusive of the multiplexer mainframe specifications.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

The Model 7015 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 precautions on handling.

Handling Precautions:

1. Always grasp the card by the side edges and shields. Do not touch the board surfaces or components.
2. When not installed in a Model 7001/7002 mainframe, keep the card in the anti-static bag and store it in the original packing carton.

After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately.

1.7.2 Shipment contents

The following items are included with every Model 7015 order:

- Model 7015 Quad 1 × 10 Multiplexer Card
- Model 7015 Instruction Manual
- Additional accessories as ordered

1.7.3 Instruction manual

If an additional instruction manual is required, order the manual package, Keithley part number 7015-901-00. The manual package includes an instruction manual and any pertinent addenda.

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1.7.4 Repacking for shipment

Should it become necessary to return the Model 7015 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Advise as to the warranty status of the multiplexer card.
- Write ATTENTION REPAIR DEPARTMENT on the shipping label.
- Fill out and include the service form located at the back of this manual.

1.8 Optional accessories

The following accessories are available for use with the Model 7015:

Model 7015-ST — This screw terminal connector card is identical to the one provided with the Model 7015-S assembly. An extra screw terminal connector card allows you to wire a second test system without disturbing the wiring configuration of the first connector card.

Model 7011-KIT-R — This connection kit includes a 96-pin female DIN connector that will mate directly to the connector on the Model 7015-C or to a standard 96-pin male DIN bulkhead connector (see Model 7011-MTR). This connector uses solder cups for connections to external circuitry. It includes an adapter for a round cable and the housing.

Model 7011-MTC-2 — This 2-meter round cable assembly is terminated with a 96-pin female DIN connector on each end. It will mate directly to the connector on the Model 7015-C and to a standard 96-pin male DIN bulkhead connector (see Model 7011-MTR).

Model 7011-MTR — This 96-pin male DIN bulkhead connector uses solder cups for connections to external circuitry. It will mate to the Model 7011-KIT-R connector, and Model 7011-MTC-2 cable assembly.

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2
Multiplexing Basics

2.1 Introduction

This section covers the basics for multiplex switching and is arranged as follows:

2.2 Basic multiplex configurations: Covers the basic multiplex configurations: quad 1 × 10 configuration, dual 1 × 20 configuration and single 1 × 40 configuration. The significance of the backplane jumpers is also covered here.

2.3 Typical multiplex switching schemes: Explains some of the basic ways a multiplexer can be used to switch source or measure applications. Covers single-ended switching, differential (floating) switching and sensing.

2.4 System expansion: Discusses the various configurations that are possible by using multiple cards.

2.2 Basic multiplexer configurations

A simplified schematic of the Model 7015 multiplexer card is shown in Figure 2-1. It is organized as four 1 × 10 multiplexer banks. Each bank has 10 inputs and one output. Two-pole switching is provided for each multiplexer input, with HI and LO switched. Two or more banks can be jumpered together to expand multiplexer inputs, and backplane jumpers provide bank connections to a second card installed in a Model 7001 or Model 7002 mainframe.

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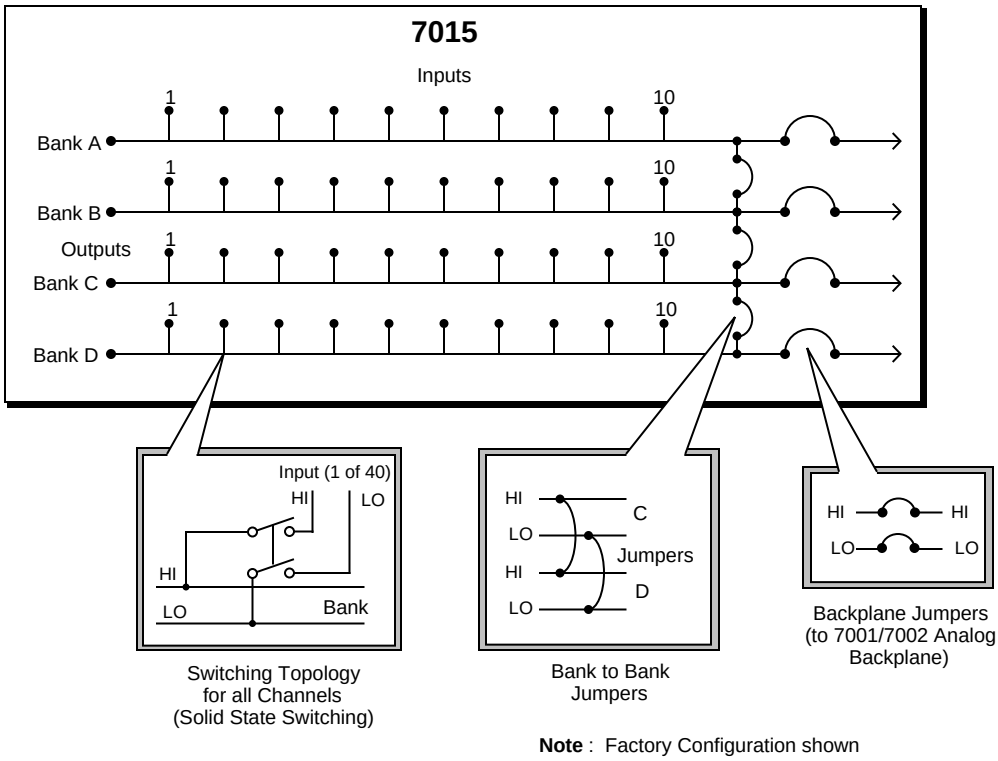


Figure 2-1
Model 7015 simplified schematic

2.2.1 Multiplexer bank-to-bank jumpers

Jumpers are installed on the connector card to connect multiplexer banks together to form a 1 × 40 multiplexer. Each jumper set connects two adjacent banks together. These jumper sets are included with the Model 7015.

The bank-to-bank jumpers allow you to configure the multiplexer card in a variety of ways. Typical multiplexer configurations include:

- Four 1 × 10 multiplexers; no jumpers installed (Figure 2-2).
- Two 1 × 20 multiplexers; Bank A jumpered to Bank B, Bank C jumpered to Bank D (Figure 2-3).
- One 1 × 40 multiplexer; all bank-to-bank jumpers installed (Figure 2-4).

Other combinations are possible, including multiplexers of various sizes (in multiples of 10 channels). For example, you could install jumpers to configure the card as one 1 × 30 and one 1 × 10 multiplexer.

Refer to Section 3 for information on installing bank-to-bank jumpers.

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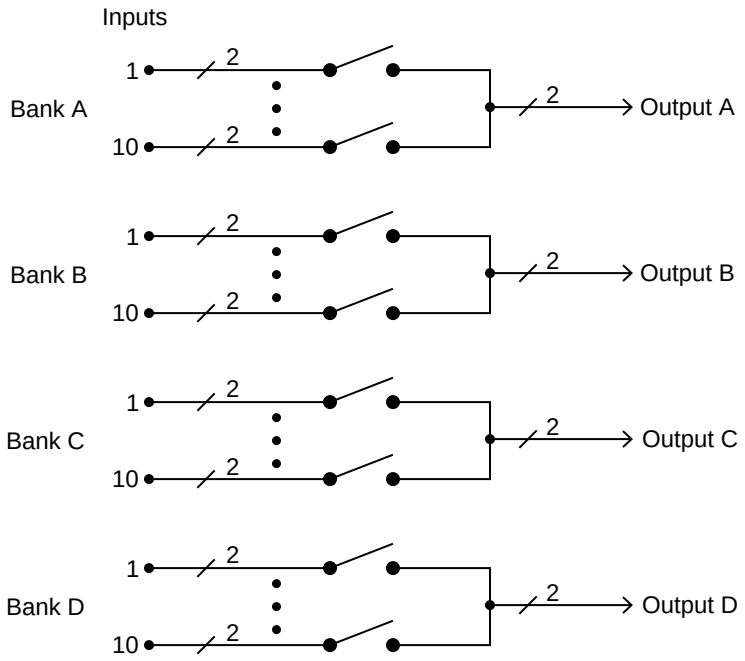


Figure 2-2
Four 1 × 10 multiplexer configuration (jumpers not installed)

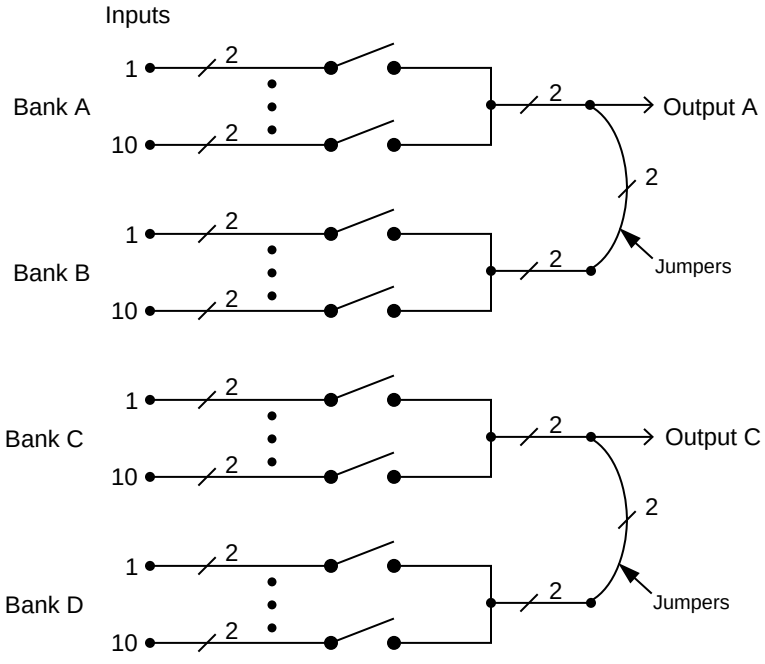


Figure 2-3
Two 1 × 20 multiplexer configuration (jumpers installed)

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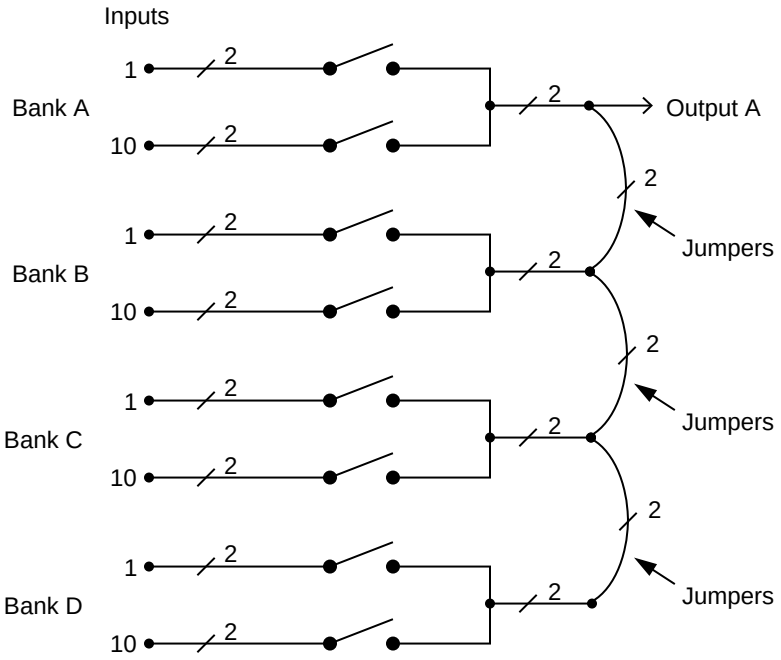


Figure 2-4
One 1 × 40 multiplexer configuration (jumpers installed)

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2.2.2 Backplane jumpers

There are four pairs of backplane jumpers located on the relay card. With the jumpers installed, the banks of the multiplexer card are connected to the analog backplane of the Model 7001/7002 allowing expansion with a second card installed in the mainframe. With the jumpers removed (cut), the multiplexer card is isolated from another card installed in the same mainframe.

The three-pole analog backplane of the Model 7001/7002 mainframe is shown in Figure 2-5. Through this analog backplane, the banks of a Model 7015 multiplexer card, installed in one slot, can be connected to the banks (or rows) of a compatible card installed in another slot of the mainframe.

Note that the Model 7002 also has backplane jumpers, which can be used to isolate cards into two groups of five.

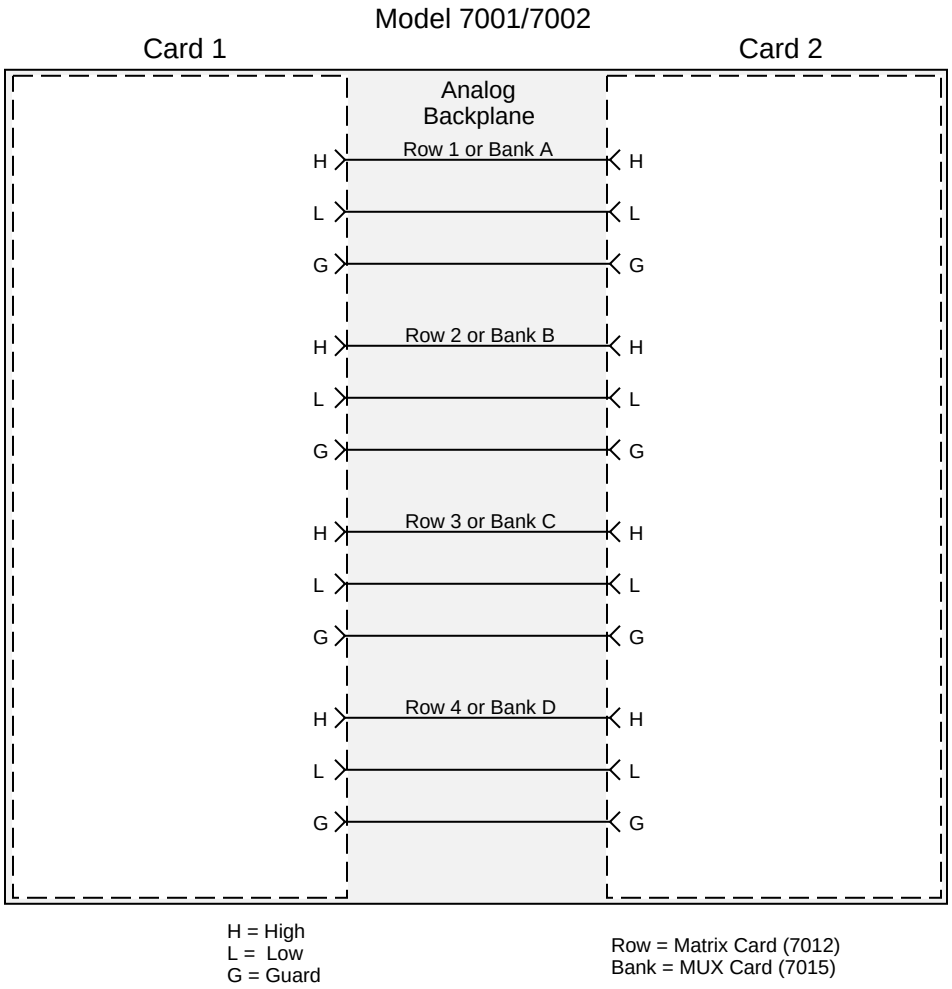


Figure 2-5
Model 7001/7002 analog backplane

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Figure 2-6 shows how each bank of the Model 7015 is connected to the backplane. Notice that since the Model 7015 is a two-pole card, there is no connection made to the Guard terminal of the backplane. The Model 7015 is shipped from the factory with the backplane jumpers installed.

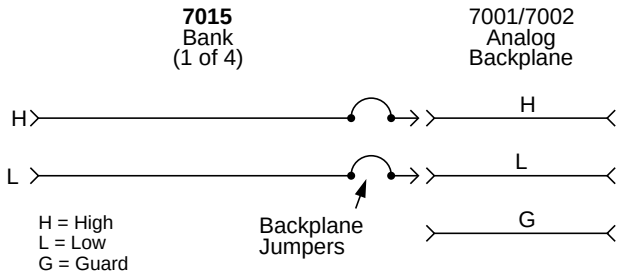


Figure 2-6
Bank connections to backplane

Removing (cutting) the backplane jumpers isolates the card from the backplane, and subsequently, any card installed in an other slot. For information on removing the jumpers, refer to Section 3.

NOTE

The Model 7001/7002 does not provide an analog backplane for the non-701X series cards. As a result, any of these cards installed in one slot in the mainframe is electrically isolated from any card(s) installed in an other slot. The only way to connect a Model 7015 to one of these cards is to wire them together using the connector blocks or terminals.

2.3 Typical multiplexer switching schemes

The following paragraphs describe some basic switching schemes that are possible with a two-pole switching multiplexer. These switching schemes include some various shielding configurations to help minimize noise pickup in sensitive measurement applications. These shields are shown connected to chassis ground. For some test configurations, shielding may prove to be more effective with shields connected to circuit common or LO. Chassis ground is accessible at the rear panel of the Model 7001/7002.

2.3.1 Single-ended switching

In the single-ended switching configuration, the source or measure instrument is connected to the DUT through a single pathway, as shown in Figure 2-7. The instrument is connected to the output of one of the banks, and the DUT is shown connected to one of the inputs for that bank.

2.3.2 Differential switching

The differential or floating switching configuration is shown in Figure 2-8. The advantage of using this configuration is that the terminals of the source or measure instrument are not confined to the same pathway. Each terminal of the instrument can be switched to any available input in the test system.

2.3.3 Sensing

Figure 2-9 shows how the multiplexer card can be configured to use instruments that have sensing capability. The main advantage of using sensing is to cancel the effects of switch card path resistance (<210Ω, <130Ω typical) and the resistance of external cabling. Whenever path resistance is a consideration, sensing should be used.

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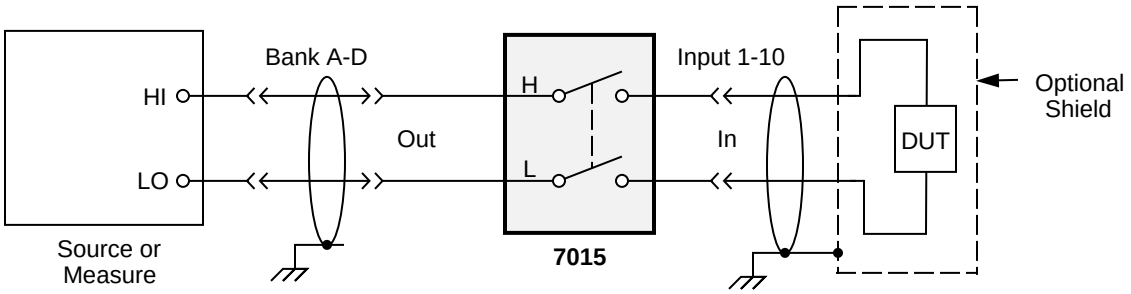


Figure 2-7
Single-ended switching example

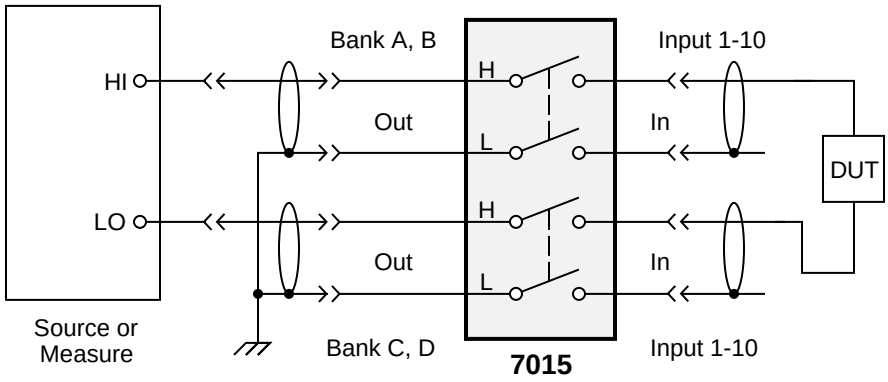


Figure 2-8
Differential switching example

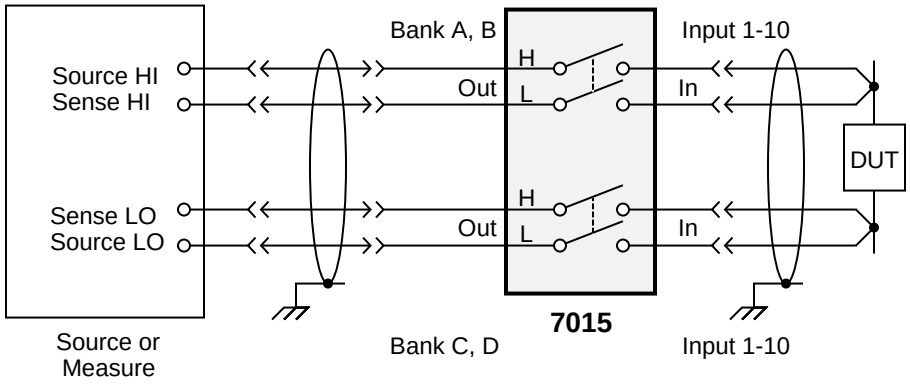


Figure 2-9
Sensing example

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2.4 Multiplexer expansion

With the use of additional switching cards and mainframes, larger systems can be configured. Each Model 7001 Switch System mainframe will accommodate up to two cards, and the Model 7002 Switch System mainframe can accommodate up to 10 cards.

2.4.1 Multi-card switching systems

Separate switching systems

Multiple single-card systems can be configured by removing the backplane jumpers from each additional card. All cards will be controlled by the same mainframe, but they will be electrically isolated from each other. Figure 2-10 shows an example using two Model 7015 multiplexer cards.

Multiplexer input expansion

You can double the number of multiplexer inputs by simply installing two “as shipped” Model 7015s in the Model 7001 mainframe. Similarly, the number of multiplexer inputs can be increased by a factor of 10 by installing 10, “as shipped” Model 7015s in a Model 7002. By leaving the backplane jumpers installed, the banks of the multiplexer card installed in slot 1 (CARD 1) are automatically connected to the banks of the multiplexer card installed in slot 2 (CARD 2) through the analog backplane (and with any remaining cards installed in a Model 7002).

Figure 2-11 shows an example of input expansion. Each Model 7015 card is configured as four 1 × 10 multiplexers. By connecting the banks together (via Model 7001/7002 analog backplane), the resulting multiplexer system has 20 2-pole inputs for each of the four banks. Note that, if all the bank-to-bank jumpers on any card are installed (as shipped), the result would be a single 1 × 80 multiplexer. A total of 10 Model 7015 cards installed in a Model 7002 would yield a single 1 × 400 multiplexer with all bank-to-bank jumpers installed.

NOTE

Connecting any two banks on one card together also connects the corresponding banks of the backplane together. Thus, the corresponding banks of other card(s) will be connected together even if the bank-to-bank jumpers on those cards are not installed.

