Instruction Manual

Model 7174A

8×12 Low Current Matrix Card

Contains Operating and Servicing Information

KEITHLEY

7174A-901-01 Rev. A / 9-98

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

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Model 7174A 8×12 Low Current Matrix Card
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 7174A-901-01).. September 1998

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, 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.

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 the 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.

7174A 8×12 Low Current Matrix Card Specifications

MATRIX CONFIGURATION: Single 8 rows×12 columns. Expanding the columns can be done internally by connecting the rows of multiple 7174A cards together with coax jumpers.

CROSSPOINT CONFIGURATION: 2-pole Form A (Signal Guard).

CONNECTOR TYPE: 3-lug triax (Signal, Guard, Chassis).

MAXIMUM SIGNAL LEVEL:
Pin to Pin or Pin to Chassis: 200V. 2A carry current.

CONTACT LIFE: Cold Switching: 10^8 closures.

OFFSET CURRENT: 100fA max., 10fA typical (with 0V applied to inputs and outputs).

ISOLATION: Path (Signal to Signal): >$2\times10^{14}\Omega$, 1pF.
Common (Signal to Chassis): >$10^{14}\Omega$, <10pF.

SETTLING TIME: <2.5s to 400fA (all pathways) after 10V applied (typical).

CROSSTALK (1MHz, 50Ω Load): <–70dB.

INSERTION LOSS (1MHz, 50Ω Load): <–0.2dB typical.

3dB BANDWIDTH:
(50Ω Load, 50Ω Source): 30MHz typical.
(1MΩ Load, 50Ω Source): 40MHz typical.

RELAY DRIVE CURRENT (per crosspoint): 17mA.

RELAY SETTLING TIME: <1ms.

ENVIRONMENT:
Offset Current and Path Isolation Specifications: 23°C, <60% R.H.
Operating: 0° to 50°C, up to 35°C at 70% R.H.
Storage: –25° to +65°C.

MAXIMUM LEAKAGE:
Pin to Ground: 0.01pA/V. **Pin to Pin:** 0.005pA/V.

INSULATION RESISTANCE: $6.7\times10^{13}\Omega$ minimum.

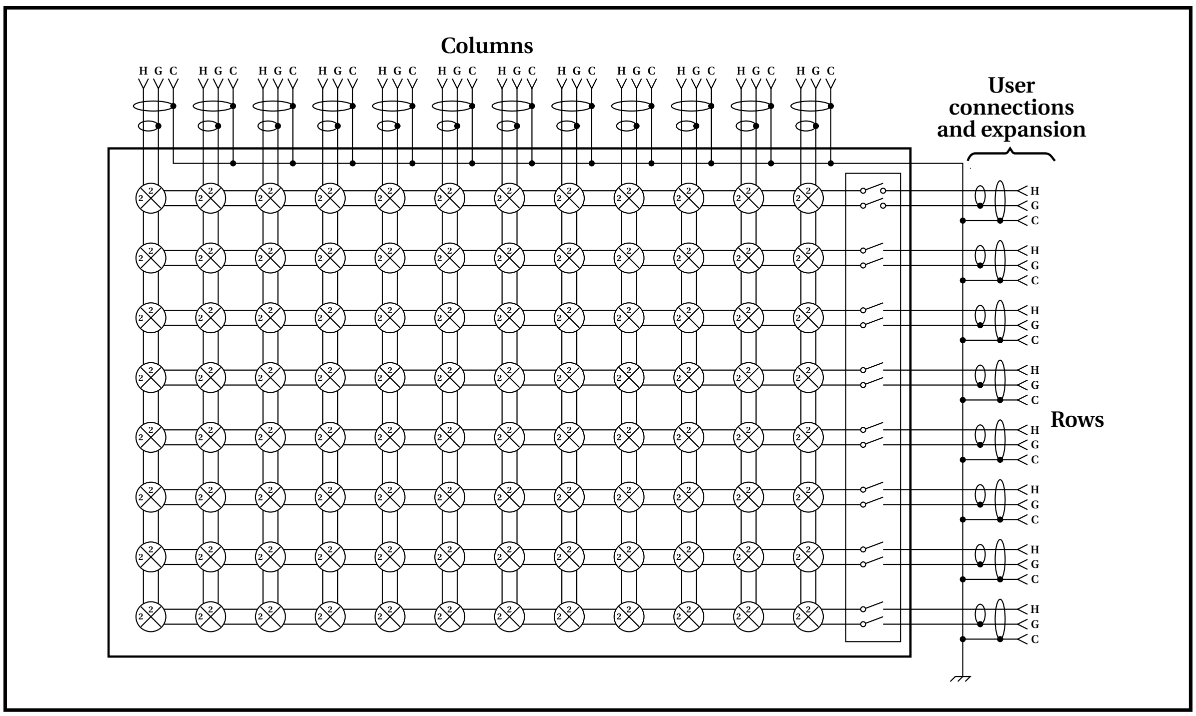
CAPACITANCE: (Guard Driven): Path to Ground: <10pF. **Path to Path:** 1pF typical.