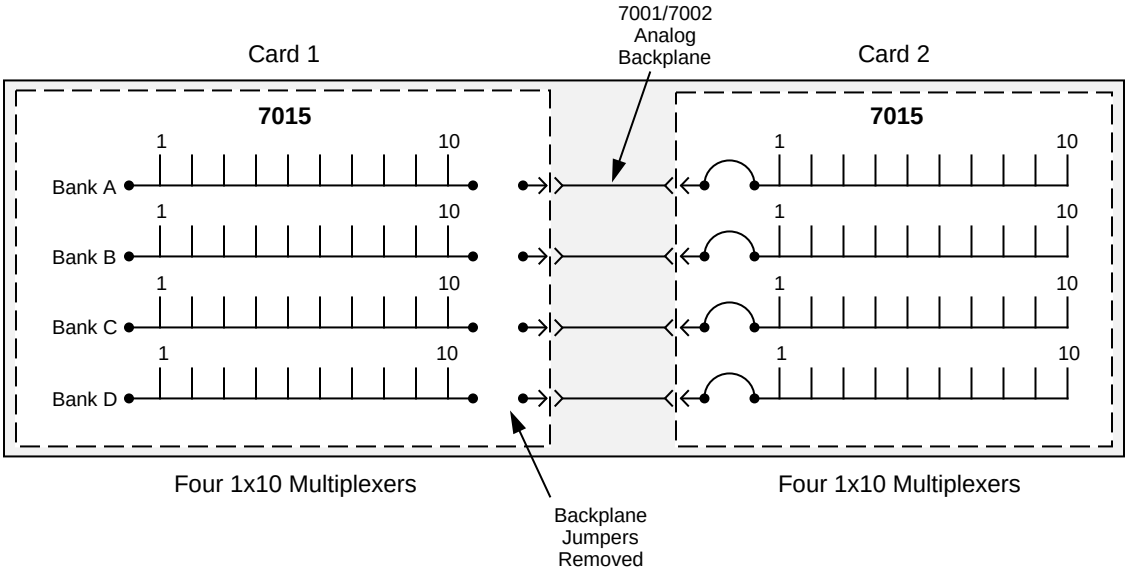


Figure 2-10
Two separate multiplexer systems

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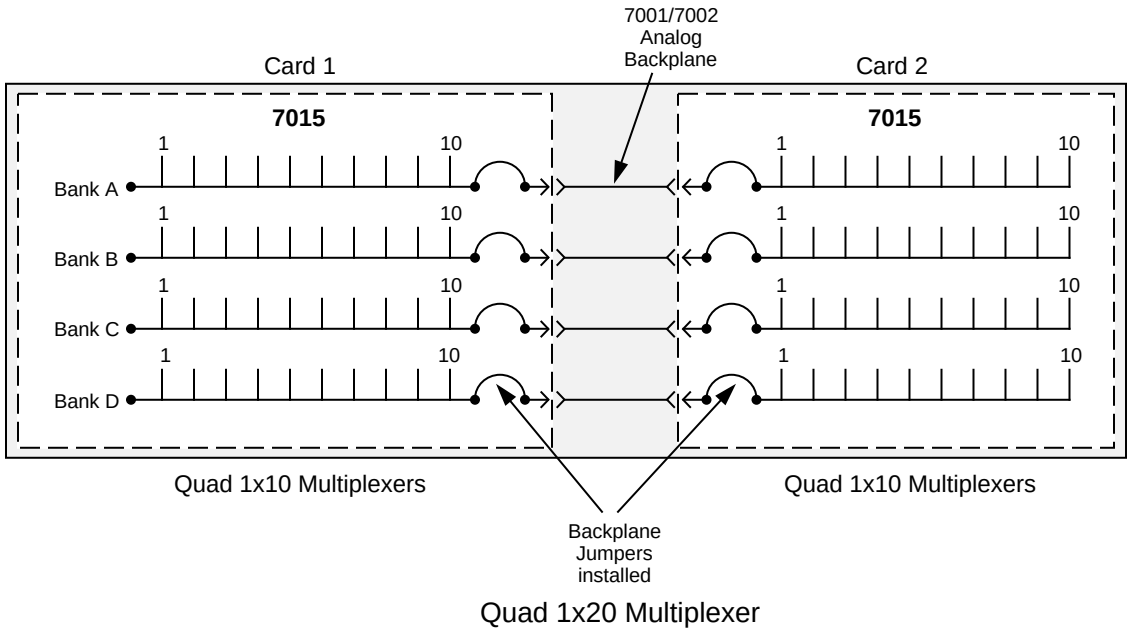


Figure 2-11
Multiplexer input expansion example

Mixing card types

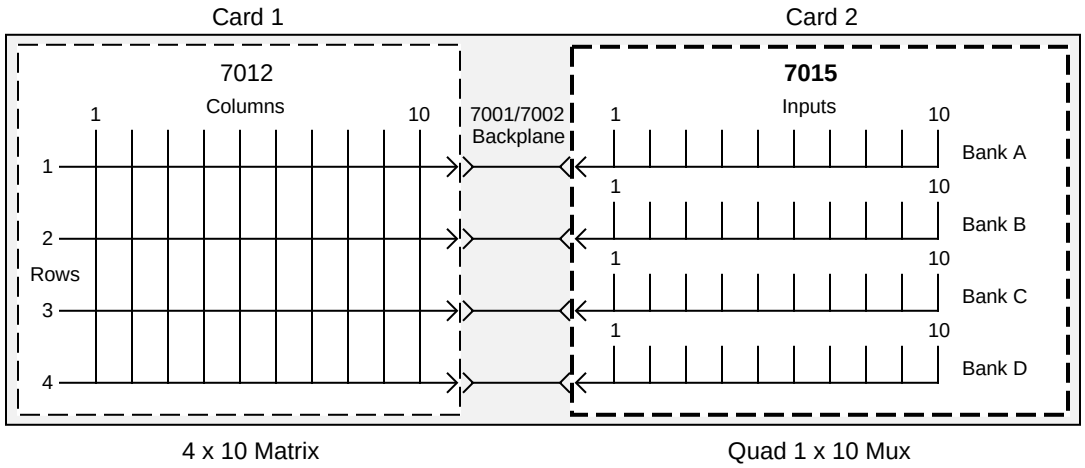
Different types of cards can be used together to create some unique switching systems. For example, you could have a Model 7015 multiplexer card installed in one slot and a Model 7012 matrix card installed in another slot.

Figure 2-12 shows one possible switching system using a matrix card and a multiplexer card. The backplane jumpers for both the matrix and multiplexer cards must be installed. This arrangement allows matrix rows to be connected to multiplexer banks. On the multiplexer card, the bank-to-bank jumpers must be removed to maintain isolation between matrix rows. See the instruction manual for the Model 7012 for complete information on the matrix card.

2.4.2 Mainframe multiplexer expansion

Multiplexer systems using up to 12 or 60 multiplexer cards are possible by using six Model 7001 or 7002 mainframes together. Each Model 7015 added to the system provides 40 additional inputs. Paragraph 3.4.3 explains how to connect a test system using two mainframes.

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Notes : 1. Models 7015 and 7012 backplane jumpers must be installed.
2. Model 7015 bank-to-bank jumpers must be removed.

Figure 2-12
Mixed card type example

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3

Card Connections & Installation

3.1 Introduction

WARNING

The procedures in this section are intended only for qualified service personnel. Do not perform these procedures unless qualified to do so. Failure to recognize hazards and observe normal safety precautions could result in personal injury or death.

The information in this section is arranged as follows:

3.2 Handling precautions: Explains precautions that must be followed to prevent contamination to the multiplexer card assembly. Contamination could degrade the performance of the multiplexer card.

3.3 Connections: Covers the basics for connecting external circuitry to the two available connector cards for the multiplexer; the screw terminal connector card and the multi-pin connector card.

3.4 Typical connection schemes: Provides some typical connection schemes for single card, two-card and two-mainframe system configurations.

3.5 Model 7015 installation: Provides a procedure to install the multiplexer card assembly in the Model 7001 or Model 7002 mainframe.

3.2 Handling precautions

To maintain high-impedance isolation, care should be taken when handling the relay card to avoid contamination from such foreign materials as body oils. Such contamination can substantially lower leakage resistances, thus degrading performance.

To avoid possible contamination, always grasp the relay and connector cards by the side edges or shields. Do not touch the board surfaces, components, or areas adjacent to the electrical contacts. Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the mainframe and multiplexer card in a clean environment.

If a card becomes contaminated, it should be thoroughly cleaned as explained in paragraph 5.2.

3.3 Connections

This paragraph provides the basic information needed to connect your external test circuitry to the multiplexer. It includes the installation of the bank-to-bank jumpers on the connector card, installation/removal of backplane jumpers on the relay card, and detailed information on making external connections to the two available connector cards.

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WARNING

The following connection information is intended to be used by qualified service personnel. Failure to recognize hazards and observe standard safety precautions could result in personal injury or death.

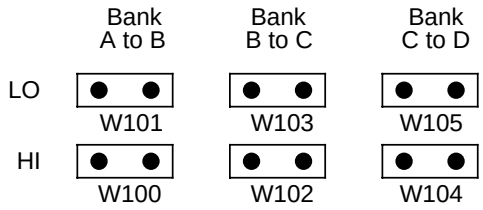


Figure 3-2
Bank-to-bank jumper terminal identification

3.3.1 Bank-to-bank jumpers

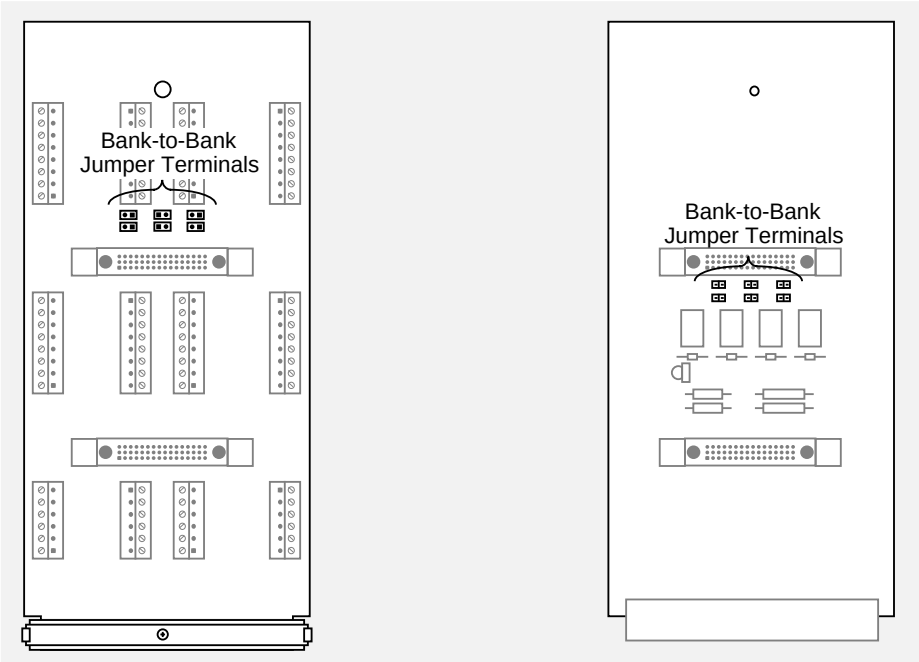
As explained in paragraph 2.2.1, the banks of the multiplexer card can be connected together (using plug-in jumpers) to form larger multiplexers. The locations of the bank-to-bank jumper terminals for both connector cards are shown in Figure 3-1.

Terminal identification is provided by Figure 3-2. On the drawing, the six terminal pairs are labeled W100 through W105. The top three terminal pairs (W101, W103 and W105) are used to connect the LO terminals of the banks together. The bottom terminal pairs (W100, W102 and W104) are used to connect the HI terminals of the banks together. Table 3-1 summarizes the purpose of each jumper.

Table 3-1
Bank-to-bank jumpers (on connector card)

Installed jumper*	Connection
W101	Bank A LO to Bank B LO
W100	Bank A HI to Bank B HI
W103	Bank B LO to Bank C LO
W102	Bank B HI to Bank C HI
W105	Bank C LO to Bank D LO
W104	Bank C HI to Bank D HI

*See Figure 3-1 for location.



A. Screw Terminal Connector Card (Model 7015-S)

B. Multi-pin Connector Card (Model 7015-C)

Figure 3-1
Bank-to-bank jumper locations

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Referring to Figure 3-1 for jumper locations, perform the following steps to install bank-to-bank jumpers:

1. If mated together, separate the relay card from the connector card by removing the mounting screw and pulling the two cards away from each other. Remember to handle the cards only by the edges and shields to avoid contamination.
2. Refer to Figure 3-2 and Table 3-1 to determine which jumpers to install.
3. Using Figure 3-3 as a guide, install the jumpers on the appropriate terminal pairs.

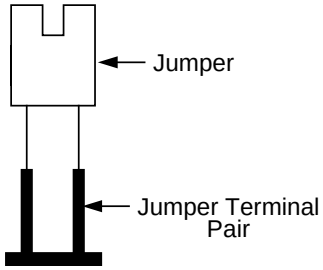


Figure 3-3
Bank-to-bank jumper installation

3.3.2 Backplane jumpers

The Model 7001 and Model 7002 mainframes have an analog backplanes that allow the banks of a Model 7015 multiplexer to be internally connected to a compatible switching card installed in another slot (see paragraph 2.4.1 for details).

The backplane jumpers for the multiplexer card assembly are located on the relay card as shown in Figure 3-4, and Table 3-2 summarizes jumper connections. The card is shipped from the factory with the jumpers installed.

Jumper removal

Perform the following steps to remove backplane jumpers:

1. If mated together, separate the relay card from the connector card by removing the mounting screw and pulling the two cards away from each other. Remember to handle the cards only by the edges and shields to avoid contamination.
2. Use Figure 3-4 and Table 3-2 to locate the jumpers that are to be removed.
3. It is not necessary to unsolder the jumpers from the PC board. Using a pair of wire cutters, cut both ends of each jumper, then remove each cut jumper completely.

Table 3-2
Backplane jumpers (on relay card)

Jumper*	Backplane connection
W100	Bank A HI
W101	Bank A LO
W102	Bank B HI
W103	Bank B LO
W104	Bank C HI
W105	Bank C LO
W106	Bank D HI
W107	Bank D LO

*See Figure 3-4 for location.

Jumper installation

Referring to Figure 3-4 for jumper locations, perform the following steps to install backplane row jumpers:

1. If mated together, separate the relay card from the connector card by removing the mounting screw and pulling the two cards away from each other. Remember to handle the cards only by the edges and shields to avoid contamination.
2. Physically remove a cut jumper by unsoldering the two cut ends from the PC board.
3. Install a new #22 AWG jumper wire (Keithley P/N J-15), and solder it to the PC board.
4. Remove the solder flux from the PC board. The cleaning procedure is explained in paragraph 5.2.

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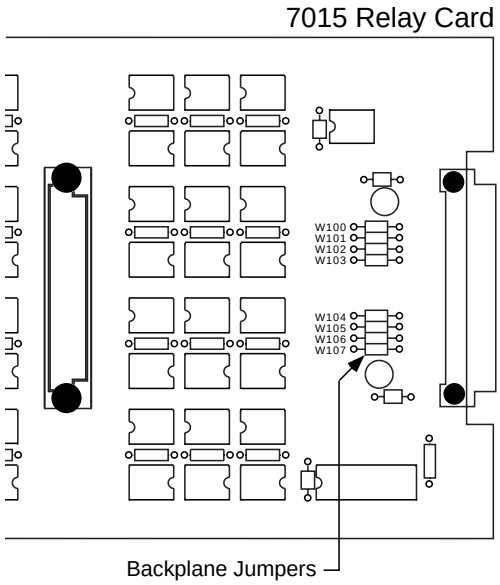


Figure 3-4
Backplane jumpers

3.3.3 Screw terminal connector card

The screw terminal connector card is shown in Figure 3-5. Connections are made directly to the screw terminals of the twelve terminal blocks. Each screw terminal will accommodate #16-22 AWG wire.

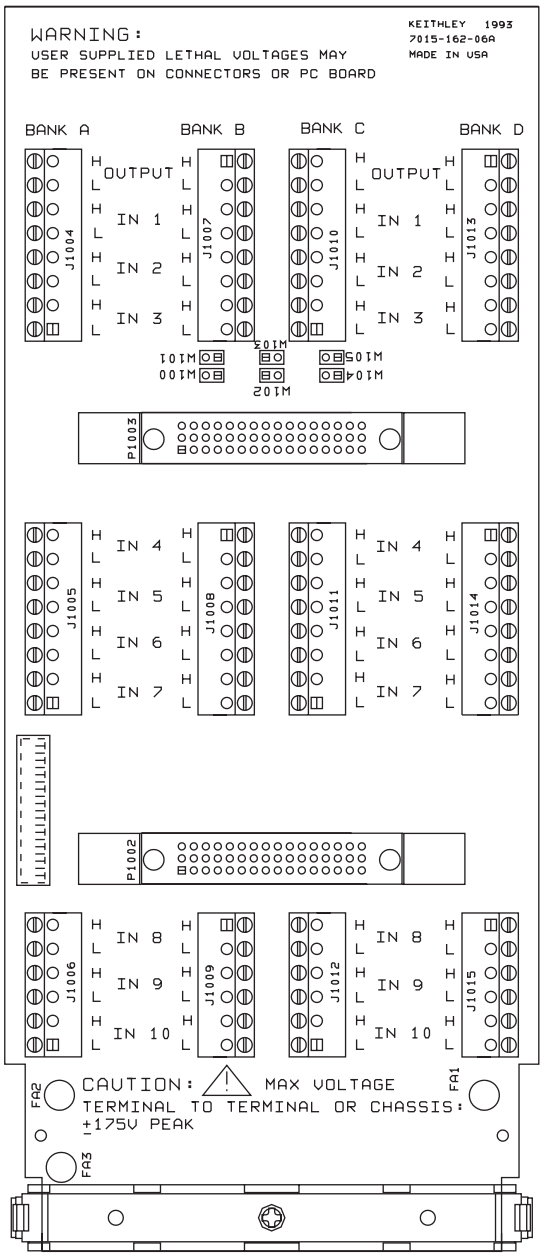


Figure 3-5
Model 7015 screw terminal connector card

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Wiring procedure

Perform the following procedure to wire circuitry to the screw terminal connector card:

WARNING

Make sure all power is off and that any stored energy in external circuitry is discharged.

1. If mated together, separate the connector card from the relay card by removing the mounting screw and pulling the two cards away from each other. Remember to handle the cards only by the edges and shields to avoid contamination.
2. Using an insulated screwdriver, connect the circuitry to the appropriate terminals. Figure 3-6 shows how the output of Bank A would be connected to a DMM.
3. Referring to Figure 3-7, remove the top half of the cable clamp as follows:
   A. Loosen the cable clamp screw enough to disengage it from the bottom half of the cable clamp.
   B. Using your thumb and forefinger, press the retaining clips inward and, with your other hand, remove the top half of the clamp.
4. Route wires under wire guide/connector shim.
5. Route the wires through the bottom half of the cable clamp.
6. Replace the top half of the clamp. It simply snaps onto the bottom half of the clamp. Tighten the cable clamp screw. The clamp serves as a strain relief for terminal block wires.
7. Mate the connector card to the relay card. The Model 7015 is now ready to be installed in the Model 7001 or Model 7002 mainframe. See paragraph 3.5 for details.

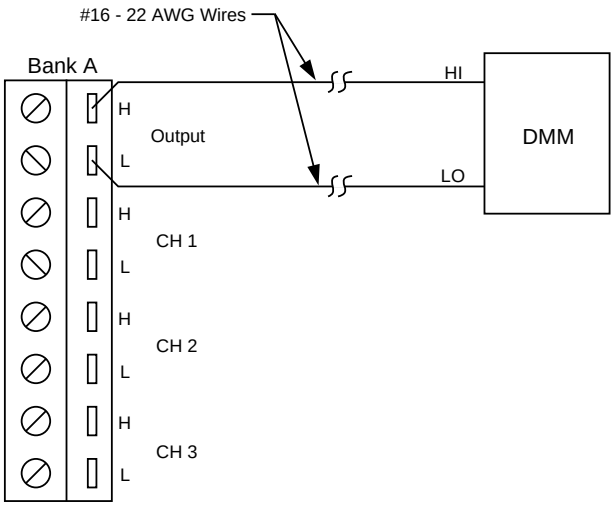


Figure 3-6
Typical screw terminal connections

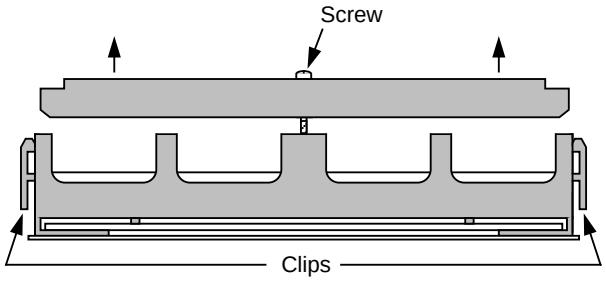


Figure 3-7
Cable clamp for screw terminal connector card

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3.3.4 Multi-pin (mass termination) connector card

Since connections to external circuitry are made at the 96-pin male DIN bulkhead connector, there is no need to separate the connector card from the relay card. If the connector card is separated from the relay card, carefully mate them together and install the supplied 4-40 mounting screw. Be sure to handle the cards by the edges and shields to avoid contamination.

Terminal identification for the DIN connector of the multi-pin connector card is provided by Table 3-3. This connector will mate to a 96-pin female DIN connector.

Keithley has a variety of cable and connector accessories available to accommodate connections from the connector card to test instrumentation and DUT (devices under test). In general, these accessories, which are summarized in Table 3-4, utilize a round cable assembly for connections.

Table 3-3
Multipin card terminal identification

Mux Terminal	Connector Desig. 1a-32c	Schem. Desig. 1-96	Mux Terminal	Connector Desig. 1a-32c	Schem. Desig. 1-96	Mux Terminal	Connector Desig. 1a-32c	Schem. Desig. 1-96	Mux Terminal	Connector Desig. 1a-32c	Schem. Desig. 1-96
Bank A			Bank B			Bank C			Bank D		
Input 1 HI	32c	96	Input 1 HI	24c	88	Input 1 HI	16c	80	Input 1 HI	8c	72
LO	32b	64	LO	24b	56	LO	16b	48	LO	8b	40
Input 2 HI	32a	32	Input 2 HI	24a	24	Input 2 HI	16a	16	Input 2 HI	8a	8
LO	31c	95	LO	23c	87	LO	15c	79	LO	7c	71
Input 3 HI	31b	63	Input 3 HI	23b	55	Input 3 HI	15b	47	Input 3 HI	7b	39
LO	31a	31	LO	23a	23	LO	15a	15	LO	7a	7
Input 4 HI	30c	94	Input 4 HI	22c	86	Input 4 HI	14c	78	Input 4 HI	6c	70
LO	30b	62	LO	22b	54	LO	14b	46	LO	6b	38
Input 5 HI	30a	30	Input 5 HI	22a	22	Input 5 HI	14a	14	Input 5 HI	6a	6
LO	29c	93	LO	21c	85	LO	13c	77	LO	5c	69
Input 6 HI	29b	61	Input 6 HI	21b	53	Input 6 HI	13b	45	Input 6 HI	5b	37
LO	29a	29	LO	21a	21	LO	13a	13	LO	5a	5
Input 7 HI	28c	92	Input 7 HI	20c	84	Input 7 HI	12c	76	Input 7 HI	4c	68
LO	28b	60	LO	20b	52	LO	12b	44	LO	4b	36
Input 8 HI	28a	28	Input 8 HI	20a	20	Input 8 HI	12a	12	Input 8 HI	4a	4
LO	27c	91	LO	19c	83	LO	11c	75	LO	3c	67
Input 9 HI	27b	59	Input 9 HI	19b	51	Input 9 HI	11b	43	Input 9 HI	3b	35
LO	27a	27	LO	19a	19	LO	11a	11	LO	3a	3
Input 10 HI	26c	90	Input 10 HI	18c	82	Input 10 HI	10c	74	Input 10 HI	2c	66
LO	26b	58	LO	18b	50	LO	10b	42	LO	2b	34
Output HI	26a	26	Output HI	18a	18	Output HI	10a	10	Output HI	2a	2
LO	25c	89	LO	17c	81	LO	9c	73	LO	1c	65

Notes: 1. Pins 9a and 9b (pins 9 and 41 on schematic) are shield.
2. Short pin 1a to 1b on the mating connector (pins 1 and 33 on schematic) to allow the output relays on the connector card to close.

Pins of the Model 7015-C mass termination connector can be identified in one of three ways:

1. Mux terminal, consisting of banks A-D and inputs 1-10.
2. Connector description, consisting of rows a-c and columns 1-32.
3. Schematic and component layout designation (1-96).

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Table 3-4
Mass termination accessories

Model	Description
7011-KIT-R	96-pin female DIN connector and housing for round cable.
7011-MTC-2	Two-meter round cable assembly terminated with a 96-pin female DIN connector on each end.
7011-MTR	96-pin male DIN bulkhead connector.

Typical connection techniques

All external circuitry, such as instrumentation and DUTs, that you wish to connect to the multiplexer card must be terminated with a single 96-pin female DIN connector. The following connection techniques provide some guidelines and suggestions for wiring your circuitry.

WARNING

Before beginning any wiring procedures, make sure all power is off, and any stored energy in external circuitry is discharged.

NOTE

External circuitry should be connected (plugged in) only with the mainframe power off, after the Model 7015 assembly is installed in the Model 7001 or 7002 mainframe. Installation is covered in paragraph 3.5.

Output relays— The multi-pin connector card uses a relay for each of the four output banks. These output relays are normally open to prevent any hazardous voltages (via the mainframe backplane) from appearing on the pins of the male DIN connector. The output relays will close only when the Model 7011-MTC-2 cable assembly is connected to card. If building your own cable assembly, you must make sure that it shorts pin 1a to 1b of the card connector (Table 3-3) when it is mated to the card. Shorting pin 1a to 1b allows the output relays to close.

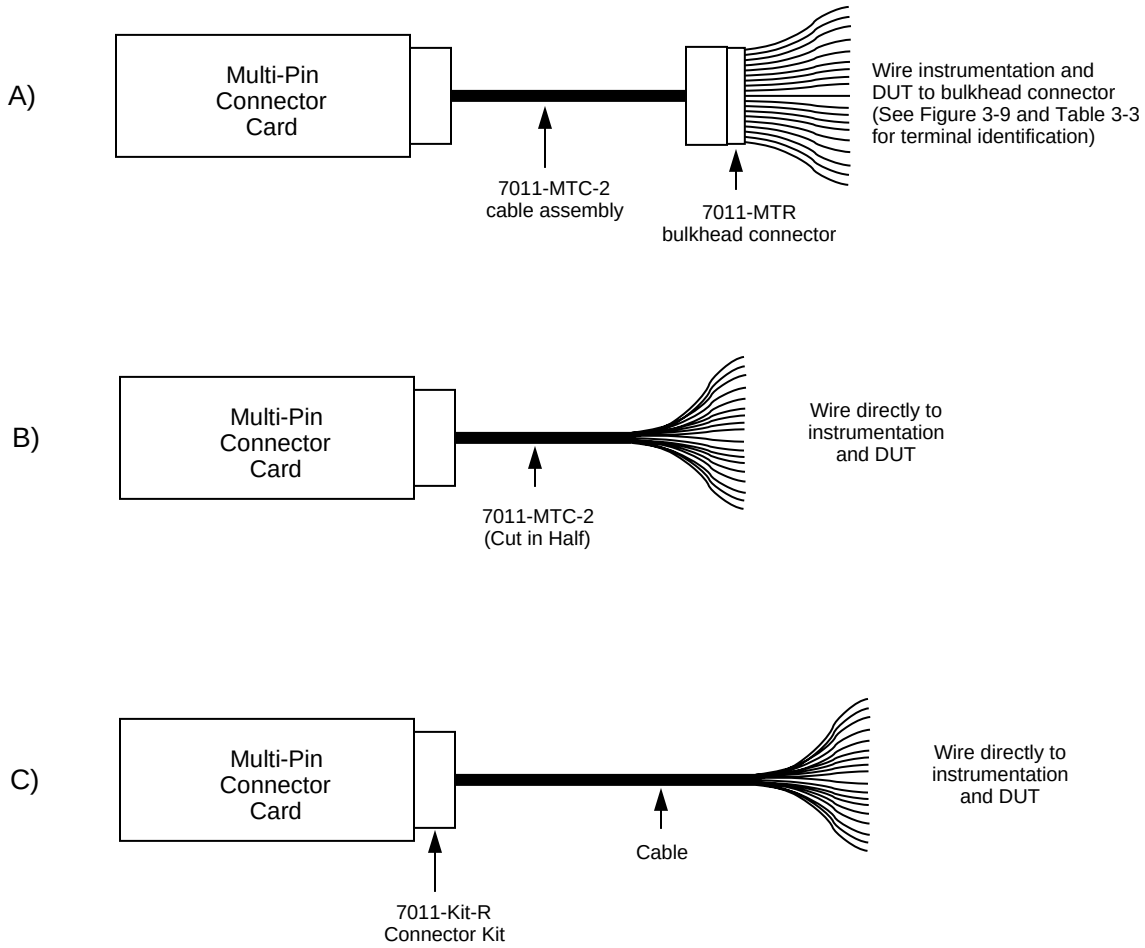
Round cable assemblies — Figure 3-8 shows typical round cable connection techniques using accessories available from Keithley.

In Figure 3-8A, connections are accomplished using a Model 7011 MTC-2 cable and a Model 7011-MTR bulkhead connector. The two-meter round cable is terminated with a 96-pin female DIN connector at each end. This cable mates directly to the multi-pin connector card and to the bulkhead connector. The bulkhead connector has solder cups to allow direct connection to instrumentation and DUT. Figure 3-9 provides the pinout for the bulkhead connector.

In Figure 3-8B, connections are accomplished using a Model 7011 MTC-2 cable assembly that is cut in half. The 96-pin female DIN connector on one end of the cable mates directly to the multi-pin connector card. The unterminated end of the cable is wired directly to instrumentation and DUT. The other half of the cable assembly could be used for a second switching card.

In Figure 3-8C, connections are accomplished using a custom-built cable assembly that consists of a Model 7011-KIT-R connector and a suitable round cable. Hitachi cable part number N2807-P/D-50TAB is a 50-conductor cable. Two of these cables can be used to supply 100 conductors.The connector has solder cups to accommodate the individual wires of the unterminated cable. Figure 3-10 provides an exploded view of the connector assembly and shows how the cable is connected. The connector end of the resultant cable assembly mates directly to the multi-pin connector card. The unterminated end of the cable assembly is wired directly to instrumentation and DUT.

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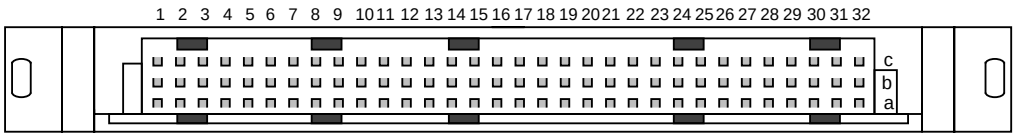


Notes : Figure 3-10 provides an exploded view showing how the connector (with cable) is assembled.

Cable Hitachi p/n N2807-P/D-50TAB is a 50-conductor round cable. Two of these cables can be used to supply 100 conductors.

Figure 3-8
Typical round cable connection techniques

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Note : See Table 3-3 for terminal identification.

Figure 3-9
Model 7011-MTR connector pinout

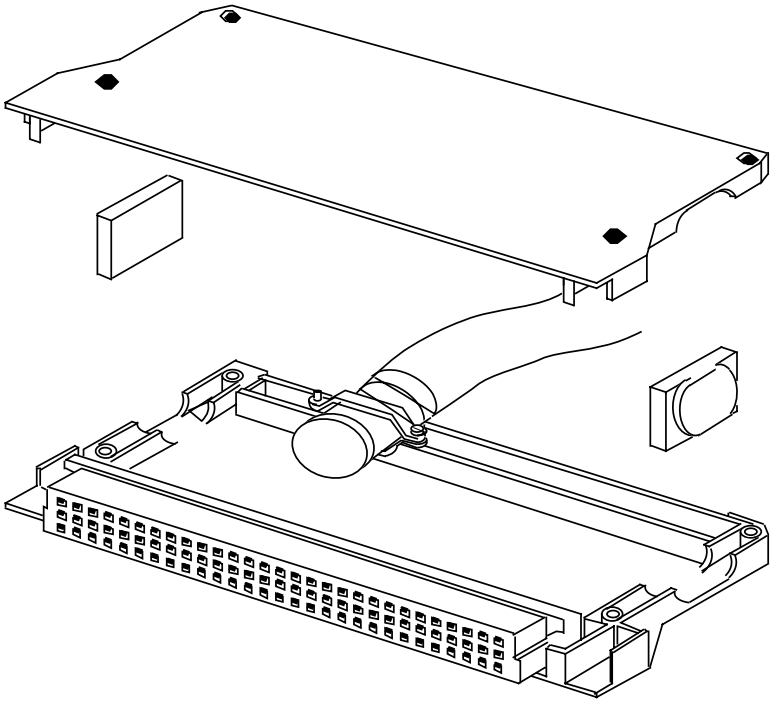


Figure 3-10
Model 7011-KIT-R (with/cable) assembly

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3.4 Typical connection schemes

The following information provides some typical connection schemes for single card, two-card and two-mainframe system configurations. Connection schemes for the multi-pin connector card use some of the techniques presented in paragraph 3.3.2. Keep in mind that these are only examples to demonstrate various ways to wire a test system. Connection details for both connector cards (multi-pin and screw terminal connector cards) are provided in paragraph 3.3.

3.4.1 Single-card system

Figure 3-11 shows external connections for a single-card system that uses the multi-pin connector card. This single-card system is configured as two 1 × 20 multiplexers. To do so, the appropriate bank-to-bank jumpers must be installed to connect Banks A and B together and Banks C and D together.

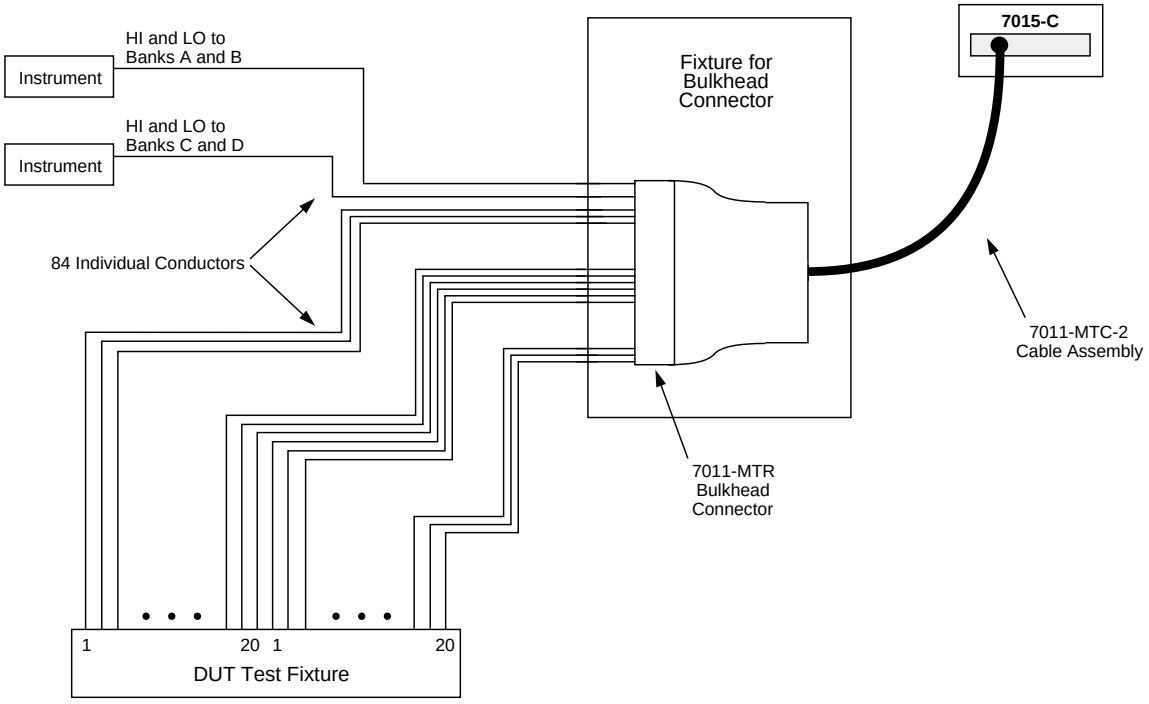
Instrumentation and DUTs are hard-wired to the Model 7011-MTR male bulkhead connector. This connector has solder cups that will accept wire sizes up to #24 AWG. The test system is connected to the multiplexer using the Model 7011-MTC-2 round cable assembly. This cable mates directly to both the external bulkhead connector and the Model 7015-C multiplexer card assembly. Note that the bulkhead connector is shown mounted to a fixture to help keep the cabling stable during the test.

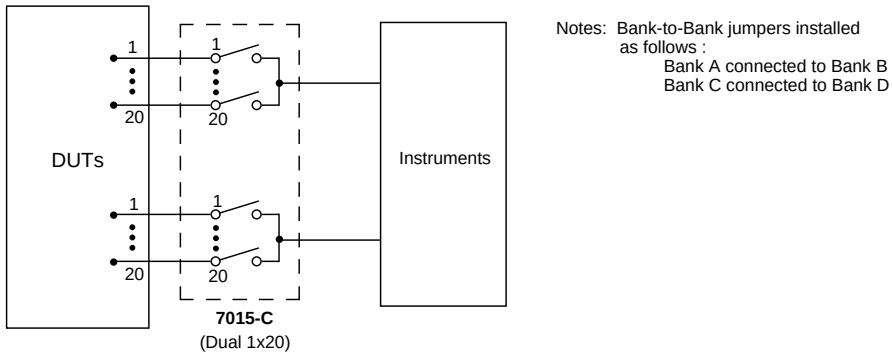
The single-card system in Figure 3-12 is identical to the system in the previous illustration except for the connection scheme. The system in Figure 3-12 uses the screw terminal connector card. With this card, single-conductor connections are made directly from the terminal blocks of the connector card to instrumentation and DUTs.

When using a single-card system, make sure that the card remains electrically isolated from any other switching cards. There are several ways to ensure isolation for a single card in the Model 7001 or Model 7002 mainframe:

1. Vacate other mainframe slots. If there are Model 701X cards installed in other slots, remove them.
2. Remove the backplane jumpers on the multiplexer card. Doing so will disconnect the card from the analog backplane of the mainframe.
3. Remove the backplane jumpers from switching cards installed in all other slots.

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Simplified Equivalent Circuit

Figure 3-11
Single-card system example (multi-pin connector card)

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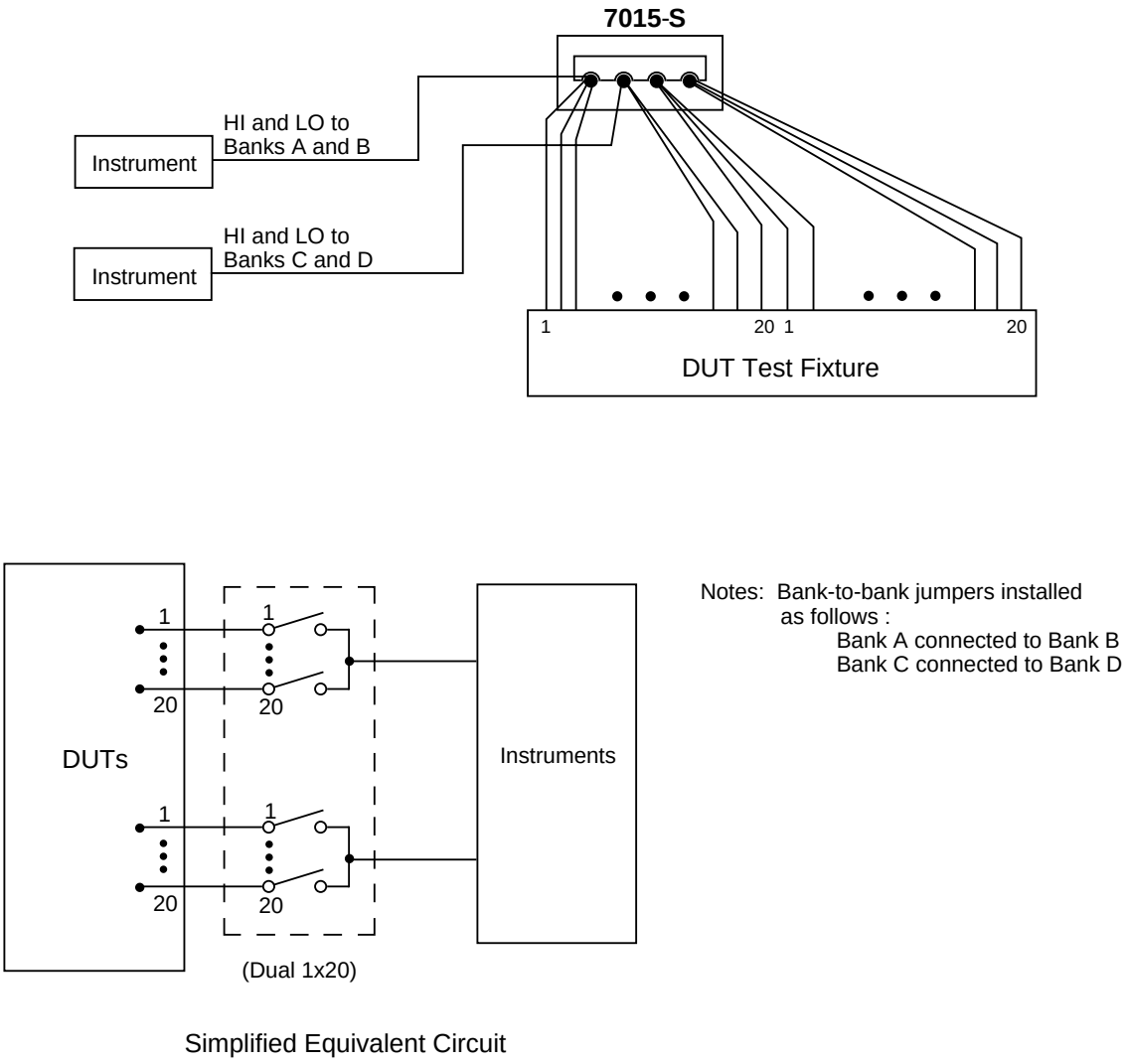


Figure 3-12
Single-card system example (screw terminal connector card)

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3.4.2 Two-card system

Both Figure 3-13 and Figure 3-14 show a system using two multiplexer cards installed in one Model 7001 mainframe to configure a single 1 × 80 multiplexer system. Each card is configured as a single 1 × 40 multiplexer. All bank-to-bank jumpers (both cards) are installed to connect Banks A, B, C, and D together. By leaving the backplane jumpers of both cards installed, the banks of Card 1 are connected to the banks of Card 2 through the analog backplane of the Model 7001 mainframe resulting in the 1 × 80 configuration.

Figure 3-13 shows how external connections can be made for the multi-pin connector cards. In this example, a single Model 7011-MTC-2 round cable assembly is cut in half to provide two cables, each of which is unterminated at one end. The unterminated ends of the two cables are hard-wired to the instrument and DUT as shown in the drawing. The other ends of these cables mate directly to the Model 7015-C multiplexer card assemblies.

Figure 3-14 shows how external connections can be made for the screw terminal connector card. Single conductor connections are made directly from the screw terminals of the connector card to the instrument and DUT.

3.4.3 Multiple-card systems

The same general system configuration shown in Figure 3-13 and Figure 3-14 can be expanded further by substituting a Model 7002 mainframe for the Model 7001. Since a single Model 7002 can hold 10 cards, a 1 × 400 multiplexer can be configured using 10 Model 7015 cards in a single mainframe.

3.4.4 Two-mainframe system

Both Figure 3-15 and Figure 3-16 show a system using three multiplexer cards installed in two Model 7001 mainframes to configure a single 1 × 120 multiplexer system. Each card is configured as a single 1 × 40 multiplexer. Bank-to-bank jumpers of all three cards must be installed to connect Banks A, B, C, and D together.

By leaving the backplane jumpers of the cards in mainframe #1 installed, the banks of Card 1 are connected to the banks of Card 2 through the analog backplane of the Model 7001 mainframe resulting in a 1 × 80 configuration. External bank connections from the instrument to the card in the second mainframe connect the banks of all three cards together to form the 1 × 120 multiplexer system. This system is similar to the Two-card System (see previous paragraph) except that a third multiplexer card (installed in a second mainframe) is added.

Figure 3-15 shows the connection scheme for the multi-pin connector cards. External circuit connections to the Model 7001 #1 mainframe are identical to the ones used for the Two-card System. The third multiplexer card (installed in Model 7001 #2 mainframe) shows how a custom-built cable can be used to make connections to external circuitry. A suitable round cable can be constructed using a 96-pin female DIN connector (Model 7011-KIT-R) with two lengths of Hitachi cable P/N N2807-P/D-50TAB. This cable contains 50 conductors; two lengths provide 100 conductors. This cable will mate to the Model 7015-C multiplexer card assembly. The unterminated end of the cable is connected directly to the instrument and DUT. Notice that the bank connections for the third multiplexer card are made at the instruments.

Figure 3-16 shows connections for the screw terminal connector card. Single conductor connections are made directly from the screw terminals of the connector card to the instrument and DUT.