ACCESSORY SUPPLIED: Instruction manual and eight MCX expansion cables.

ACCESSORIES AVAILABLE:

7078-TRX-TBC	3-Lug Triax to BNC Adapter
7078-TRX-T	3-Lug Triax Tee Adapter
7078-TRX-3	3-Lug Triax Cable, 0.9m (3 ft.)
7078-TRX-10	3-Lug Triax Cable, 3m (10 ft.)
7078-TBC	3-Lug Female Triax Bulkhead Connector with Cap
7078-CSHP	Cable Set to Connect 7174 to HP 4145, 4155, 4156

Specifications are subject to change without notice.



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1

General Information

1.1 Introduction

This section contains general information about the Model 7174A Low Current Matrix Card. The Model 7174A Low Current Matrix Card is designed for semiconductor research, development, and production applications that require high quality and performance switching I-V (current versus voltage) and C-V (capacitance versus voltage) signals. The model 7174A is ideal for use with Keithley Model 236 Source Measure Unit for semiconductor testing and other low current switching applications. Model 237 and Model 238 Source Measure Units can also be used below the maximum signal level (200V, 2A carry) of the Model 7174A Low Current Matrix Card (for full specifications, refer to paragraph 1.6). The Model 7174A also can be used with Models 590 and 595 C-V instruments.

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 Packing for shipment

1.9 Optional accessories

1.2 Features

Key features of the Model 7174A Low Current Matrix Card include:

- Eight row by twelve column (8×12) switching matrix configuration, with signal and guard switched at each crosspoint
- Paths have offset currents of less than 100fA with typical offset currents of 50fA
- Maximum Leakage Currents:

  Pin to Ground -- 0.01 pA/V

  Pin to Pin -- 0.005 pA/V
- 3-lug Triaxial Connectors (Signal, Guard, Chassis) for all row and columns allow guarding of each signal pathway, minimizing effects of stray capacitance, leakage current, and leakage resistance
- Model 7174A cards can be connected together internally using the supplied SMB to SMB cables (jumpers) to expand the number of columns in the matrix.

1.3 Warranty information

Warranty information is located on the inside front cover of this manual. Should your Model 7174A require warranty service, contact your Keithley representative or authorized repair facility in your area for further information.

1.4 Manual addenda

Any improvements or changes concerning the matrix card or manual will be explained in an addendum included with the unit. Be sure to note these changes and incorporate them into the manual before using or servicing the unit.

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  symbol on an instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNINGS** 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 matrix card. Such damage may invalidate the warranty.

1.6 Specifications

Model 7174A specifications may be found at the front of this manual. These specifications are exclusive of the matrix card file specifications, which are located in the Model 707A Switching Matrix manual.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

If you ordered the Model 7174A separately from a system, carefully unpack it from its shipping carton and inspect the card for any obvious signs of physical damage. Report any such damage to the shipping agent immediately. Save the original packing carton for possible future reshipment.