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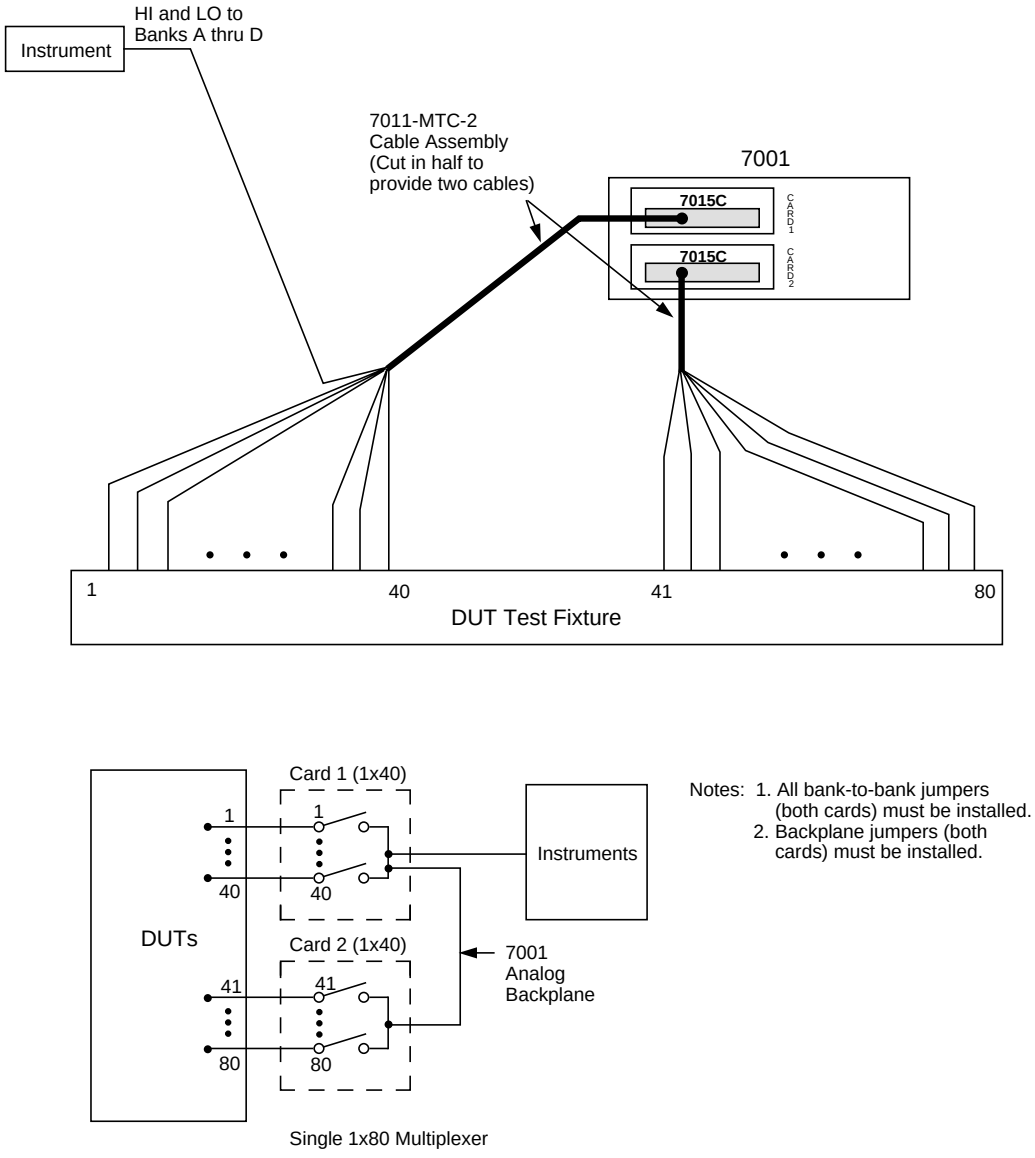
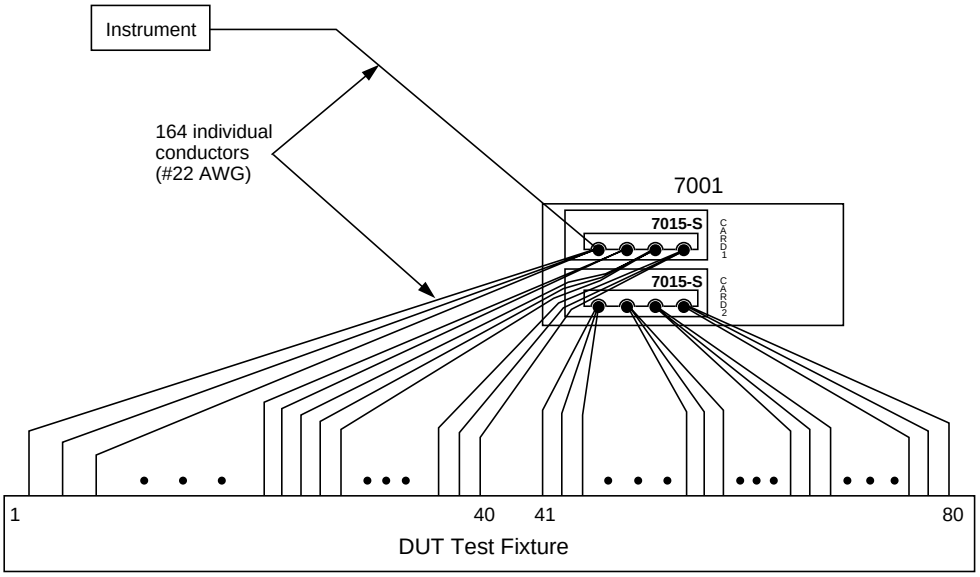
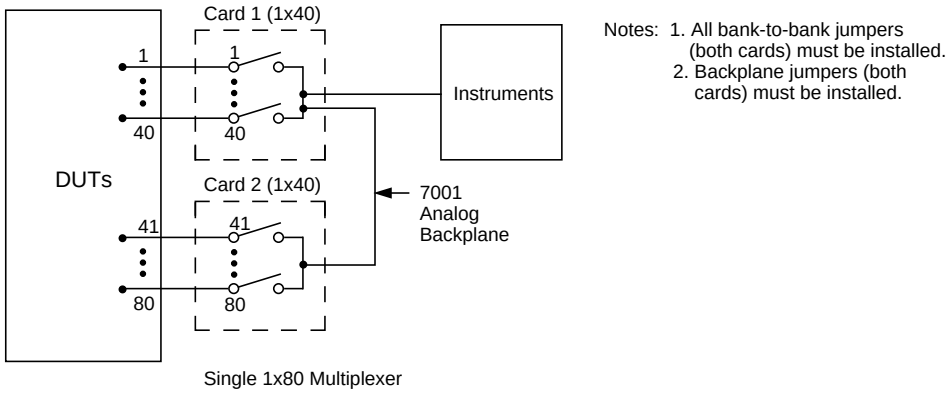


Figure 3-13
Two-card system example (multi-pin connector card)

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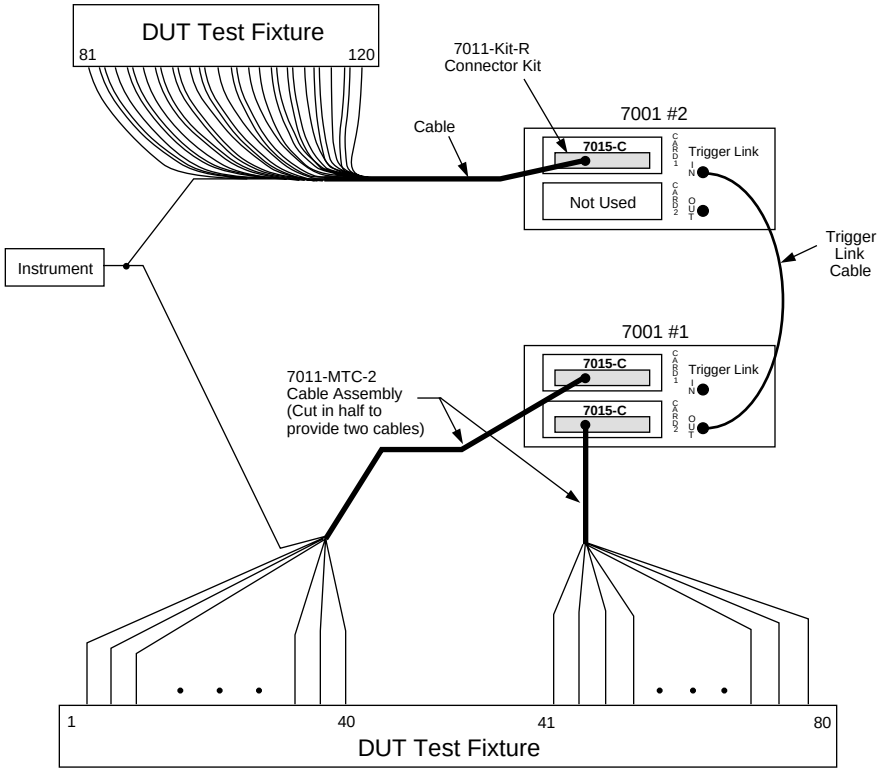


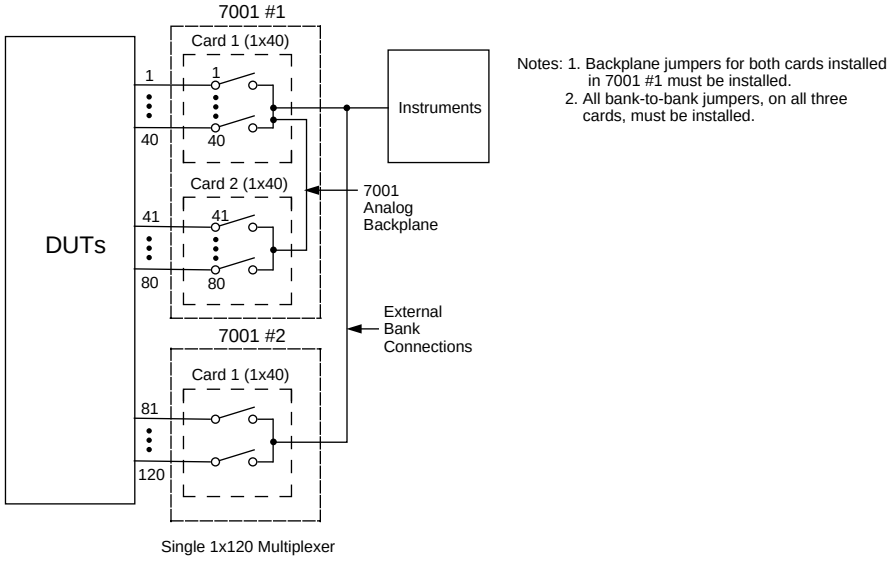


Simplified Equivalent Circuit

Figure 3-14
Two-card system example (screw terminal connector card)

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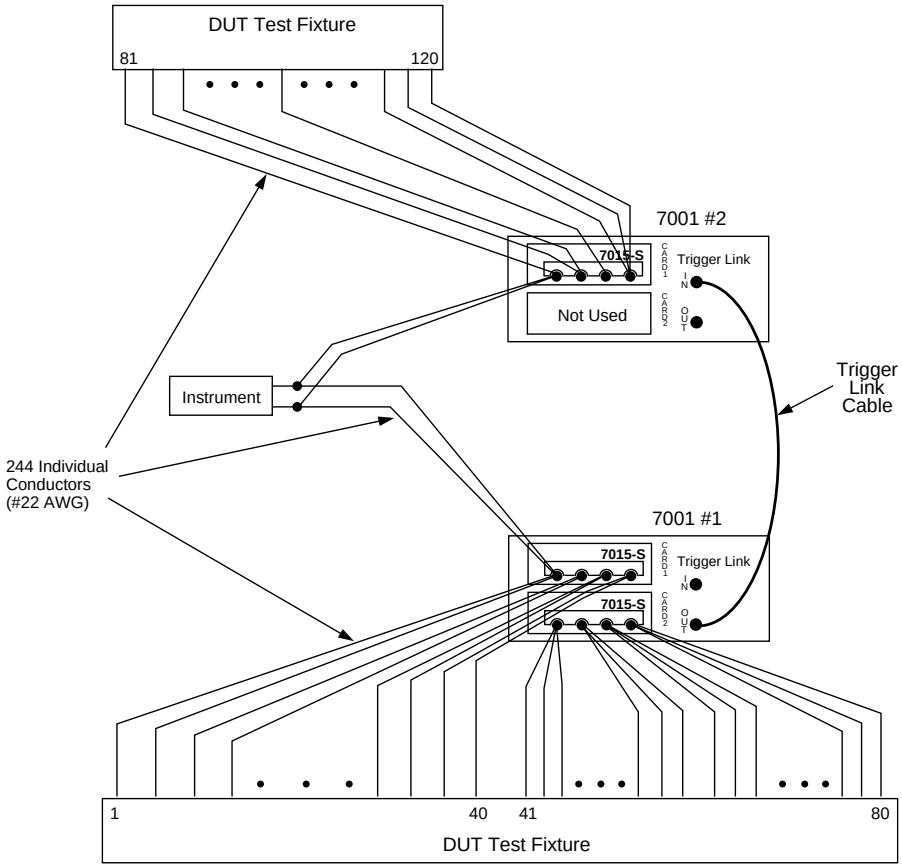


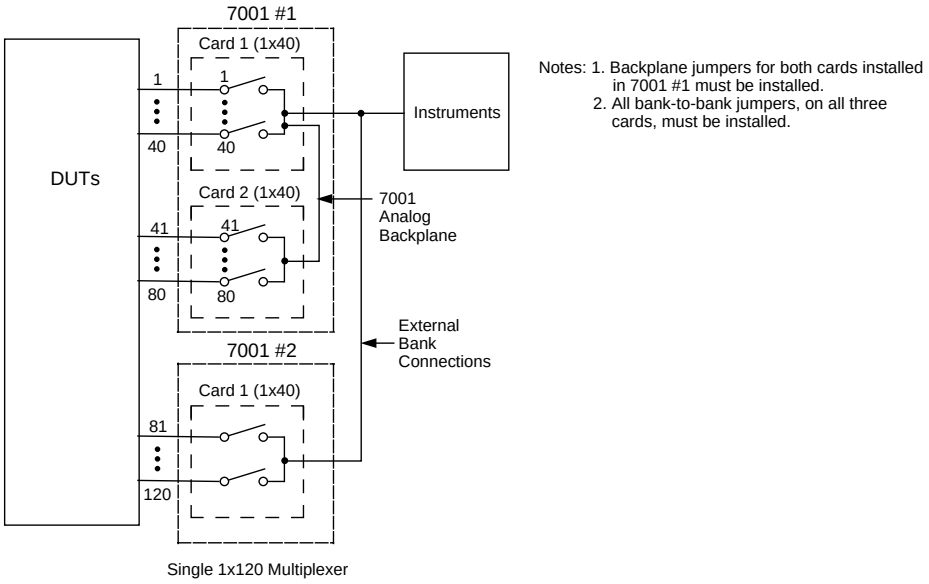


Simplified Equivalent Circuit

Figure 3-15
Two-mainframe system example (multi-pin connector card)

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Simplified Equivalent Circuit

Figure 3-16
Two-mainframe system example (screw terminal connector card)

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3.5 Model 7015 installation and removal

This paragraph explains how to install and remove the Model 7015 multiplexer card assembly from the Model 7001 or Model 7002 mainframe.

WARNING

Installation or removal of the Model 7015 is to be performed by qualified service personnel. Failure to recognize and observe standard safety precautions could result in personal injury or death.

NOTE

If using the screw terminal connector card, make sure your external circuitry is wired to the card (as explained in paragraph 3.3.1) before installing the card assembly in the Model 7001 or Model 7002 mainframe.

CAUTION

To prevent contamination to the multiplexer card that could degrade performance, handle the card assembly only by the edges and shields.

Multiplexer card installation

Perform the following steps to install the multiplexer card assembly in the Model 7001 or Model 7002 mainframe:

WARNING

Turn off all instrumentation power (including the Model 7001 or Model 7002 mainframe), and disconnect their line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Mate the connector card to the relay card if they are separated. Install the supplied 4-40 screw at the end of the card to secure the assembly. Make sure to handle the cards by the edges and shields to prevent contamination.
2. Facing the rear panel of the mainframe, select the slot that you wish to install the card in.
3. Referring to Figure 3-17 or Figure 3-18 for Model 7015-C installation or Model 7015-S installation, feed the multiplexer card assembly into the desired slot such that the edges of the relay card ride in the rails.
4. With the ejector arms in the unlocked position, push the card assembly all the way into the mainframe until the arms engage into the ejector cups, then push both arms inward to lock the card into the mainframe.
5. Tighten ground screw shown in Figure 3-17 and Figure 3-18.

WARNING

Failure to tighten the ground screw may result in a shock hazard or damage to the multiplexer card.

Multiplexer card removal

To remove the multiplexer card assembly, first loosen the ground screw, unlock the card by pulling the latches outward, then pull the card assembly out of the mainframe. Remember to handle the card assembly by the edges and shields to avoid contamination that could degrade performance.

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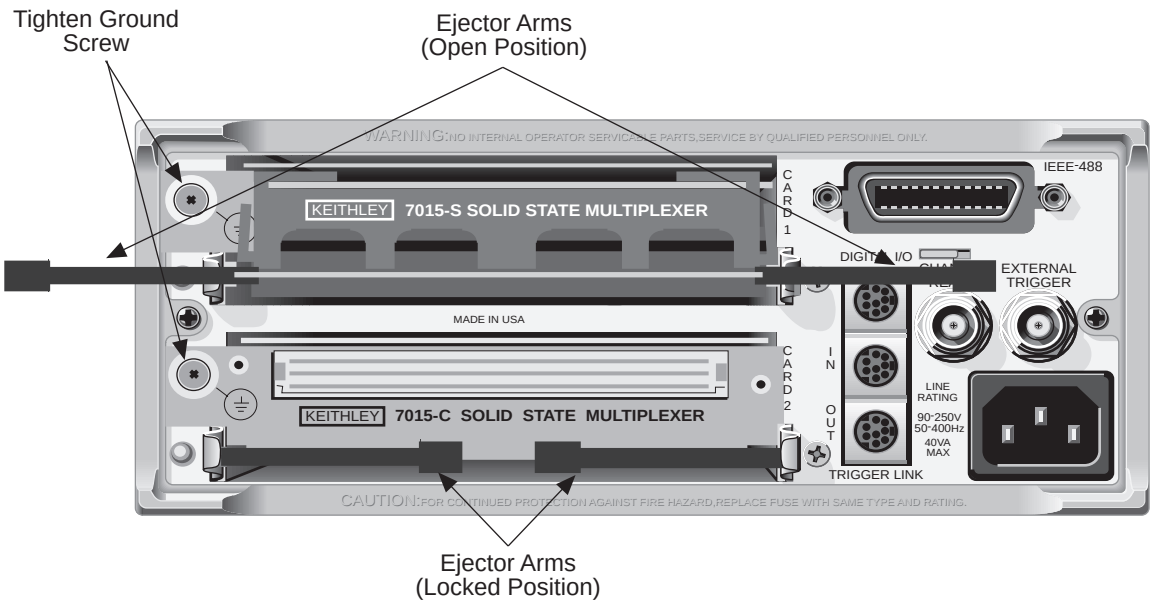


Figure 3-17
Model 7015 card installation in Model 7001

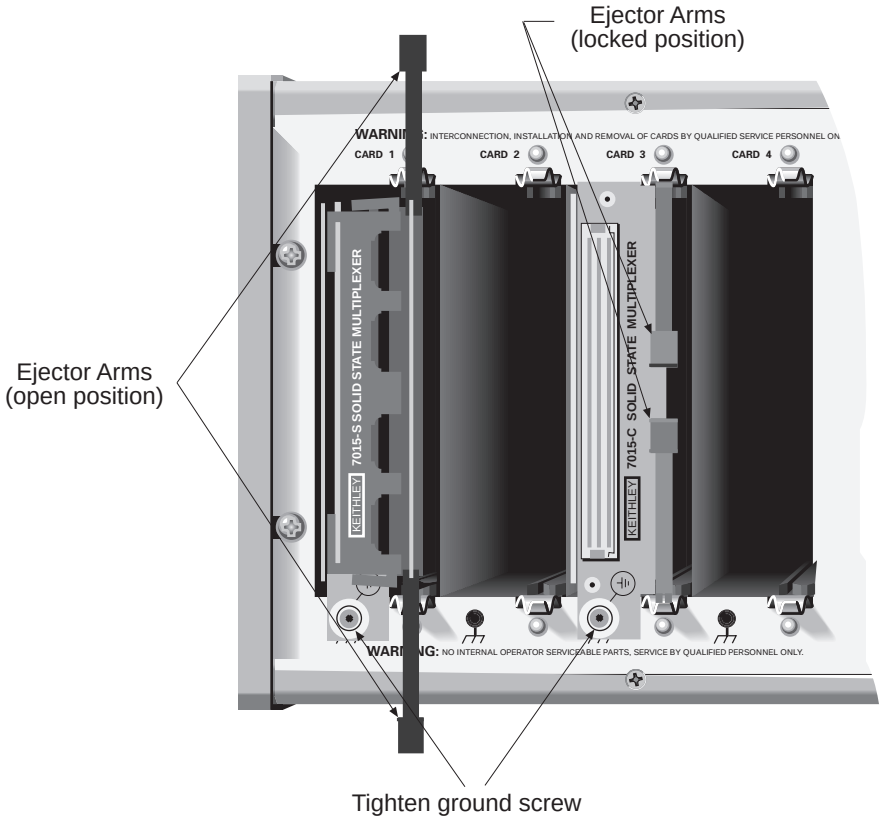


Figure 3-18
Model 7015 card installation in Model 7002

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4
Operation

4.1 Introduction

This section contains detailed information on operating the Model 7015 and is formatted as follows:

4.2 Maximum signal levels: Summarizes the maximum signal levels of the Model 7015 multiplexer card assembly.

4.3 Mainframe control of multiplexer card: Summarizes programming steps to control the multiplexer card from the Model 7001 or Model 7002.

4.4 Multiplexer switching examples: Provides some typical applications for using the Model 7015.

4.5 Measurement considerations: Reviews a number of considerations when using the Model 7015 to make measurements.

4.2 Maximum signal levels

CAUTION

To prevent damage to the card, do not exceed its maximum signal level specifications.

Do not use the Model 7015 to switch inductive loads, or the solid-state relays may sustain damage.

To prevent damage to the solid-state relays, never exceed the following maximum signal levels:

±175V peak between any two pins, 34mA resistive load, 0.3VA max, 1×10^6V•Hz max.

4.3 Mainframe control of multiplexer card

The following information pertains to the Model 7015 Solid-State Multiplexer Card. It assumes that you are familiar with operation of the Model 7001 or Model 7002 mainframe.

If you are not familiar with operation of the mainframe, it is recommended that you proceed to Getting Started (Section 3) of the mainframe Instruction Manual after reading the following information.

4.3.1 Channel assignments

The Model 7001 has a channel status display (Figure 4-1) that provides the real-time state of each available channel. The left portion of the display is for slot 1 (Card 1), and the right portion is for slot 2 (Card 2). The Model 7002 displays channel assignments for each card slot, as shown in Figure 4-2.

The Model 7015 card contains 40 channels and is made up of four banks (Bank A, B, C, and D) of 10 multiplexer inputs

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as shown in the illustration. Model 7002 row assignments are shown in parentheses.

To control the multiplexer (mux) card from the mainframe, each multiplexer input must have a unique CHANNEL assignment that includes the slot number in which the card is installed. The CHANNEL assignments for the multiplexer card are provided in Figure 4-3. Each CHANNEL assignment is made up of the slot designator (1 or 2 for the Model 7001; 1-10 for the Model 7002) and the multiplexer channel.

To be consistent with Model 7001/7002 operation, the slot designator and mux input are separated by exclamation points (!). Some examples of CHANNEL assignments are as follows:

CHANNEL 1!1 = Slot 1, Channel 1 (Input 1 of Bank A)

CHANNEL 1!40 = Slot 1, Channel 40 (Input 10 of Bank D)

CHANNEL 2!23 = Slot 2, Channel 23 (Input 3 of Bank C)

CHANNEL 2!36 = Slot 2, Channel 36 (Input 6 of Bank D)

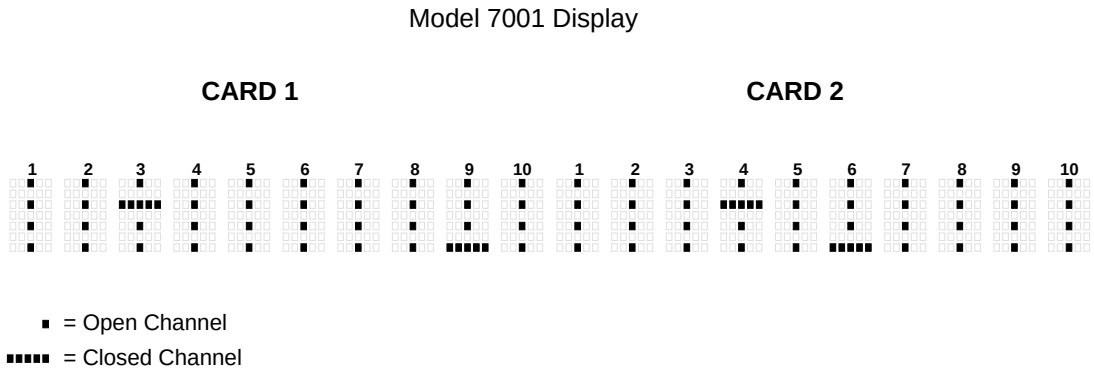


Figure 4-1
Channel status display

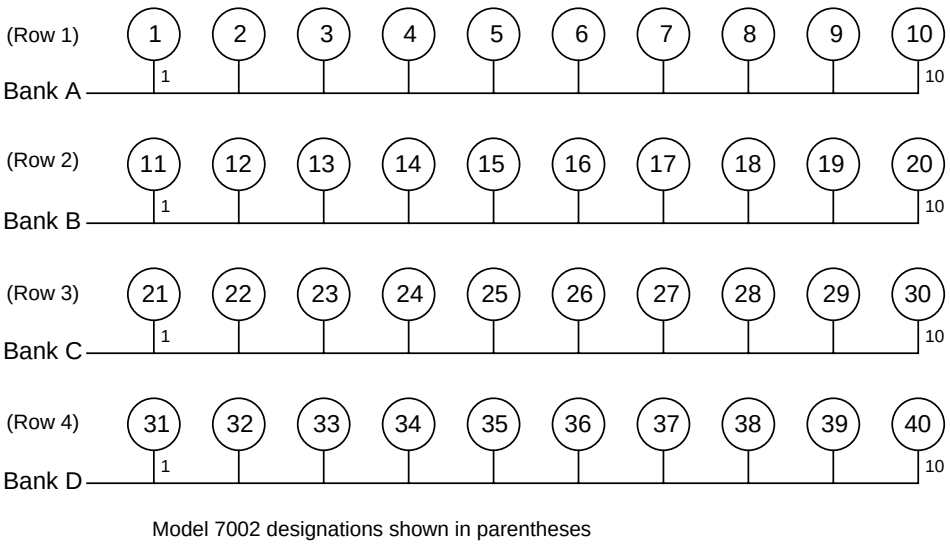
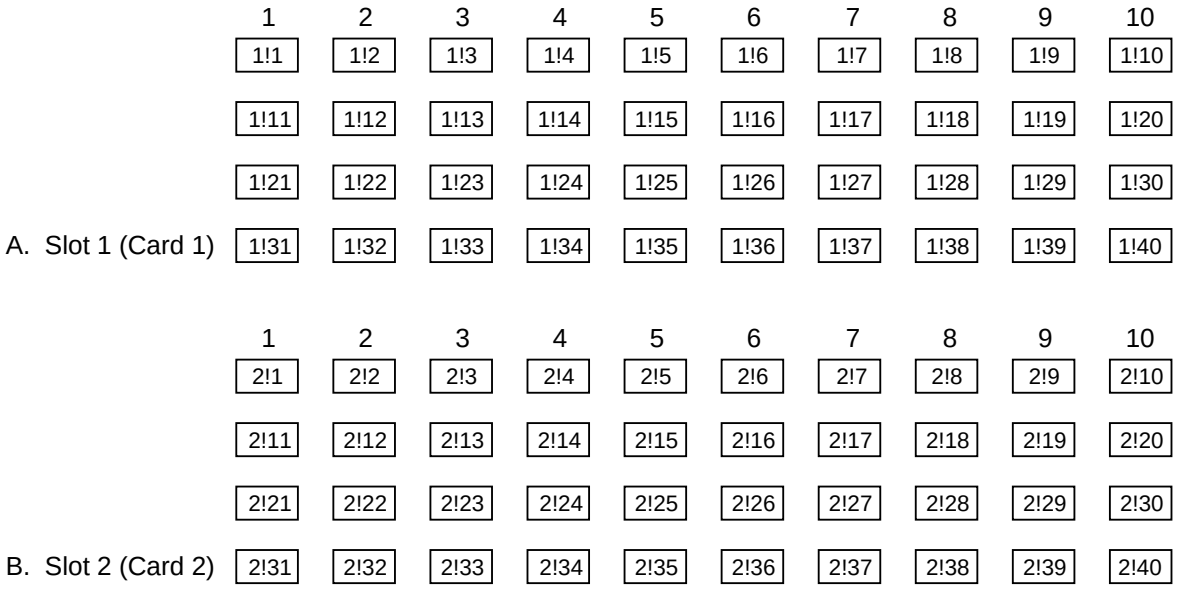


Figure 4-2
Display organization for multiplexer channels

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Examples : 1!18 = Slot 1, Channel 18 (Input 8, Bank B)
2!36 = Slot 2, Channel 36 (Input 6, Bank D)

Note : For Model 7002 slots 3-10, substitute slot number for first number in channel assignments.

Figure 4-3
Model 7015 programming channel assignments

4.3.2 Front panel control

Closing and opening channels

A multiplexer channel is closed from the front panel by simply keying in the CHANNEL assignment and pressing CLOSE. For example, to close channel 36 (Input 6 of Bank D) of a multiplexer card installed in slot 2, key in the following channel list, and press CLOSE:

SELECT CHANNELS 2!36

The above closed channel can be opened by pressing OPEN or OPEN ALL. The OPEN key opens only the channels specified in the channel list, and OPEN ALL opens all channels.

The following display is an example of a channel list that consists of several channels:

SELECT CHANNELS 2!1, 2!3, 2!22-2!25

Notice that channel entries are separated by commas (,). A comma is inserted by pressing ENTER or the right cursor key (►). The channel range is specified by using the hyphen (-) key to separate the range limits. Pressing CLOSE will close all the channels specified in the channel list. Pressing OPEN (or OPEN ALL) will open the channels.

Scanning channels

Multiplexer channels are scanned by creating a scan list and configuring the Model 7001 or Model 7002 to perform a scan. The scan list is created in the same manner as a channel list (see Closing and Opening Channels). However, the scan list is specified from the “SCAN CHANNEL” display mode. (The SCAN LIST key toggles between the channel list and the scan list.) The following shows an example of a scan list:

SCAN CHANNELS 2!1, 2!3, 2!21-2!25

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When a scan is performed, the channels specified in the scan list will be scanned in the order that they are presented in the scan list.

A manual scan can be performed by using the RESET default conditions of the Model 7001 or Model 7002. RESET is selected from the SAVESETUP menu of the main MENU. When RESET is performed, the mainframe is configured for an infinite number of manual scans. The first press of STEP takes the mainframe out of the idle state. The next press of STEP will close the first channel specified in the scan list. Each subsequent press of STEP will select the next channel in the scan list.

4.3.3 IEEE-488 bus operation

Bus operation is demonstrated using HP BASIC 4.0. The programming statements assume that the primary address of the mainframe is 07.

Closing and opening channels

The following SCPI commands are used to close and open channels:

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

The following statement closes channels 1!1, and 1!3 through 1!11:

```
OUTPUT 707; ":clos (@ 1!1, 1!3:1!11)"
```

Notice that the colon (:) is used to separate the range limits.

Either of the following statements will open channels 1!1, and 1!3 through 1!11:

```
OUTPUT 707; ":open (@ 1!1, 1!3:1!11)"
OUTPUT 707; ":open all"
```

Scanning channels

There are many commands associated with scanning. However, it is possible to configure a scan using as little as four commands. These commands are listed as follows:

```
*RST
:TRIGger:SEQuence:COUNt:AUTo ON
:ROUTe:SCAN <list>
:INIT
```

The first command resets the mainframe to a default scan configuration. The second command automatically sets the channel count to the number of channels in the Scan List, the third command defines the Scan List, and the fourth command takes the mainframe out of the idle state.

The following program will perform a single scan through all 40 channels of a multiplexer card installed in slot 1:

```
10 OUTPUT 707; "*RST"
20 OUTPUT 707; ":trig:seq:coun:auto on"
30 OUTPUT 707; ":scan (@ 1!1:1!40)"
40 OUTPUT 707; ":init"
50 END
```

Line 10 Selects a default configuration for the scan.

Line 20 Sets channel count to the scan-list-length.

Line 30 Defines the scan list.

Line 40 Take the Model 7001/7002 out of the idle state. The scan is configured to start as soon as this command is executed.

When the above program is run, the scan will be completed as rapidly as possible. An additional relay delay can be added to the program to slow down the scan for viewing. The program is modified by adding line 25 to slow down the scan. Also, Line 5 is added to the beginning of the program to ensure that all channels are open before the scan is started.

```
5  OUTPUT 707; ":open all"
10 OUTPUT 707; "*RST"
20 OUTPUT 707; ":trig:seq:coun:auto on"
25 OUTPUT 707; ":trig:del 0.25"
30 OUTPUT 707; ":scan (@ 1!1:1!40)"
40 OUTPUT 707; ":INIT"
50 END
```

Line 5 Opens all channels.

Line 25 Sets a 1/4 second delay after each channel closes.

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4.4 Multiplexer applications

The following paragraphs discuss some typical applications for the Model 7015. These applications include various forms of resistor testing, transistor testing, as well as a discussion of how to combine the Model 7015 with a matrix card to increase switching versatility.

Although many Model 7015 applications are similar to those of cards using conventional mechanical relays, the solid-state switching used by the Model 7015 offers several distinct advantages over more traditional mechanical switching methods:

- Faster switching for more rapid scanning.
- Indefinite “contact” life with little or no change in on characteristics regardless of the number of switching cycles.
- Noise-free operation.

4.4.1 High-speed scanning

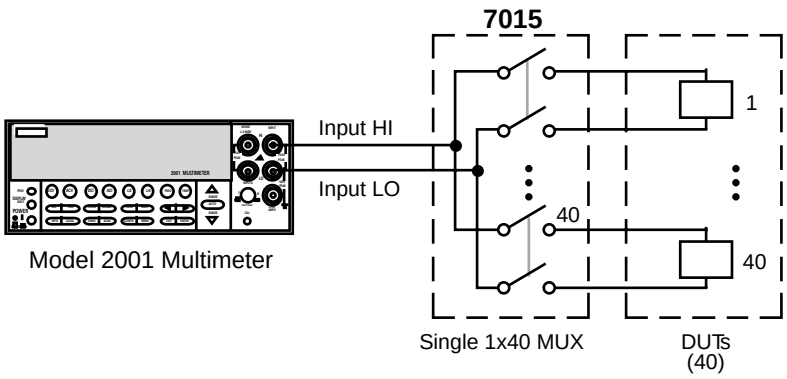
The Model 7015 and its host Model 7001/7002 mainframe can be used with a Model 2001 Multimeter to perform high-speed scanning, as shown in Figure 4-4. Using the typical 2-pole connection scheme shown, a total of 40 DUTs per card can be tested at high scanning rates (with break-before-make off; Model 7002 only). The type of measurement can vary, although some sort of voltage measurements are usually made using the setup shown.

To provide synchronization between scanner card channel closure and multimeter measurements, a trigger link cable is connected between the multimeter and switching mainframe, as shown in Figure 4-4C. A total of six instruments can be connected together using the trigger link, allowing the system to be expanded to a maximum of one multimeter and five switching mainframes. Five Model 7001s can accommodate a total of 10 Model 7015 cards, for testing up to 400 DUTs. Similarly, five Model 7002 mainframes can hold a total of 50 Model 7015 cards for testing a maximum of 2,000 DUTs.

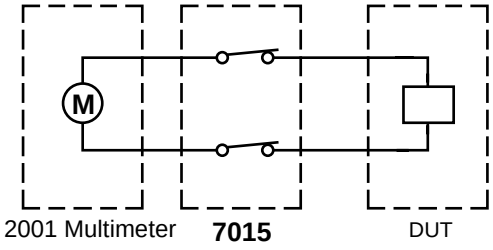
To optimize measuremernt speed using this test configuration:

- Use the trigger link.
- Operate the Model 2001 in the semi-synchronous trigger and burst modes.
- Turn break-before-make off (Model 7002 only).

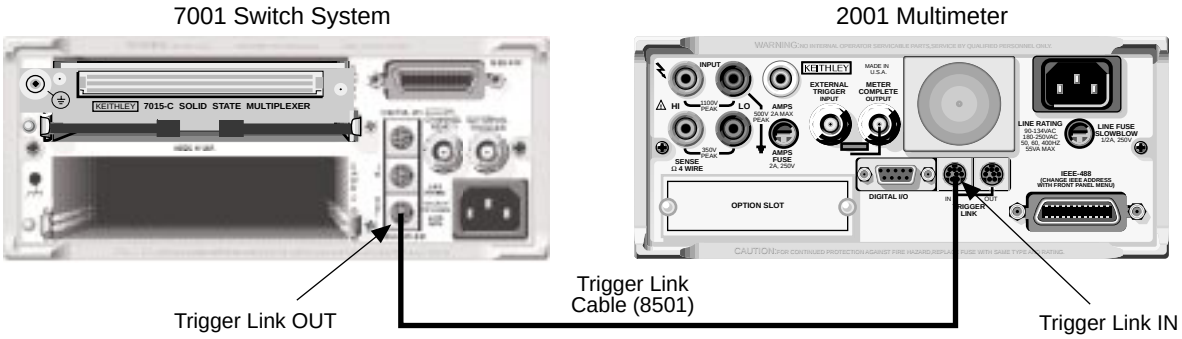
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A. Test Configuration



B. Simplified Equivalent Circuit



C. Trigger Link Connections

Figure 4-4
High-speed scanning connections

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4.4.2 Resistor testing

The Model 7015 can be used to test a number of resistors using only one test instrument or a group of instruments. Such tests include four-wire resistance measurements using a DMM, and low-resistance measurements using a separate current source and sensitive digital voltmeter.

Two-wire resistance tests

The Model 7015 should not normally be used for two-wire resistance testing because of the relatively high on resistance (<210Ω; <130Ω typical) of the solid-state relays. However, if the DUT resistance is >100kΩ, errors caused by multiplexer card path resistance can be kept to under 0.25%.

Four-wire resistance tests

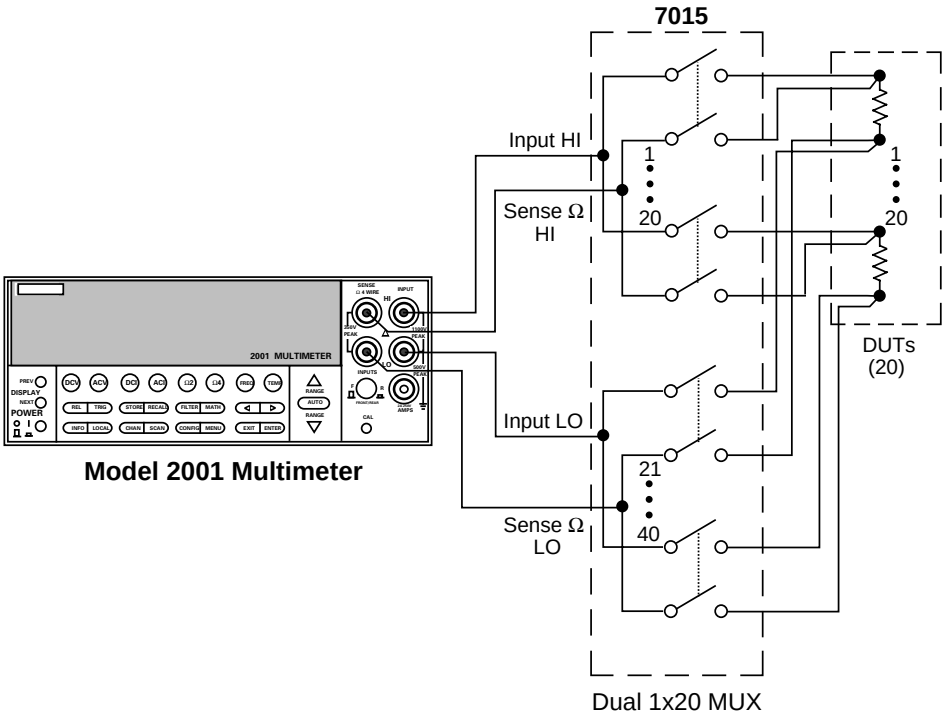
More precise measurements over a wider range of system and DUT conditions can be obtained by using the four-wire measurement scheme shown in Figure 4-5. Here, separate sense leads from the Model 2001 Multimeter are routed through the multiplexer card to the resistor under test. The extra set of sense leads minimizes the effects of voltage drops across the card relay contacts that supply the test current to the DUT. (The current through the sense leads is negligible, resulting in virtually no voltage drop across the sense lead relay contacts.) Note, however, that an extra two poles of switching per device are required for four-wire resistance measurements. For this reason, only 20 resistors per card can be tested using this configuration. Also note that the Model 2001 is limited to the 200Ω range and above because the sense lead resistance is too high for the 20Ω range.

The Model 7015 can be configured for 20 channels of 4-pole operation by isolating Banks A and B from Banks C and D, and by programming the Model 7001/7002 mainframe for the 4-pole mode. (See Section 4 of the Model 7001/7002 Instruction Manual.) Bank jumper removal is described in paragraph 3.3.1. To configure the connector card for 4-pole operation, remove only the jumpers between Banks B and C (W102 and W103). The resulting paired channels are shown in Table 4-1.

Table 4-1
Paired Channels in 4-pole Operation

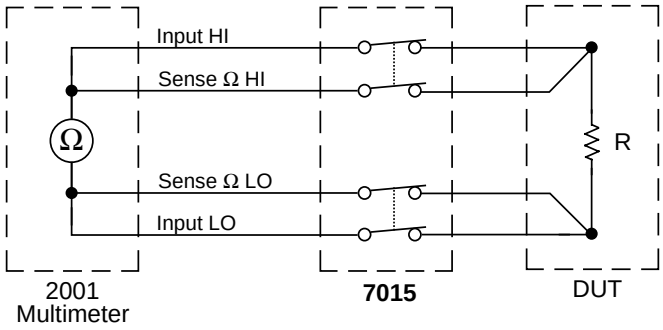
7001/7002 CHANNEL assignment	Channel pair in 4-pole	Connection designations
1	1 and 21	Bank A, In 1 and Bank C, In 1
2	2 and 22	Bank A, In 2 and Bank C, In 2
3	3 and 23	Bank A, In 3 and Bank C, In 3
4	4 and 24	Bank A, In 4 and Bank C, In 4
5	5 and 25	Bank A, In 5 and Bank C, In 5
6	6 and 26	Bank A, In 6 and Bank C, In 6
7	7 and 27	Bank A, In 7 and Bank C, In 7
8	8 and 28	Bank A, In 8 and Bank C, In 8
9	9 and 29	Bank A, In 9 and Bank C, In 9
10	10 and 30	Bank A, In 10 and Bank C, In 10
11	11 and 31	Bank B, In 1 and Bank D, In 1
12	12 and 32	Bank B, In 2 and Bank D, In 2
13	13 and 33	Bank B, In 3 and Bank D, In 3
14	14 and 34	Bank B, In 4 and Bank D, In 4
15	15 and 35	Bank B, In 5 and Bank D, In 5
16	16 and 36	Bank B, In 6 and Bank D, In 6
17	17 and 37	Bank B, In 7 and Bank D, In 7
18	18 and 38	Bank B, In 8 and Bank D, In 8
19	19 and 39	Bank B, In 9 and Bank D, In 9
20	20 and 40	Bank B, In 10 and Bank D, In 10

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Note : Jumpers between Banks B and C are removed.

A. Test Configuration



B. Simplified Equivalent Circuit

Figure 4-5
Four-wire resistance testing

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Low-level resistance measurements

Many times, it is necessary to make resistance measurements with either lower voltage sensitivity or higher currents than are available with ordinary DMMs. Examples of cases where low-level resistance measurements may be necessary include the testing of PC board traces, contacts, bus bars, and low-resistance shunts.

Figure 4-6 shows a typical test configuration for a switching system capable of testing a number of low resistance devices. The Model 220 Current Source forces current through the device under test, while the Model 182 Sensitive Digital Voltmeter measures the resulting voltage across the device.

Since low voltage levels are being measured, thermal EMF offsets generated by relay and connector contacts will have a detrimental effect on measurement accuracy unless steps are taken to avoid them. Thermal EMF effects can be virtually eliminated by taking two voltage measurements, E_1 and E_2, the first with the current, I, flowing in one direction, and the second with a current, I, of the same magnitude flowing in the opposite direction. The resistance can then be calculated as follows:

$$R = \frac{E_2 - E_1}{2I}$$

Note that simply reversing the current source polarity will result in a 2× accuracy specification change. To avoid this problem, matrix switching could be added to the test system to reverse the current. See paragraph 4.4.4.

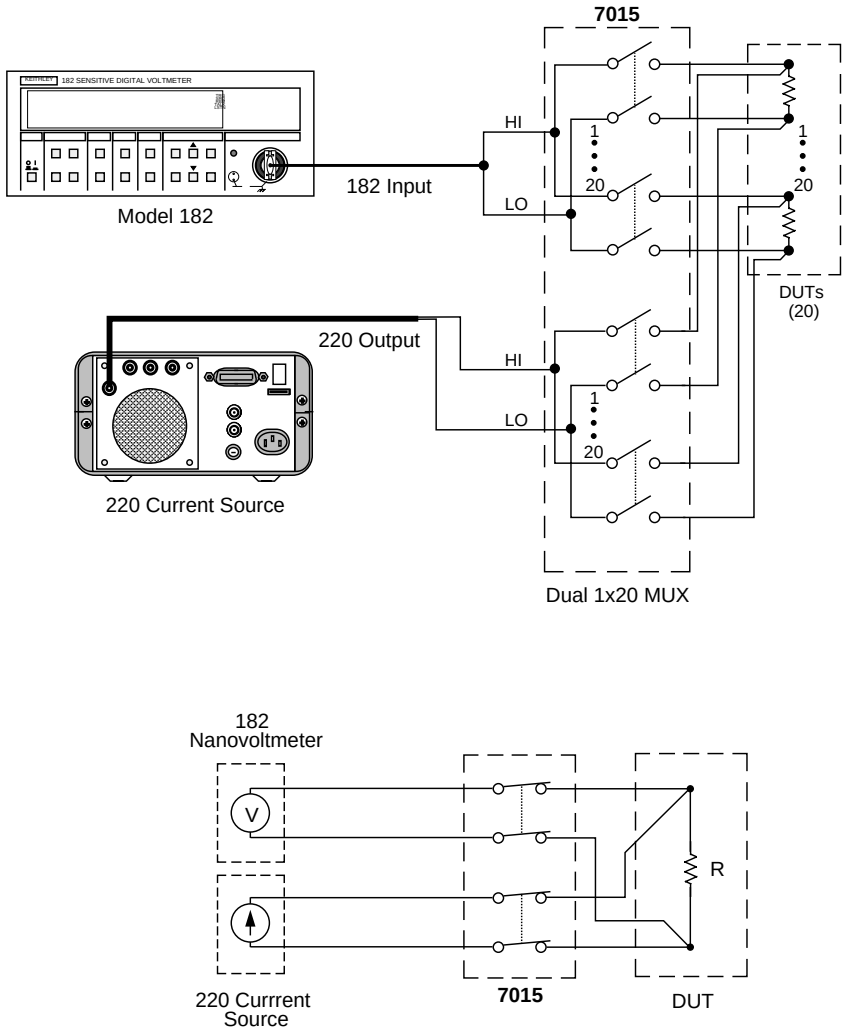


Figure 4-6
Low-resistance testing

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4.4.3 Transistor current gain testing

The DC or static common-emitter current gain of a transistor can be determined by biasing the transistor for a specific value of base current, I_B, and then measuring the collector current, I_C. The DC common-emitter current gain, β, of the transistor is then determined as follows:

$$\beta = \frac{I_C}{I_B}$$

Figure 4-7 shows the test configuration and equivalent circuit for the current gain test. The Model 224 Current Source is used to source the base current, I_B. The Model 230 Voltage Source supplies the collector-emitter voltage, V_{CE}, and the collector current, I_C, is measured by the Model 2001 Multimeter. Switching among the transistors being tested is, of course, performed by the Model 7015 multiplexer card.

In order to perform the current gain test, the voltage source is first set to the desired value of V_{CE}. The current source is then set to a base current value that will result in the desired value of I_C as measured by the DMM. The current gain can then be calculated as outlined above.

Because of the 130Ω (typical) channel resistance of the Model 7015, collector current values should be kept as small as possible to minimize voltage drops across the relay contacts. For example, a 1mA collector current will result in a nominal 0.1 to 0.2V voltage drop across the relay contacts.

4.4.4 Testing with matrix cards

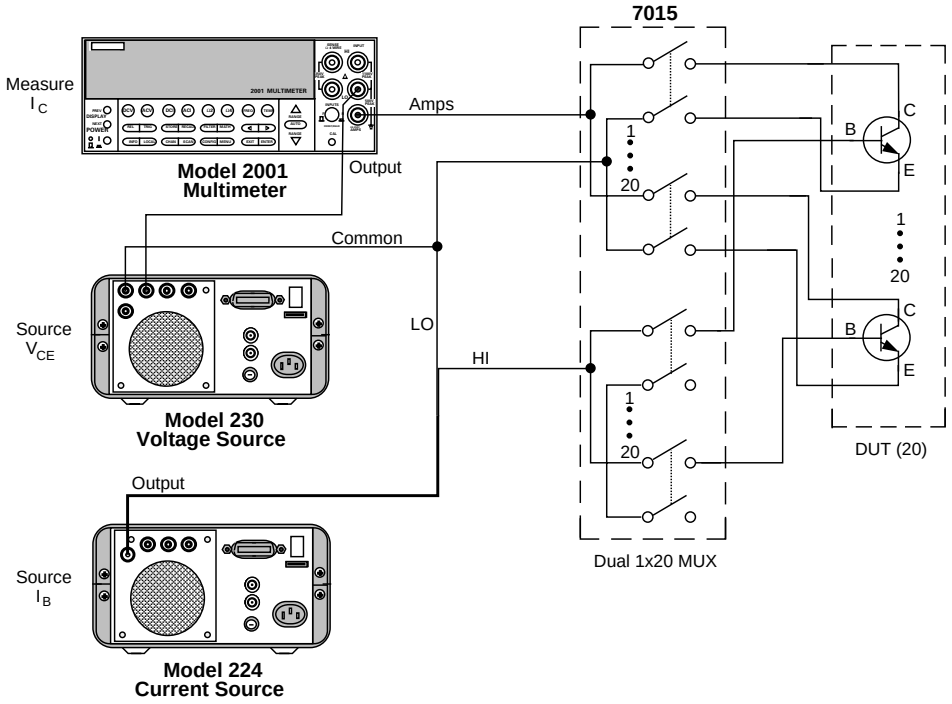
The Model 7015 can be added to a matrix switching system to enhance the test capabilities of that system. The following paragraphs discuss an overall multiplexer/matrix switching system.