1.7.2 Shipment contents

The following items are included with every Model 7174A order:

- Model 7174A Low Current Matrix Card.
- Model 7174A Instruction Manual.
- Coaxial jumper cables Model CA-121A (8) for matrix expansion.
- Additional accessories as ordered.

1.7.3 Instruction manual

The Model 7174A Instruction Manual is three-hole drilled so that it can be added to the system three-ring binder. After removing the plastic wrapping, place the manual in the binder after the mainframe instruction manual. Note that a manual identification tab is included and should precede the matrix card instruction manual.

If an additional manual is required, order the manual package (Keithley part number 7174A-901-00). The manual package includes an instruction manual and any pertinent addenda.

1.8 Packing for shipment

Should it become necessary to return the Model 7174A for repair, carefully pack the card in its original packing carton or the equivalent, and include the following information:

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

1.9 Optional accessories

Cables

Model 7078-TRX-3 — A 0.9 m (3 ft.) triaxial cable terminated at both ends with 3-slot male triax connectors. This type of cable is also available in 10 ft. (Model 7078-TRX-10) and 20 ft. (Model 7078-TRX-20) lengths.

Model CA-93-1 — BNC to right angle SMB (coaxial) cable.

Model 7078-CSHP — Is a cable set containing:

Eight 10 ft. (3m) cables — Cables to connect the Model 7174A to a HP-4145 Semiconductor Parameter Analyzer.

Four BNC to triax adapters — Used with eight cables listed above

Four 3 slot triax cables— Cable set to connect the Model 7174A to Source Measurement Units

Four BNC to BNC coax cables — Adapt the measurement and source modules in the HP-4145 to the connectors of the Model 7174A.

Adapters

Model 7078-TRX-TBC — A 3-lug female triax bulkhead connector (with cap). Use this connector for custom applications and interface connections such as test fixtures.

Model 7078-TRX-T — 3-slot male to dual 3-lug female triax tee adapter.

Model 237-BAN-3 — 3-slot male triax to male banana plug.

Model 237-ALG-2 — 3-slot male triax to alligator clips.

Model 7078-TRX-BNC — 3-slot male triax to BNC adapter, connections to center and inner shell. For non-guarded applications, use Model 7078-TRX-GND.

Model 6171 — 3-slot male triax to 2-lug female triaxial adapter.

Tools

Model 9172-314 — A tool designed to remove and install internal coaxial jumpers between adjacent Model 7174A Low Current Matrix Cards.

2 Operation

2.1 Introduction

WARNING

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

This section contains information on matrix card connections, installation and matrix programming, and is arranged as follows:

2.2 Handling precautions — Discusses precautions that should be taken when handling the card to avoid contamination that could degrade performance.

2.3 Environmental considerations — Outlines environmental aspects of using the Model 7174A.

2.4 Card installation and removal — Details installation in and removal from the Model 707A Switching Matrix.

2.5 Connections — Discusses card connectors, cables and adapters, and typical connections to other instrumentation.

2.6 Matrix configuration — Discusses the switching matrix, as well as matrix expansion by connecting two or more cards together.

2.7 Measurement considerations — Reviews a number of considerations when making low-level current and capacitance measurements.

2.8 Coaxial jumper access — Provides information on jumper removal.

2.2 Handling precautions

To maintain high impedance isolation, care should be taken when handling the matrix card to avoid contamination from such foreign materials as body oils. Such contamination can substantially lower leakage resistance, degrading performance. The areas of the card that are most sensitive to contamination are those associated with Teflon® insulators. To avoid any possible contamination, always grasp the card by the handle or the card edges. Do not touch board surfaces, components, or card edge connectors.

Dirt and other particle build-up over a period of time are other possible sources of contamination. To avoid this problem, operate the mainframe and matrix card only in a clean environment. If contamination is suspected, clean the card as discussed in Section 4.

2.3 Environmental considerations

For rated performance, the card should be operated within the temperature and humidity limits given in the specifications at the front of this manual.