Multiplexer and matrix card connections

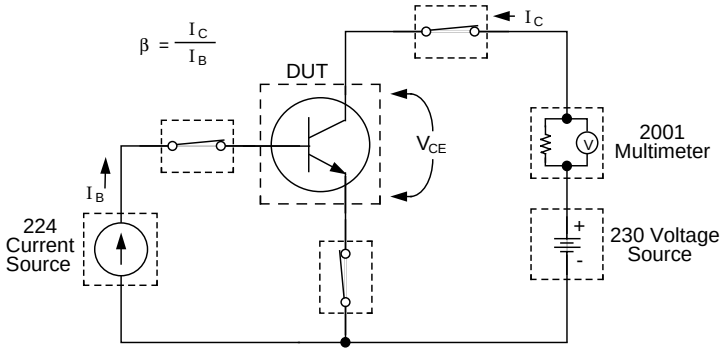
Figure 4-8 shows a typical system using Model 7012 and 7015 cards together. In this instance, the multiplexer card is configured as four 1×10 multiplexers. Note that rows of the matrix card are connected to the banks of the multiplexer card through the analog backplane of the mainframe; no external wiring is necessary to connect the two cards together.

In this application, the DUTs are connected to the bank inputs on the multiplexer card, allowing a large number of DUTs to be switched through the matrix card. Also, the instruments are connected to the columns on the matrix card. This particular configuration is best suited for applications requiring a large number of DUTs to be connected to several instruments. In other cases, the test configuration may call for a large number of instruments and few DUTs. In those situations, the instruments would be connected to the multiplexer inputs, and the DUTs would be connected to the columns.

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A. Test Configuration



B. Simplified Equivalent Circuit

Figure 4-7
Configuration for current gain test

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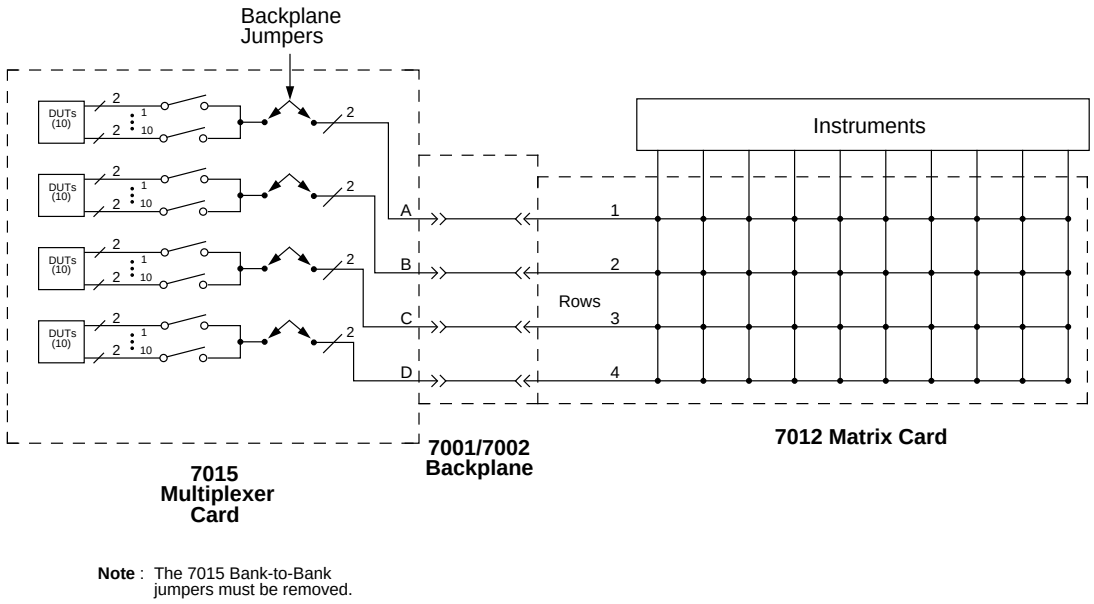


Figure 4-8
Connecting multiplexer and matrix cards together

4.5 Measurement considerations

Many measurements made with the Model 7015 are subject to various effects that can seriously affect low-level measurement accuracy. The following paragraphs discuss these effects and ways to minimize them.

4.5.1 Thermoelectric potentials

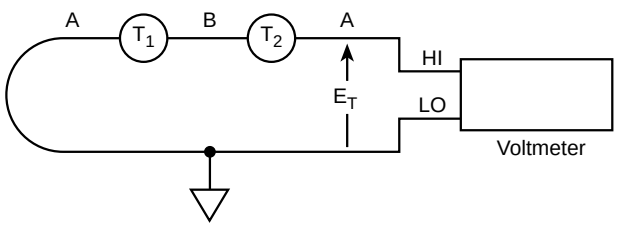
Thermoelectric potentials (thermal EMFs) are small electric potentials generated by differences in temperature at circuit connecting points such as multiplexer card terminals and connectors. Thermal EMFs can also be generated by the solid-state relays themselves.

Thermoelectric generation

Figure 4-9 shows a representation of how thermal EMFs are generated. The test leads are made of the A material, while the source under test is the B material. The temperatures between the junctions are T1 and T2.

In the unlikely event that the two junction temperatures are identical, the thermal EMFs will exactly cancel because the generated potentials oppose one another. More often, the two junction temperatures will differ, and considerable thermal EMFs will be generated.

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The thermal EMF developed by dissimilar metals A and B in a series circuit is:

$$E_T = Q_{AB} (T_1 - T_2)$$

- T_1: Temperature of the A to B junction in °C
- T_2: Temperature of the B to A junction in °C
- Q_{AB}: Thermoelectric voltage coefficient of material A with respect to B, µV/°C

Figure 4-9
Thermoelectric generation

Minimizing thermal EMFs caused by solid-state relays

Since thermal EMFs generated by the solid-state relays are largely a function of the operating temperature of those relays, thermal EMF generation can be minimized by keeping the power dissipation in relays to a minimum. (To do so, simply minimize the current flowing through the card at a given voltage.) Not only will the relays switching the power be affected, but adjacent relays on the relay card circuit board can also be affected by heating, although usually to a lesser degree. Also, minimizing on time will reduce thermal EMFs.

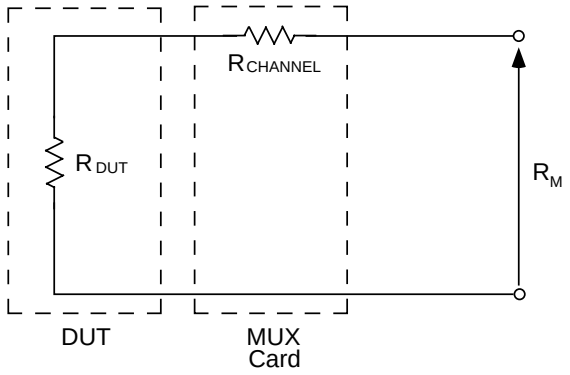
Nulling residual thermal offsets

Even if all reasonable precautions are taken, some residual thermal offsets may still be present. These offsets can be minimized by using the measuring instrument's offset-compensated ohms feature if available. Also, the zero or relative feature can be used to null them out. To do so, place the instrument on the range to be used for the measurement, and short the end of the connecting cable nearest the measured source (first disconnect the cable from the source to avoid shorting out the source). After allowing the reading to settle, press the zero or rel button to null the offset, then make your measurement as usual. Note that it may be necessary to re-zero often to counteract thermal drifts, and the rel process should be repeated whenever the range is changed for best accuracy.

4.5.2 Channel resistance

Channel resistance is the equivalent resistance between the input and output terminals of the multiplexer card. With conventional mechanical relays, the channel resistance is generally low enough to be negligible. However, the solid-state relays used in the Model 7015 have an on resistance of <210Ω (<130Ω typical), which can be a consideration in many applications.

The channel resistance of the multiplexer card is in series with the equivalent resistance of the DUT, as shown in Figure 4-10, and it adds to R_{DUT} . When measuring resistance through the card, the channel resistance can significantly affect measurement accuracy, particularly for DUT resistance values less than 100kΩ. For other types of measurements, any current that flows through the card will cause a voltage drop across $R_{CHANNEL}$, resulting in similar measurement errors.



R_{DUT} = DUT Resistance
$R_{CHANNEL}$ = Channel Resistance
R_M = Measured Resistance
$R_M = R_{DUT} + R_{CHANNEL}$

Figure 4-10
Channel resistance

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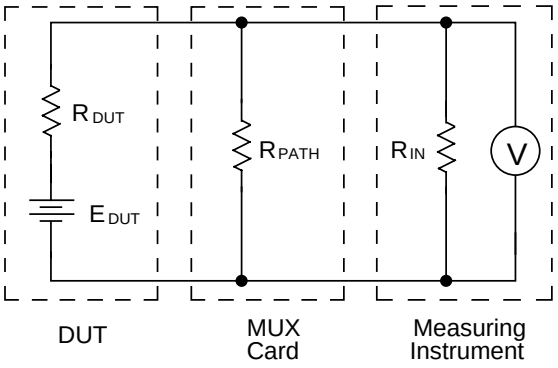
The effects of channel resistance can be minimized by following a few basic rules:

- When measuring resistance, use only the four-wire measurement technique for resistances less than 100kΩ.
- When measuring voltage, use an instrument with high input impedance.
- Whenever possible, keep the current flowing through the card to an absolute minimum.

4.5.3 Path isolation

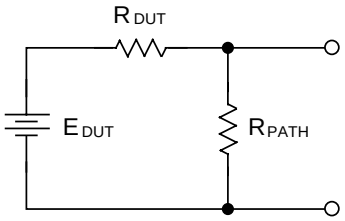
The path isolation is simply the equivalent impedance between any two test paths in a measurement system. Ideally, the path isolation should be infinite, but the actual resistance and distributed capacitance of the card, cables, and connectors results in less than infinite path isolation values for these devices.

Path isolation resistance forms a signal path that is in parallel with the equivalent resistance of the DUT, as shown in Figure 4-11. For low-to-medium device resistance values, path isolation resistance is seldom a consideration; however, it can seriously degrade measurement accuracy when testing high-impedance devices. The voltage measured across such a device, for example, can be substantially attenuated by the voltage divider action of the device source resistance and path isolation resistance, as shown in Figure 4-12. Also, leakage currents can be generated through these resistances by voltage sources in the system.



R_{DUT} = Source Resistance of DUT
E_{DUT} = Source EMF of DUT
R_{PATH} = Path Isolation Resistance
R_{IN} = Input Resistance of Measuring Instrument

Figure 4-11
Path isolation resistance



$$E_{OUT} = \frac{E_{DUT} R_{PATH}}{R_{DUT} + R_{PATH}}$$

Figure 4-12
Voltage attenuation by path isolation resistance

Any differential isolation capacitance affects DC measurement settling time as well as AC measurement accuracy. Thus, it is often important that such capacitance be kept as low as possible. Although the distributed capacitance of the multiplexer card is generally fixed by design, there is one area where you do have control over the capacitance in your system – the connecting cables. To minimize capacitance, keep all connecting cables as short as possible.

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4.5.4 Magnetic fields

When a conductor cuts through magnetic lines of force, a very small current is generated. This phenomenon will frequently cause unwanted signals to occur in the test leads of a switching system. If the conductor has sufficient length, even weak magnetic fields like those of the earth can create sufficient signals to affect low-level measurements.

Three ways to reduce these effects are: (1) reduce the lengths of the test leads, (2) minimize the exposed circuit area, and (3) keep test leads and equipment stationary. In extreme cases, magnetic shielding may be required. Special metal with high permeability at low flux densities (such as mu metal) is effective at reducing these effects.

Even when the conductor is stationary, magnetically induced signals may still be a problem. Fields can be produced by various signals such as the AC power line voltage. Large inductors such as power transformers can generate substantial magnetic fields, so care must be taken to keep the switching and measuring circuits a good distance away from these potential noise sources.

At high current levels, even a single conductor can generate significant fields. These effects can be minimized by using twisted pairs, which will cancel out most of the resulting fields.

4.5.5 Radio frequency interference

RFI (Radio Frequency Interference) is a general term used to describe electromagnetic interference over a wide range of frequencies across the spectrum. Such RFI can be particularly troublesome at low signal levels, but it can also affect measurements at high levels if the problem is of sufficient severity.

RFI can be caused by steady-state sources such as radio or TV signals, or some types of electronic equipment (microprocessors, high speed digital circuits, etc.), or it can result from impulse sources, as in the case of arcing in high-voltage environments. In either case, the effect on the measurement can be considerable if enough of the unwanted signal is present.

RFI can be minimized in several ways. The most obvious method is to keep the equipment and signal leads as far away from the RFI source as possible. Shielding the switching card, signal leads, sources, and measuring instruments will often reduce RFI to an acceptable level. In extreme cases, a specially-constructed screen room may be required to sufficiently attenuate the troublesome signal.

Many instruments incorporate internal filtering that may help to reduce RFI effects in some situations. In some cases, additional external filtering may also be required. Keep in mind, however, that filtering may have detrimental effects on the desired signal.

4.5.6 Ground loops

When two or more instruments are connected together, care must be taken to avoid unwanted signals caused by ground loops. Ground loops usually occur when sensitive instrumentation is connected to other instrumentation with more than one signal return path such as power line ground. As shown in Figure 4-13, the resulting ground loop causes current to flow through the instrument LO signal leads and then back through power line ground. This circulating current develops a small but undesirable voltage between the LO terminals of the two instruments. This voltage will be added to the source voltage, affecting the accuracy of the measurement.

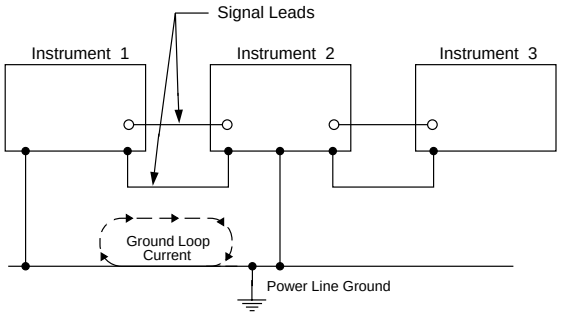


Figure 4-13
Power line ground loops

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Figure 4-14 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, only one instrument is connected to power line ground.

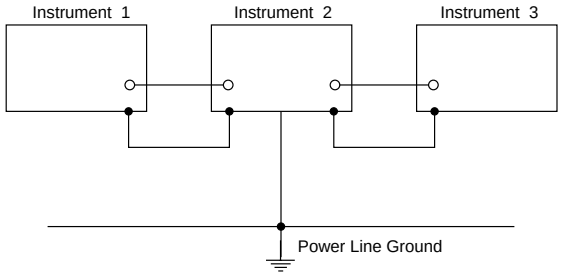


Figure 4-14
Eliminating ground loops

Ground loops are not normally a problem with instruments having isolated LO terminals. However, all instruments in the test setup may not be designed in this manner. When in doubt, consult the manual for all instrumentation in the test setup.

4.5.7 Keeping connectors clean

As is the case with any high-resistance device, the integrity of connectors can be compromised if they are not handled properly. If connector insulation becomes contaminated, the insulation resistance will be substantially reduced, affecting high-impedance measurement paths.

Oils and salts from the skin can contaminate connector insulators, reducing their resistance. Also, contaminants present in the air can be deposited on the insulator surface. To avoid these problems, never touch the connector insulating material. In addition, the multiplexer card should be used only in clean, dry environments to avoid contamination.

If the connector insulators should become contaminated, either by inadvertent touching, or from air-borne deposits, they can be cleaned with a cotton swab dipped in clean methanol. After thorough cleaning, they should be allowed to dry for several hours in a low-humidity environment before use, or they can be dried more quickly using dry nitrogen.

4.5.8 Scanning speed considerations

One key advantage of the Model 7015 is the faster switching times affordable by the solid-state relays. The following paragraphs discuss considerations for taking full advantage of this faster switching speed while scanning.

Break-before-make (Model 7002 only)

Normally, break-before-make is enabled to ensure that the presently closed channel fully opens before the subsequent channel in the scan list closes. While this feature does protect the mux card and external circuits, it also slows down the scanning speed somewhat. To maximize scanning speed, disable break-before-make operation. Note, however, that caution should be used, as simultaneous connection of two or more active sources may damage the mux card or external circuits. Break-before-make can be enabled or disabled by using the appropriate selection in the GENERAL MENU (Model 7002 only).

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5
Service Information

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.

5.1 Introduction

This section contains information necessary to service the Model 7015 multiplexer card and is arranged as follows:

5.2 Handling and cleaning precautions: Discusses handling precautions and methods to clean the card should it become contaminated.

5.3 Performance verification: Covers the procedures necessary to determine if the card meets stated specifications.

5.4 Special handling of static-sensitive devices: Reviews precautions necessary when handling static-sensitive devices.

5.5 Principles of operation: Briefly discusses circuit operation.

5.6 Troubleshooting: Presents some troubleshooting tips for the Model 7015 including relay replacement precautions.

5.2 Handling and cleaning precautions

Because of the high-impedance areas on the Model 7015, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be taken when servicing the card.

Handle the card only by the edges and shields. 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 the board if necessary.

Should it become necessary to use solder on the circuit board, use an OA-based (organic activated) flux. 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. Take care not to spread the flux to other areas of the circuit board. Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.

After cleaning, the card should be placed in a 50°C low humidity environment for several hours before use.

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5.3 Performance verification

The following paragraphs discuss performance verification procedures for the Model 7015, including path resistance, offset current, contact potential, and isolation.

With the Model 7015's backplane jumpers installed, the performance verification procedures must be performed with only one multiplexer card (the one being checked) installed in the Model 7001/7002 mainframe. These conditions do not apply if the backplane jumpers are removed.

CAUTION

Contamination will degrade the performance of the card. To avoid contamination, always grasp the card by the side edges. Do not touch the connectors, and do not touch the board surfaces or components. On plugs and receptacles, do not touch areas adjacent to the electrical contacts.

NOTE

Failure of any performance verification test may indicate that the multiplexer card is contaminated. See paragraph 5.2 for information on cleaning the card.

5.3.1 Environmental conditions

All verification measurements should be made at an ambient temperature between 18° and 28°C, and at a relative humidity of less than 70%.

5.3.2 Recommended equipment

Table 5-1 summarizes the equipment necessary for performance verification, along with an application for each unit.

Table 5-1
Verification equipment

Description	Model or number	Specifications	Applications
DMM	Keithley Model 2001	2kΩ; 50ppm	Channel resistance
Electrometer w/voltage source	Keithley Model 617	10pA, 100pA; 1.6% 100V source; 0.2%	Offset current, path isolation
Sensitive Digital Voltmeter	Keithley Model 182	3mV; 60ppm	Contact potential
Switching mainframe	Keithley Model 7001 or 7002	—	All
Triax cable (unterminated)	Keithley Model 7025	—	Offset current
Low thermal cable (unterminated)	Keithley Model 1484	—	Contact potential

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5.3.3 Multiplexer card connections

The following information summarizes methods that can be used to connect test instrumentation to the two connector cards. Detailed connection information is provided in Section 3.

Model 7015-S — Instrumentation can simply be hard-wired directly to the screw terminals of the connector card. Jumper wires should be kept as short as possible.

Model 7015-C — One method to make instrument connections to the multiplexer card is by hard-wiring a 96-pin female DIN connector then mating it to the connector on the Model 7015-C. Input and output shorting connections can also be done at the connector. The connector in the Model 7011-KIT-R connection kit (see Table 3-3) can be used for this purpose. Pin identification for the connector is provided by Figure 3-8.

CAUTION

After making solder connections to a connector, remove solder flux as explained in paragraph 5.2. Failure to clean the solder connections could result in degraded performance preventing the card from passing verification tests.

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

5.3.4 Channel resistance tests

Perform the following steps to verify that each relay is closing properly and that the channel resistance is within specification.

1. Turn off the Model 7001/7002 if it is on.
2. Turn on the Model 2001, and allow it to warm up for one hour before making measurements.
3. Connect all input terminals of Bank A together to form one common terminal, as shown in Figure 5-1.
4. Set the Model 2001 to the 2kΩ range, and connect the four test leads to the INPUT and SENSE jacks.
5. Short the four test leads together and enable REL. Leave REL enabled for the entire test.
6. Connect INPUT HI and SENSE HI of the Model 2001 to the common terminal (jumper on Bank A inputs). It is recommended that the physical connections be made at inputs 1 and 10 of Bank A, as shown in Figure 5-1.
7. Connect INPUT LO and SENSE LO to the HI (H) terminal of Bank A.
8. Install the Model 7015 in slot 1 (CARD 1) of the Model 7001/7002.
9. Turn on the Model 7001/7002, and program it to close Channel 1!1 (Bank A, Input 1). Verify that the resistance of this path is <210Ω.
10. Open Channel 1!1 and close Channel 1!2 (Bank A, Input 2). Verify that the resistance of this path is <210Ω.
11. Using the basic procedure in steps 9 and 10, check the resistance of Bank A HI (H) terminal paths for Inputs 3 through 10 (Channels 1!3 through 1!10).
12. Turn off the Model 7001/7002, and move the INPUT LO and SENSE LO test leads to the LO (L) terminal of Bank A.
13. Repeat steps 9 through 11 to check the LO (L) terminal paths of Bank A (Channels 1!1 through 1!10).
14. Repeat the basic procedure in steps 1 through 13 for Banks B through D (Channels 1!11 through 1!40).

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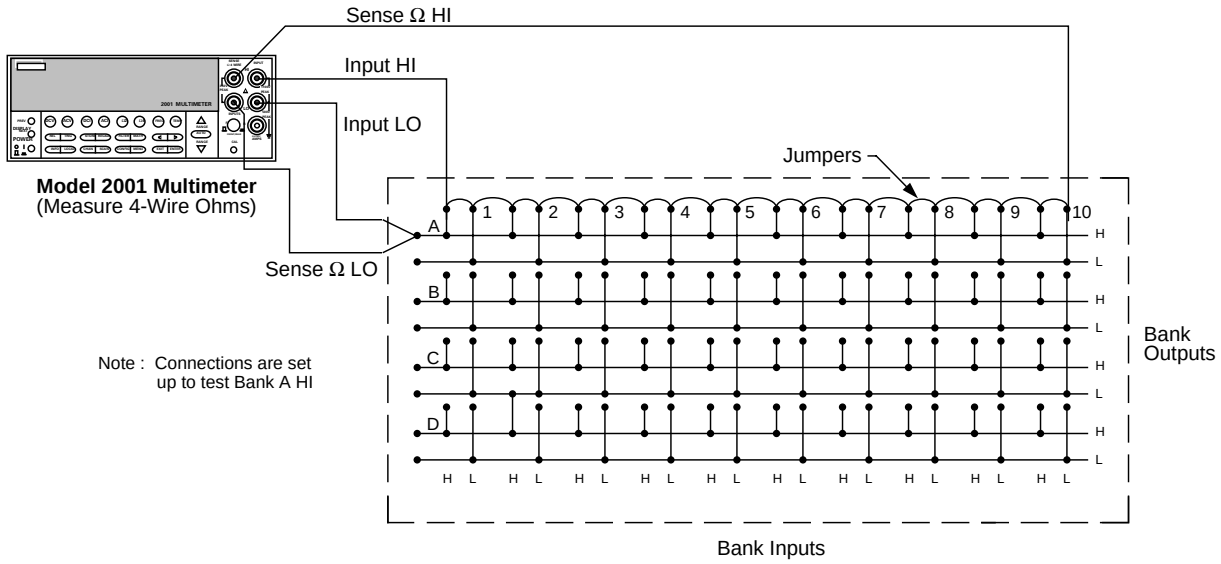


Figure 5-1
Path resistance test connections

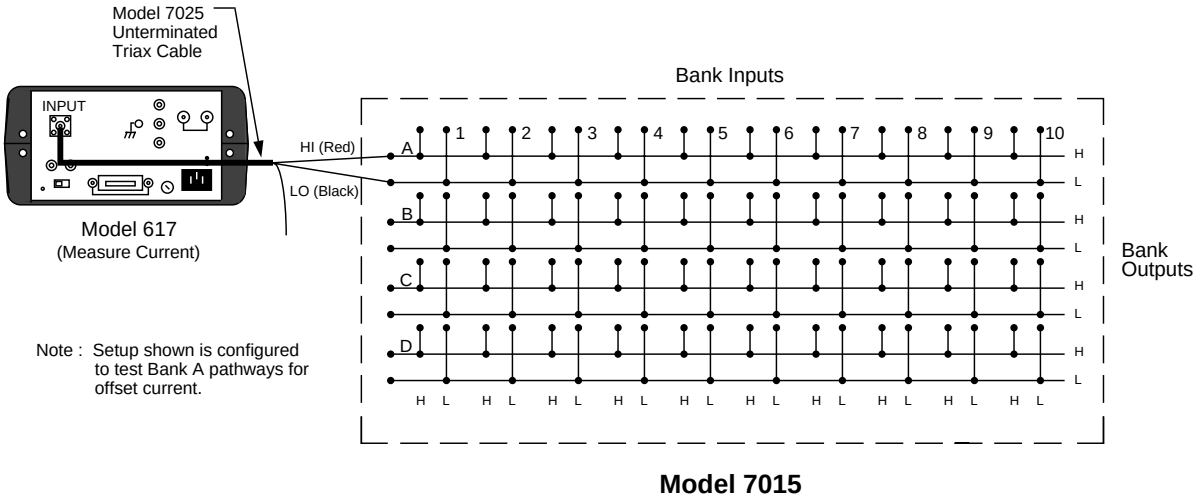
5.3.5 Offset current tests

These tests check leakage current between HI (H) and LO (L) (differential offset current) and from HI (H) and LO (L) to chassis (common-mode offset current) of each pathway. In general, these tests are performed by simply measuring the leakage current with an electrometer. In the following procedure, the Model 617 is used to measure the leakage current. Test connections are shown in Figure 5-2.

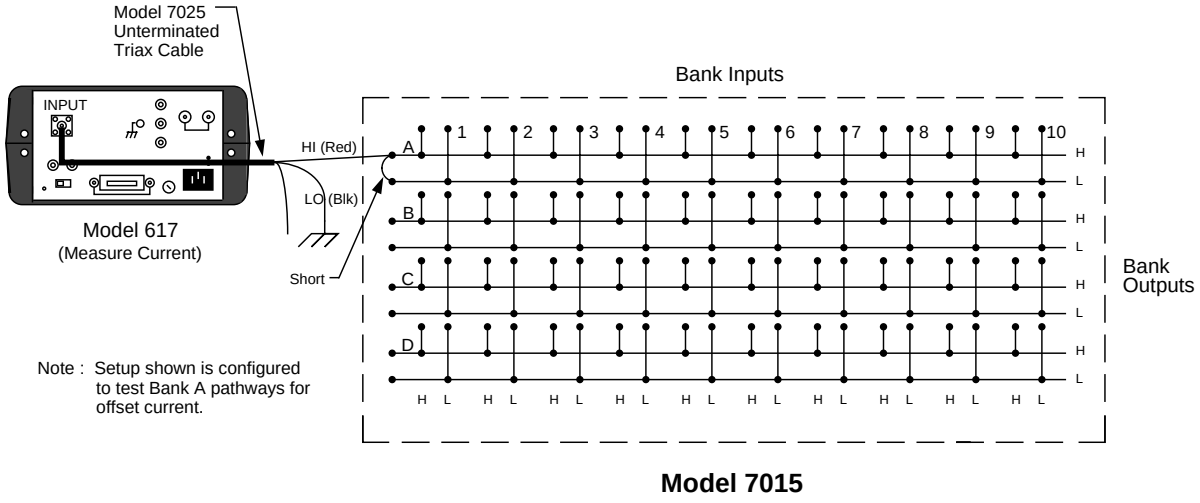
Perform the following procedure to check offset current:

1. Turn off the Model 7001/7002 if it is on, and remove any jumpers or wires connected to the multiplexer card.
2. Connect the triax cable to the Model 617, but do not connect it to the multiplexer card at this time.
3. Turn on the Model 617, and allow the unit to warm up for two hours before testing. After warm-up, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure. Also, be certain that V-Ω, GUARD is OFF and that the ground strap is connected to LO.
4. Connect the triax cable to Bank A HI and LO, as shown in Figure 5-2A.
5. Install the Model 7015 in slot 1 (CARD 1) of the Model 7001/7002.
6. Turn on the Model 7001/7002, and program the unit to close Channel 1!1 (Bank A, Input 1).
7. On the Model 617, disable zero check, and allow the reading to settle. Verify that the reading is <1nA. This specification is the offset (leakage) current of the pathway.
8. Enable zero check on the Model 617 and open Channel 1!1 from the front panel of the Model 7001/7002.
9. Repeat the basic procedure in steps 6 through 8 to check the rest of the pathways (Inputs 2 through 10) of Bank A (Channels 1!2 through 1!10).
10. Turn off the Model 7001/7002, and change the electrometer connections to Bank B.
11. Repeat the basic procedure in steps 6 through 10 to check Bank B, Inputs 1 through 10 (Channels 1!11 through 1!20).
12. Repeat the basic procedure in steps 6 through 11 for Banks C and D (Channels 1!21 through 1!40).
13. Turn off the Model 7001/7002 and change the electrometer connections, as shown in Figure 5-2B. Note that electrometer HI is connected to HI and LO of the Bank A output, which are jumpered together. Electrometer LO is connected to chassis.
14. Repeat steps 6 through 12 to check that the common mode offset current is <1nA.

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A) Differential



B) Common-Mode

Figure 5-2
Differential and common mode offset current test connections

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5.3.6 Contact potential tests

These tests check the EMF generated by each relay contact pair (H and L) for each pathway. The tests simply consist of using a sensitive digital voltmeter (Model 182) to measure the contact potential.

Perform the following procedure to check contact potential of each path:

1. Turn off the Model 7001/7002 if it is on.
2. Place jumpers between Banks A-B, B-C, and C-D.
3. Turn on the Model 182, and allow the unit to warm up to achieve rated accuracy.
4. Place a short between HI to LO on each input (Channels 1-40).
5. Place a short between HI to LO on output Bank D (long enough to cut with wire cutters).
6. Connect the Model 182 input leads to HI and LO output Bank A using copper wires.
7. Install the Model 7015 in slot 1, and turn the Model 7001/7002 on.
8. Allow Models 7001/7002, 7015 and 182 to warm up for two hours.
9. Select the 3mV range on the Model 182.
10. Press REL READING (on the Model 182) to null out internal offsets. Leave REL READING enabled for the entire procedure.
11. Turn off the Model 7001/7002. Remove the Model 7015 from slot 1. Cut the short on B and D output HI to LO.
12. Install the Model 7015 in the Model 7001/7002 slot 1, and turn power on.
13. Wait 15 minutes.
14. Program the Model 7001/7002 to close Channel 1!1.
15. After settling, verify that reading on the Model 182 is within required limits (see specifications). This measurement represents the contact potential of the pathway.
16. From the Model 7001/7002, open Channel 1!1.
17. Repeat steps 12 through 14 for all 40 channels.

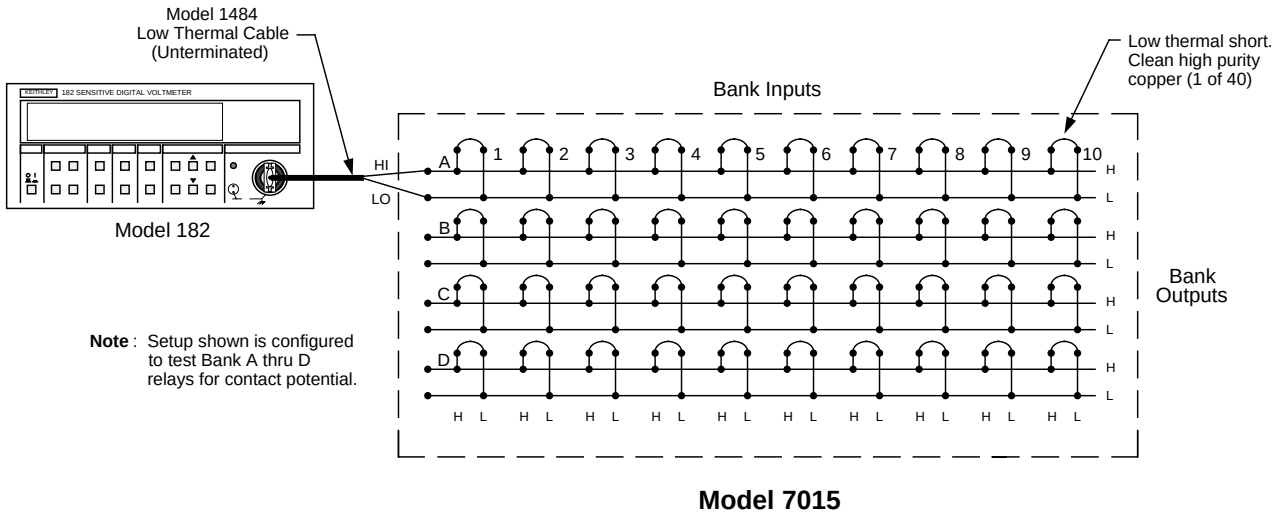


Figure 5-3
Contact potential test connections

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5.3.7 Bank and channel-to-channel isolation tests

Bank isolation tests check the leakage resistance between adjacent banks. Channel-to-channel isolation tests check the leakage resistance between a Bank Output connection and a Bank Input connection with an adjacent Bank Input relay closed. In general, the tests are performed by applying a voltage (100V) across the leakage resistance and then measuring the current. The isolation resistance is then calculated as R = V/I. In the following procedure, the Model 617 functions as both a voltage source and an ammeter. In the V/I function, the Model 617 internally calculates the resistance from the known voltage and current levels and displays the resistive value.

Perform the following steps to check bank and channel-to-channel isolation:

1. Turn off the Model 7001/7002 if it is on, and remove any jumpers or test leads connected to the multiplexer card.
2. Turn on the Model 617, and allow the unit to warm up for two hours before testing.
3. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
4. Connect the electrometer to the Model 7015, as shown in Figure 5-4.
5. Install the Model 7015 in slot 1 of the Model 7001/7002, and turn on the mainframe.
6. On the Model 617, select the 20pA range and release zero check.
7. On the Model 617, press SUPPRESS to cancel offset current, then enable zero check.

WARNING

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

8. On the Model 617, set the voltage source for +100V, and select the 20nA current range. Make sure the voltage source is in standby.
9. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.
10. Program the Model 7001/7002 to close Channels 1!1 and 1!12 (Bank A, Input 1 and Bank B, Input 2).

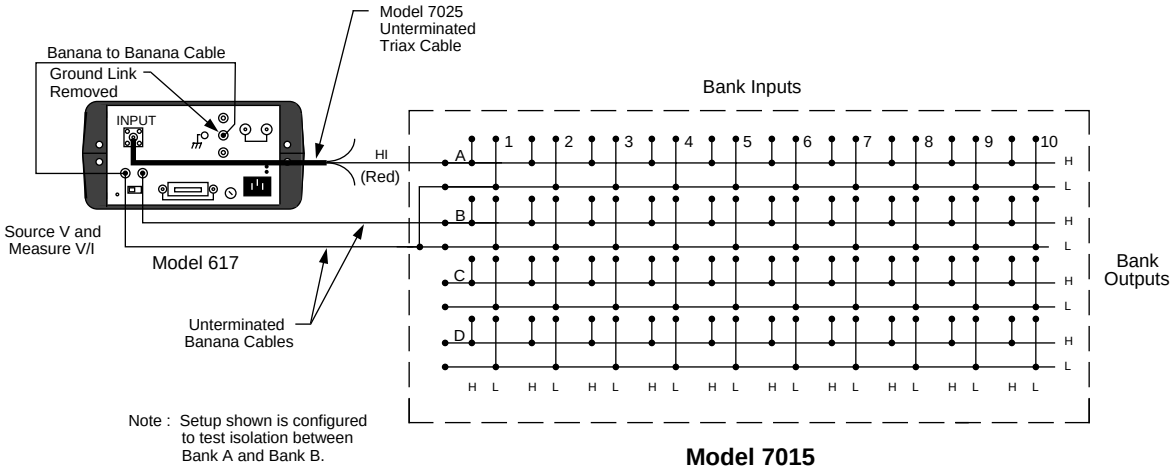


Figure 5-4
Bank isolation test connections

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11. On the Model 617, disable zero check, and press OPERATE to source +100V.
12. After allowing the reading on the Model 617 to settle, verify that it is >1GΩ (10^9Ω). This measurement is the leakage resistance (bank isolation) between Bank A, Input 1 and Bank B, Input 2.
13. Place the Model 617 voltage source in standby, and enable zero check.
14. Turn off the Model 7001/7002, and move the electrometer connections to Banks B and C.
15. Install the Model 7011 in slot 1 of the mainframe, and turn on the Model 7001.
16. Program the Model 7001/7002 to close Channels 1!12 and 1!23 (Bank B, Input 2 and Bank C, Input 3).
17. On the Model 617, disable zero check, and press OPERATE to source +100V.
18. After allowing the reading on the Model 617 to settle, verify that it is >1GΩ (10^9Ω).
19. Place the Model 617 voltage source in standby, and enable zero check.
20. Turn off the Model 7001/7002 and move the electrometer connections to Banks C and D.
21. Install the Model 7015 in slot 1 of the mainframe, and turn on the Model 7001/7002.
22. Using Table 5-2 as a guide, repeat the basic procedure of steps 16 through 18 for the rest of the path pairs (test numbers 3 through 9 in the table).
23. Place the Model 617 voltage source in standby, and enable zero check.

NOTE

Refer to the following procedure to check channel-to-channel isolation.

24. Turn off the Model 7001/7002, and connect the Model 617 to the card as shown in Figure 5-5.
25. Install the Model 7015 in slot 1 of the Model 7001/7002, and turn on the mainframe.
26. Program the Model 7001/7002 to close Channel 1!2 (Bank A, Input 2). Make sure all other channels are open.
27. On the Model 617, disable zero check, and press OPERATE to source 100V.
28. After allowing the reading on the Model 617 to settle, verify that it is >1GΩ (10^9Ω).
29. Place the Model 617 voltage source in standby, and enable zero check.
30. Using Table 5-3 as a guide, perform tests 2 through 9 for the remaining Bank A Inputs. Remember to move Bank Input connections as indicated in the table.
31. Use Table 5-3 (test numbers 10 through 36) and the above procedure to test Banks B, C, and D.

Table 5-2
Bank isolation test summary

Test number	Bank isolation	Test equipment location	Channels closed*
1	Bank A, Input 1 to Bank B, Input 2	Bank A and Bank B	1!1 and 1!12
2	Bank B, Input 2 to Bank C, Input 3	Bank B and Bank C	1!12 and 1!23
3	Bank C, Input 3 to Bank D, Input 4	Bank C and Bank D	1!23 and 1!34
4	Bank C, Input 4 to Bank D, Input 5	Bank C and Bank D	1!24 and 1!35
5	Bank C, Input 5 to Bank D, Input 6	Bank C and Bank D	1!25 and 1!36
6	Bank C, Input 6 to Bank D, Input 7	Bank C and Bank D	1!26 and 1!37
7	Bank C, Input 7 to Bank D, Input 8	Bank C and Bank D	1!27 and 1!38
8	Bank C, Input 8 to Bank D, Input 9	Bank C and Bank D	1!28 and 1!39
9	Bank C, Input 9 to Bank D, Input 10	Bank C and Bank D	1!29 and 1!40

*Assumes Model 7015 installed in slot 1 of mainframe. Programmed as slot (1) and channel.

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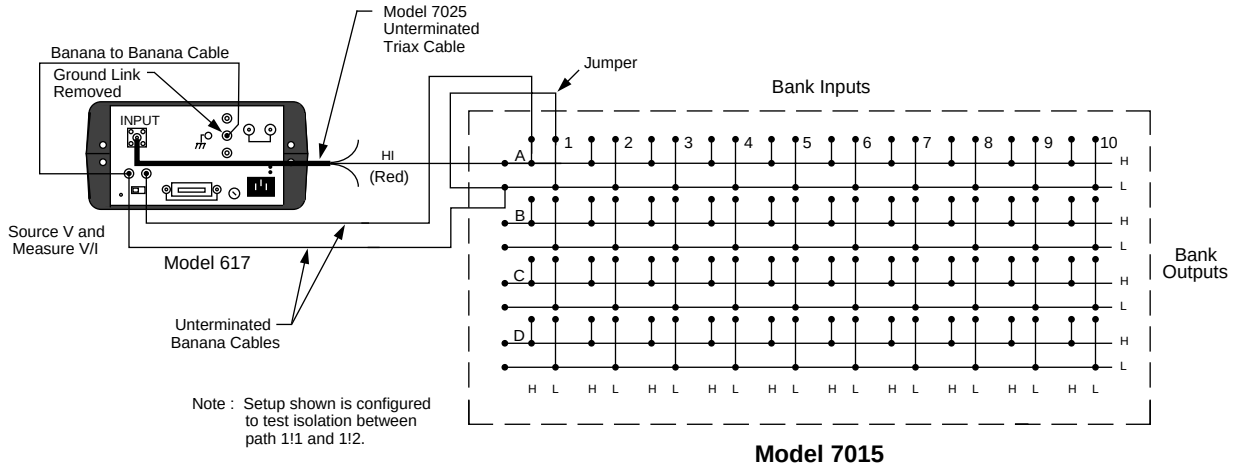


Figure 5-5
Channel-to-channel isolation test connections

Table 5-3
Channel-to-channel isolation test summary

Test number	Channel-to-channel isolation	Test equipment location	Channel closed*
1	Bank A, Input 1 to Bank A, Input 2	Bank A and Input 1	1!2
2	Bank A, Input 2 to Bank A, Input 3	Bank A and Input 2	1!3
3	Bank A, Input 3 to Bank A, Input 4	Bank A and Input 3	1!4
4	Bank A, Input 4 to Bank A, Input 5	Bank A and Input 4	1!5
5	Bank A, Input 5 to Bank A, Input 6	Bank A and Input 5	1!6
6	Bank A, Input 6 to Bank A, Input 7	Bank A and Input 6	1!7
7	Bank A, Input 7 to Bank A, Input 8	Bank A and Input 7	1!8
8	Bank A, Input 8 to Bank A, Input 9	Bank A and Input 8	1!9
9	Bank A, Input 9 to Bank A, Input 10	Bank A and Input 9	1!10

*Assumes Model 7015 installed in slot 1 of mainframe. Programmed as slot (1) and channel.

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Table 5-3 (continued)
Channel-to-channel isolation test summary

Test number	Channel-to-channel isolation	Test equipment location	Channel closed*
10	Bank B, Input 1 to Bank B, Input 2	Bank B and Input 1	1!12
11	Bank B, Input 2 to Bank B, Input 3	Bank B and Input 2	1!13
12	Bank B, Input 3 to Bank B, Input 4	Bank B and Input 3	1!14
13	Bank B, Input 4 to Bank B, Input 5	Bank B and Input 4	1!15
14	Bank B, Input 5 to Bank B, Input 6	Bank B and Input 5	1!16
15	Bank B, Input 6 to Bank B, Input 7	Bank B and Input 6	1!17
16	Bank B, Input 7 to Bank B, Input 8	Bank B and Input 7	1!18
17	Bank B, Input 8 to Bank B, Input 9	Bank B and Input 8	1!19
18	Bank B, Input 9 to Bank B, Input 10	Bank B and Input 9	1!20
19	Bank C, Input 1 to Bank C, Input 2	Bank C and Input 1	1!22
20	Bank C, Input 2 to Bank C, Input 3	Bank C and Input 2	1!23
21	Bank C, Input 3 to Bank C, Input 4	Bank C and Input 3	1!24
22	Bank C, Input 4 to Bank C, Input 5	Bank C and Input 4	1!25
23	Bank C, Input 5 to Bank C, Input 6	Bank C and Input 5	1!26
24	Bank C, Input 6 to Bank C, Input 7	Bank C and Input 6	1!27
25	Bank C, Input 7 to Bank C, Input 8	Bank C and Input 7	1!28
26	Bank C, Input 8 to Bank C, Input 9	Bank C and Input 8	1!29
27	Bank C, Input 9 to Bank C, Input 10	Bank C and Input 9	1!30
28	Bank D, Input 1 to Bank D, Input 2	Bank D and Input 1	1!32
29	Bank D, Input 2 to Bank D, Input 3	Bank D and Input 2	1!33
30	Bank D, Input 3 to Bank D, Input 4	Bank D and Input 3	1!34
31	Bank D, Input 4 to Bank D, Input 5	Bank D and Input 4	1!35
32	Bank D, Input 5 to Bank D, Input 6	Bank D and Input 5	1!36
33	Bank D, Input 6 to Bank D, Input 7	Bank D and Input 6	1!37
34	Bank D, Input 7 to Bank D, Input 8	Bank D and Input 7	1!38
35	Bank D, Input 8 to Bank D, Input 9	Bank D and Input 8	1!39
36	Bank D, Input 9 to Bank D, Input 10	Bank D and Input 9	1!40

*Assumes Model 7015 installed in slot 1 of mainframe. Programmed as slot (1) and channel.

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5.3.8 Differential and common-mode isolation tests

These tests check the leakage resistance (isolation) between HI (H) and LO (L) (differential), and from HI (H) and LO (L) to chassis (common-mode) of every bank and channel. In general, the test is performed by applying a voltage (100V) across the terminals and then measuring the leakage current. The isolation resistance is then calculated as R = V/I. In the following procedure, the Model 617 functions as a voltage source and an ammeter. In the V/I function, the Model 617 internally calculates the resistance from the known voltage and current levels, and displays the resistance value.

Perform the following steps to check differential and common mode isolation:

1. Turn off the Model 7001/7002 if it is on, and remove any jumpers and test leads connected to the multiplexer card.
2. Turn on the Model 617, and allow the unit to warm up for two hours for rated accuracy.
3. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.

WARNING

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

4. On the Model 617, set the voltage source for +100V, and select the 200nA current range. Make sure the voltage source is still in standby.
5. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.
6. With the Model 617 in standby, connect the electrometer to Bank A of the multiplexer card, as shown in Figure 5-6.
7. Install the Model 7015 in slot 1 (CARD 1) of the mainframe, and turn on the Model 7001/7002.
8. Make sure all the relays are open. (Press OPEN ALL on the Model 7001/7002.)
9. On the Model 617, disable zero check, and press OPERATE to source 100V.
10. After allowing the reading on the Model 617 to settle, verify that it is >1GΩ (10^9Ω). This measurement is the differential leakage resistance (isolation) of Bank A.
11. Place the Model 617 in standby, and enable zero check.