2.4 Card installation and removal

Before making connections, the Model 7174A should be installed within the Model 707A Switching Matrix, as summarized below. Figure 2-1 shows the installation procedure.

WARNING

Turn off the system power before installing or removing matrix cards.

NOTE

The coaxial jumpers used to expand the matrix with two or more Model 7174A cards can not be installed before card insertion; an access door on top of the mainframe allows access to the connectors after the card is installed.

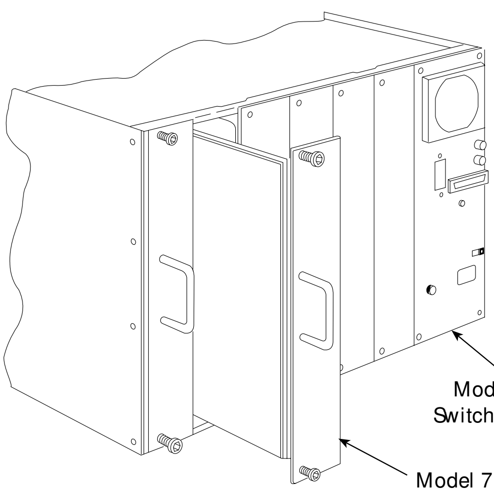


Figure 2-1
Model 7174A installation

1. Before installing the card, make sure the access door on top of the Model 707A Switching Matrix is fully closed and secured. The access door contains tracks for the card slots and must be in place to properly install the card.

CAUTION

Do not touch the card surfaces or any components to avoid contamination that could degrade card performance.

2. With one hand grasping the handle, and the other holding the bottom of the card, line up the card with the tracks in the desired slot. Make certain that the component side of the card is facing the fan on the mainframe.
3. Slide the card into the mainframe until it is properly seated in the edge connectors at the back of the slot. Once the card is properly seated, secure it to the mainframe by finger tightening the spring-loaded screws.

WARNING

The mounting screws must be secured to ensure proper chassis ground connections between the card and the mainframe. Failure to properly secure this ground connection may result in personal injury or death due to electric shock.

4. To remove a card, first turn off the system power. Disconnect all external and internal jumper cables (internal cables can be reached through the access door). Loosen the mounting screws, then pull the card out of the mainframe by the handle. When the back edge of the card clears the mainframe, support it by grasping the bottom edge near the back or back edge.

2.5 Connections

Card connectors, recommended cables and adapters, and typical connections to test instruments are discussed in the following paragraphs.

2.5.1 Card connectors

The card connectors are shown in Figure 2-2. Each pin is equipped with a 3-lug triax connector. As shown in Figure 2-3, the center conductor is signal, the inner shield is guard, and the outer shield is chassis ground.

CAUTION

Do not exceed 200V between any two pins or between any pin and chassis.

The Model 7174A has 12 columns (labeled 1 through 12) and 8 rows (labeled A through H).