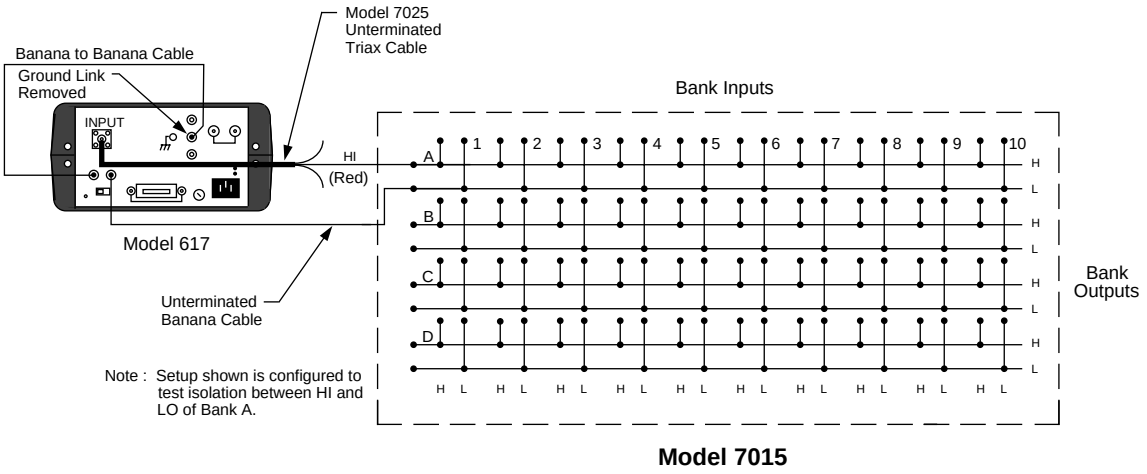


Figure 5-6
Differential isolation test connections

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12. Program the Model 7001/7002 to close Channel 1!1 (Bank A, Input 1).
13. On the Model 617, disable zero check, and press OPERATE to source +100V.
14. After allowing the reading on the Model 617 to settle, verify that it is also >1GΩ (10^9Ω). This measurement checks the differential isolation of Input 1.
15. Using Table 5-4 as a guide, repeat the basic procedure in steps 11 through 14 to test Inputs 2 through 10 of Bank A (test numbers 3 through 11 of the table).
16. Use Table 5-4 (test numbers 12 through 42) and the above procedure to test Banks B, C and D.
17. Place the Model 617 voltage source in standby, and enable zero check.

NOTE

Refer to Figure 5-7 for the following procedure to check common mode isolation.

18. Turn off the Model 7001/7002, and connect the electrometer to the Model 7015 as shown in Figure 5-7.
19. Repeat steps 4 through 16 to check common mode isolation. Verify that each reading is >1GΩ (10^9Ω).

Table 5-4
Differential and common-mode isolation testing

Test number	Differential or common mode isolation	Channel closed*
1	Bank A	None
2	Bank A, Input 1	1!1
3	Bank A, Input 2	1!2
4	Bank A, Input 3	1!3
5	Bank A, Input 4	1!4
6	Bank A, Input 5	1!5
7	Bank A, Input 6	1!6
8	Bank A, Input 7	1!7
9	Bank A, Input 8	1!8
10	Bank A, Input 9	1!9
11	Bank A, Input 10	1!10

Table 5-4 (continued)
Differential and common-mode isolation testing

Test number	Differential or common mode isolation	Channel closed*
12	Bank B	None
13	Bank B, Input 1	1!11
14	Bank B, Input 2	1!12
15	Bank B, Input 3	1!13
16	Bank B, Input 4	1!14
17	Bank B, Input 5	1!15
18	Bank B, Input 6	1!16
19	Bank B, Input 7	1!17
20	Bank B, Input 8	1!18
21	Bank B, Input 9	1!19
22	Bank B, Input 10	1!20
23	Bank C	None
24	Bank C, Input 1	1!21
25	Bank C, Input 2	1!22
26	Bank C, Input 3	1!23
27	Bank C, Input 4	1!24
28	Bank C, Input 5	1!25
29	Bank C, Input 6	1!26
30	Bank C, Input 7	1!27
31	Bank C, Input 8	1!28
32	Bank C, Input 9	1!29
33	Bank C, Input 10	1!30
34	Bank D	None
35	Bank D, Input 1	1!31
36	Bank D, Input 2	1!32
37	Bank D, Input 3	1!33
38	Bank D, Input 4	1!34
39	Bank D, Input 5	1!35
40	Bank D, Input 6	1!36
41	Bank D, Input 7	1!37
42	Bank D, Input 8	1!38
43	Bank D, Input 9	1!39
44	Bank D, Input 10	1!40

*Assumes Model 7015 installed in slot 1 of mainframe. Programmed as slot (1) and channel.

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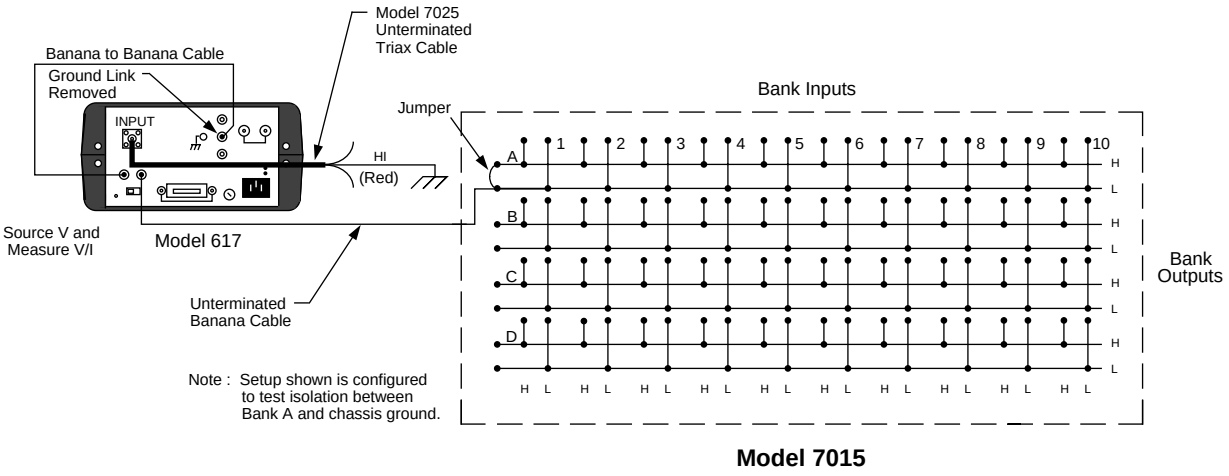


Figure 5-7
Common-mode isolation test connections

5.4 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, use the precautions listed below.

NOTE

In order to prevent damage, assume that all parts are static-sensitive.

1. 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.
2. 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.
3. Handle the devices only by the body; do not touch the pins or terminals.
4. Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.
5. Use only anti-static type de-soldering tools and grounded-tip soldering irons.

5.5 Principles of operation

The following paragraphs discuss the basic operating principles for the Model 7015, and can be used as an aid in troubleshooting the card. The schematic drawing of the card is shown on drawing number 7015-106, located at the end of Section 6.

5.5.1 Block diagram

Figure 5-8 shows a simplified block diagram of the Model 7015. Key elements include the relay drivers and solid-state relays, as well as the ROM, which contains card ID and configuration information. These various elements are discussed in the following paragraphs.

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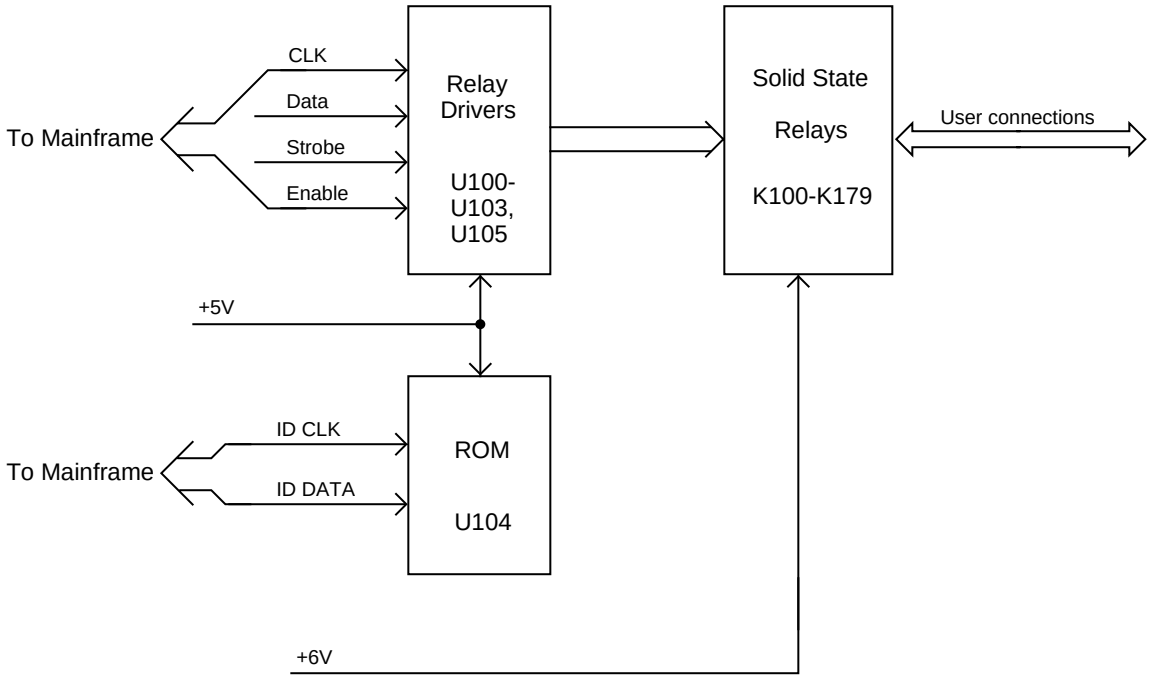


Figure 5-8
Model 7015 block diagram

5.5.2 ID data circuits

Upon power-up, card identification information from each card is read by the mainframe. This ID data includes such information as card ID, hardware settling time, and relay configuration information.

ID data is contained within an on-card EEPROM (U104). In order to read this information, the sequence described below is performed on power-up.

1. The IDDATA line (pin 6 of U104) is set from high to low while the IDCLK line (pin 5 of U104) is held high. This transition initiates a start command to the ROM to transmit data serially to the mainframe (Figure 5-9).
2. The mainframe sends the ROM address location to be read over the IDDATA line. The ROM then transmits an acknowledge signal back to the mainframe, and it then transmits data at that location back to the mainframe (Figure 5-10).
3. The mainframe then transmits an acknowledge signal, indicating that it requires more data. The ROM will then sequentially transmit data after each acknowledge signal it receives.
4. Once all data is received, the mainframe sends a stop command, which is a low-to-high transition of the IDDATA line with the IDCLK line held high (see Figure 5-9).

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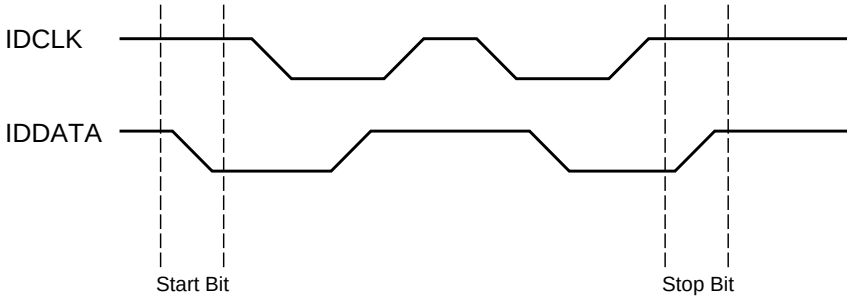


Figure 5-9
Start and stop sequences

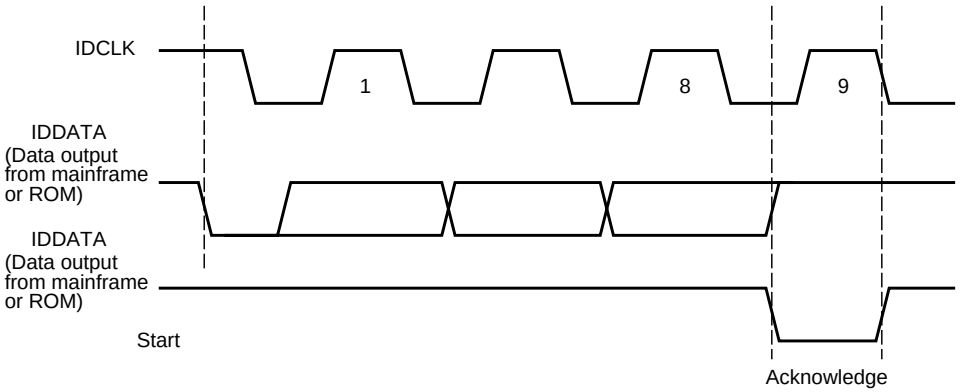


Figure 5-10
Transmit and acknowledge sequence

5.5.3 Relay control

Card relays are controlled by serial data transmitted via the relay DATA line. A total of five bytes for each card are shifted in serial fashion into latches located in the card relay driver ICs, U100-U103, U105. The serial data is clocked in by the CLK line. As data overflows one register, it is fed out the Q'S line of the register down the chain.

Once all five bytes have shifted into the card, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate relays are energized. Note that a relay driver output goes low to energize the corresponding relay.

5.5.4 Power-on safeguard

Upon power-up, the relay driver outputs are inhibited for about 200msec to avoid random engagement. The output enable (OE) signal is generated by circuitry located in the mainframe.

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5.6 Troubleshooting

5.6.1 Troubleshooting equipment

Table 5-5 summarizes recommended equipment for troubleshooting the Model 7015.

Table 5-5
Recommended troubleshooting equipment

Description	Manufacturer and model	Application
Multimeter	Keithley 2001	Measure DC voltages
Oscilloscope	TEK 2243	View logic waveforms
Switching mainframe	Keithley 7001	Control card

5.6.2 Troubleshooting access

In order to gain access to the relay card top surface to measure voltages under actual operation conditions, perform the following steps (Model 7001 only):

1. Disconnect the connector card from the relay card.
2. Remove the Model 7001 cover.
3. Install the relay card in the CARD 1 slot location.
4. Turn on Model 7001 power to measure voltages (see following paragraph).

5.6.3 Troubleshooting Procedure

Table 5-6 summarizes switch card troubleshooting.

WARNING

Lethal voltages are present within the 7001 mainframe. Some of the procedures may expose you to hazardous voltages. Observe standard safety precautions for dealing with live circuits. Failure to do so could result in personal injury or death.

CAUTION

Observe the following precautions when troubleshooting or repairing the switch card:

To avoid contamination, which could degrade card performance, always handle the card only by the handle and side edges. Do not touch edge connectors, board surfaces, or components on the card. Also, do not touch areas adjacent to electrical contacts on connectors.

Use care when removing parts from the PC board to avoid pulling traces away from the circuit board. Before attempting to remove a part, use an appropriate de-soldering tool, such as a solder sucker, to clear each mounting hole completely free of solder. Each pin must be free to move in its mounting hole before removal.

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Table 5-6
Troubleshooting procedure

Step	Item/component	Required condition	Comments
1	Ground (P2001, pins 3, 4, 15, 16)		All voltages referenced to digital ground.
2	K100-K178 even-numbered relays, pins 1 and 2	+6VDC	Relay voltage.
3	U104, pin 8	+5VDC	Logic voltage.
4	U104, pin 5	IDCLK pulses	During power-up only.
5	U104, pin 6	IDDATA pulses	During power-up only.
6	U100, pin 7	STROBE pulse	End of relay update sequence.
7	U100, pin 2	CLK pulses	During relay update sequence only.
8	U100, pin 3	DATA pulses	During relay update sequence only.
9	U100-U103, U105, pins 10-18	Low with relay energized; high with relay de-energized.	Relay driver outputs.

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6
Replaceable Parts

6.1 Introduction

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 7015.

6.2 Parts lists

Parts lists for the various circuit boards are included in tables integrated with schematic diagrams and component layout drawings for the boards. Parts are listed alphabetically in order of circuit designation.

6.3 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:

1. Card model number (7015)
2. Card serial number
3. Part description
4. Circuit description, if applicable
5. Keithley part number

6.4 Factory service

If the card is to be returned to Keithley Instruments for repair, perform the following:

1. Complete the service form at the back of this manual, and include it with the card.
2. Carefully pack the card in the original packing carton.
3. Write ATTENTION REPAIR DEPT on the shipping label.

Note: It is not necessary to return the switching mainframe with the card.

6.5 Component layouts and schematic diagrams

Component layout drawings and schematic diagrams are included on the following pages integrated with the parts lists:

7015-100 Component Layout, Solid-State Relay Card for 7015-S and 7015-C.

7015-106 Schematic, Solid-State Relay Card for 7015-S and 7015-C.

NOTE

The Models 7015-S and 7015-C use the same relay card. Only the connector cards are different.

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7015-160	Component Layout, Terminal Block Board for 7015-S.	7015-170	Component Layout, Mass Terminated Card for 7015-C.
7015-166	Schematic, Terminal Block Board for 7015-S.	7015-176	Schematic, Mass Terminated Card for 7015-C.

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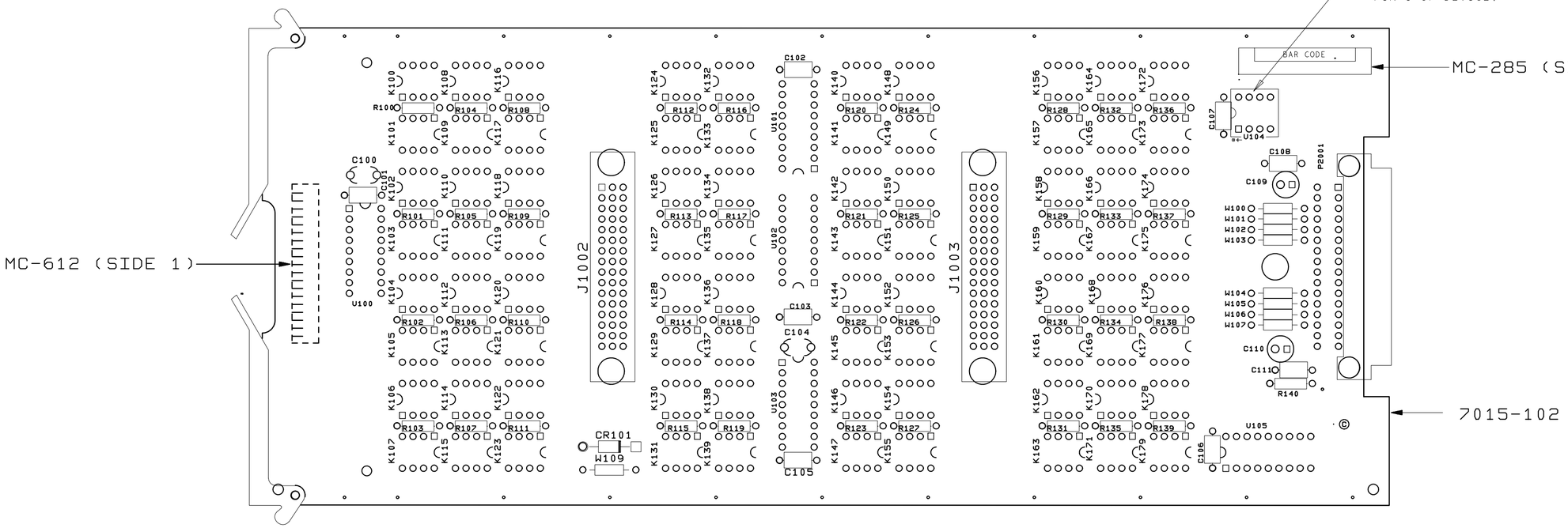
Table 6-1
Parts List, Solid-State Relay Card (Models 7015-C and 7015-S)

Circuit Desig.	Description	Keithley Part No.
	EJECTOR ARM	7011-301B
	SHIELD	7011-305B
	STANDOFF, #4-40X.812LG	ST-137-20
	STANDOFF #2 CLEARANCE	ST-204-1
C109,110	CAP, 10UF,-20+100%,25V,ALUM ELEC	C-314-10
C101,102,103,105, 106,107,108	CAP,.1UF,20%,50V,CERAMIC	C-365-.1
C100,C104	CAP,150PF,10%,1000V,CERAMIC	C-64-150P
CR101	DIODE,SILICON,IN4006 (D0-41)	RF-38
J1002,1003	CONN, 48-PIN, 3-ROWS	CS-736-2
P2001	CONNECTOR, 32-PIN, 2-ROWS	CS-775-1
R140	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R100-139	RES,2K,5%,1/4,COMPOSITION OR FILM	R-76-2K
K100-179	RELAY	RL-167
U100-103,105	IC, 8-BIT SERIAL-IN LATCH DRIVER,5841A	IC-536
U104	EPROM PROGRAM	7015-800A01
W100-107,109	JUMPER	J-15

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NO. 7015-100

LTR.	ECO NO.	REVISION	ENG.	DATE
B	930503	RELEASED	MS	5-3-93
B1	15915	ADDED MC-285 (SIDE 6).	SZ	7-29-93
B2	25917	CHG'D U104 FROM IC-737 TO TC17-100.	KK	6/19/01



NOTE: FOR COMPONENT INFORMATION,
REFER TO 7015 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.

USED ON

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 5/3/93	SCALE 5:4	TITLE COMPONENT LAYOUT, SOLID STATE RELAY CARD
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±1°	DRN. MAH	ENG. APPR. PS/MS	
	XXX=±.005 FRAC.=±1/64	MATERIAL		C NO. 7015-100
	SURFACE MAX. 63	FINISH		

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Table 6-2
Parts List,Terminal Block Board (Model 7015-S)

Circuit Desig.	Description	Keithley Part No.
	TOP CLAMP CABLE CLAMP SHIELD	7011-302B 7011-304-5C 7011-305B
J1006,1009,1012,1015 J1004,1005,1007,1008, 1010,1011	CONN, 6 PIN CONN, 8 PIN	TE-115-6 TE-115-8
P1002,1003	CONNECTOR, 48-PIN, 3 ROWS	CS-748-3
W100-105	CONN,BERG,2 PIN	CS-339-2

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Table 6-3
Parts List, Mass Terminated Card (Model 7015-C)

Circuit Desig.	Description	Keithley Part No.
	BRACKET	7011-307
	CONNECTOR SHIM	7011-309A
	SHIELD	7011-311A
	STANDOFF	ST-203-1
C101,102	CAP,1UF,20%,50V, CERAMIC	C-237-1
C103	CAP,.1UF,20%,50V,CERAMIC	C-365-.1
CR101-105	DIODE,SILICON,IN4148 (DO-35)	F-28
E101,102	FERRITE BEAD	CT-1
J1004	CONN, 96-PIN, 3 ROWS	CS-514
K101-104	RELAY, ULTRA-SMALL POLARIZED TF2E-5V	RL-149
P1002,1003	CONNECTOR, 48-PIN, 3 ROWS	CS-748-3
Q101-103	TRANS,N CHAN MOSPOW FET,2N7000 (TO-92)	TG-195
R103,104	RES, 1M, 10%, 1/2W, COMPOSITION	R-1-1M
R106	RES,10,5%,1/4W,COMPOSITION OR FILM	R-76-10
R109	RES,100K,5%,1/4W,COMPOSITION OR FILM	R-76-100K
R108,110	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R105	RES, 68, 5%, 1/4W, COMPOSITION OR FILM	R-76-68
R111	RES,10K,1%,1/8W,METAL FILM	R-88-10K
R107	RES,4.99K,1%,1/8W,METAL FILM	R-88-4.99
U101	IC,QUAD 2 INPUT NOR,74HC02	IC-412
U102	IC, DUAL, VOLTAGE COMPARATOR, LM393	IC-343
W100-105	CONN,BERG,2 PIN	CS-339-2

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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
❑ IEEE failure
❑ Front panel operational
❑ Analog output follows display
❑ Obvious problem on power-up
❑ All ranges or functions are bad
❑ Particular range or function bad; specify _____
❑ Batteries and fuses are OK
❑ Checked all cables

Display or output (check one)

❑ Drifts
❑ Unstable
❑ Overload
❑ Unable to zero
❑ Will not read applied input

❑ Calibration only
❑ Data required
❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system 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.

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KEITHLEY

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