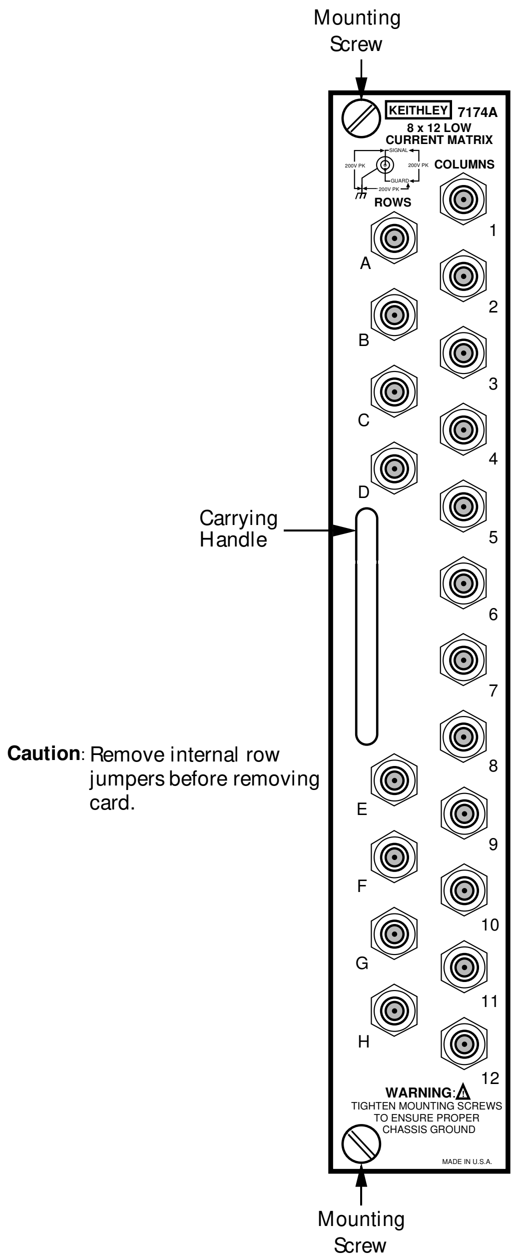


Figure 2-2
Card connectors

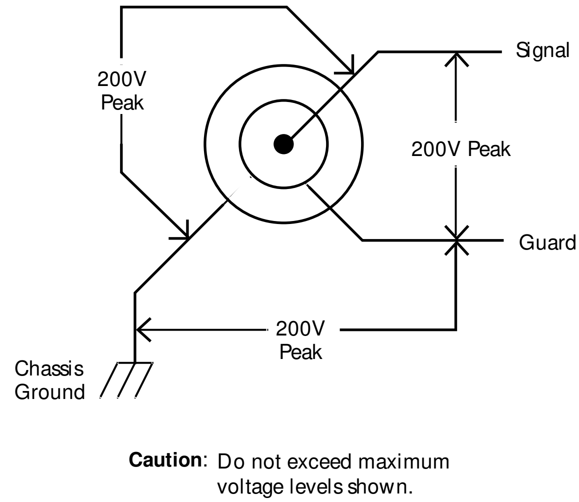


Figure 2-3
Triax connector configuration

2.5.2 Recommended cables and adapters

Table 2-1 summarizes the cables recommended for use with the Model 7174A. Equivalent user-supplied items may be substituted as long as they are of sufficient quality (low offset current, high leakage resistance). Using substandard cables and connectors may degrade the integrity of the measurements made. See paragraph 2.7 for a discussion of measurement considerations.

Table 2-1
Recommended cables and adapters

Model	Description
7078-TRX-x	3-slot male triax connectors on both ends (x=3, 10 or 20 ft.)
237-BAN-3	3-slot male triax to male banana plug
237-ALG-2	3-slot male triax to alligator clips
7078-TRX-BNC	3-slot male triax to BNC adapter, connections to center and inner shell
7078-TRX-GND	3-slot male triax to BNC adapter, connections to center and outer shell
7078-TRX-T	3-slot male to dual 3-lug female triax tee adapter
6171	3-slot male triax to 2-lug female triax adapter
CA-93-1	BNC to right angle SMB cable

2.5.3 Triax banana plug adapter

For instruments that use banana jacks, you need a triax cable terminated with a 3-slot male triax and a single banana plug. Use the Model 237-BAN-3 or prepare a special cable as outlined below (**Special triax to banana plug cable preparation**) using the parts listed in Table 2-2.

Table 2-2
Parts for special triaxial cable

Keithley part or model number	Description
7078-TRX-3 triax cable*	Triax cable terminated with 3-slot male triax connectors
BG-10-2	Red banana plug

*One connector must be cut off

Figure 2-4 shows the conductors and insulation layers of a triaxial cable. These layers must be carefully stripped back, cleaned thoroughly and insulated with high insulation resistance material such as Teflon® to maintain the integrity of the cable and measurement system. With the Model 237-BAN-3, the center conductor of the triax is connected to the banana plug. The inner and outer shields have no connection. With the special cable shown in Figure 2-4, the inner shield is shorted to the center conductor. Which cable to use depends on your application. The length of unshielded conductor that is connected to the banana plug should be minimized to maintain signal integrity. The topic of signal integrity is also discussed in paragraph 2.7 Measurement considerations.

Note that you can use either an unterminated triax cable, or cut a dual-connector cable (7078-TRX-10) in half to construct two special cables.

Special triax to banana plug cable preparation

The following steps outline a procedure for installing a banana plug on the end of a triaxial cable (with inner shield shorted to center conductor).

1. Using a knife, cut and strip back the jacket about 1-1/2 inches.
2. Remove the outer insulation, then cut away the outer shield as far as the insulation is stripped as shown in Figure 2-4(A).
3. Carefully strip away the insulation over the inner shield one inch, then cut the inner shield and guard wire off even with the stripped insulation as shown in Figure 2-4(B).
4. Strip the insulator back 1/2 inch, then twist the strands of the conductor together as shown in Figure 2-4(C).
5. Unscrew the cover from a banana plug, then slide the cover over the conductor.
6. Insert the stripped center conductor through the hole in the body of the banana plug, then wrap the wire around the plug body as shown in Figure 2-4(D).
7. Screw on the plastic cover as shown in Figure 2-4(E). Make certain the wire is secure by gently pulling on the plug.

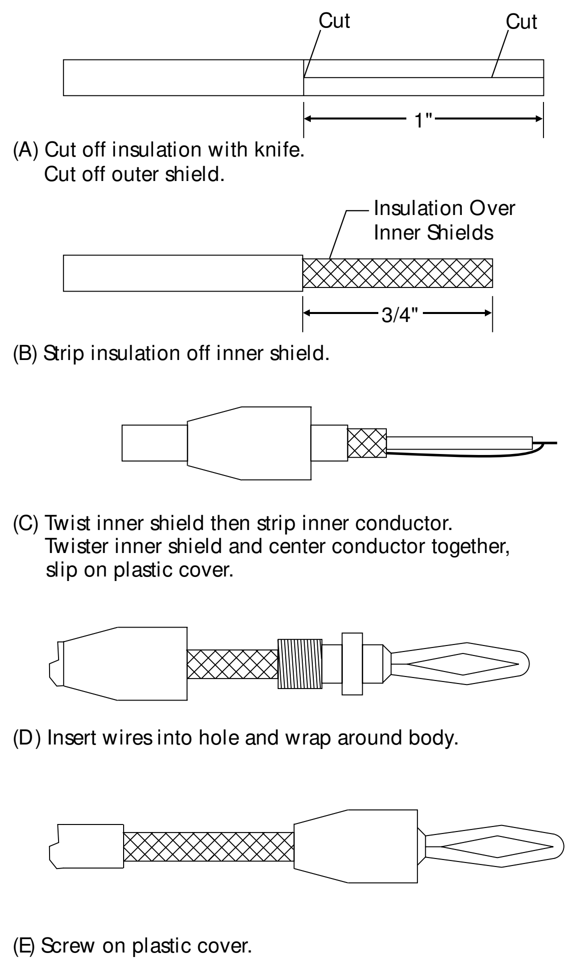


Figure 2-4
Triax cable preparation

2.5.4 General instrument connections

The following paragraphs discuss connecting the Model 7174A to various general classes of instrumentation such as DMMs, electrometers, sources, and source/measure units. Because these configurations are generic in nature, some modification of the connecting schemes may be necessary for your particular instrumentation. Also, special cables or adapters may be necessary. In all cases, 3-lug triax cables must be used to make the connections.

WARNING

Do not use coaxial cables and adapters because hazardous voltage from guard sources may be present on the cable shields.

Figure 2-5 shows the general instrument connections for the discussions below. Note that DUT guarding or shielding are not included here; see Figures 2-22 and 2-23 for shielding and guarding information. As shown, all figure assume instruments are connected to rows, and the DUT is connected to columns.

DMM connections

General DMM connections are shown in Figure 2-5 (A), (B), and (C). Floating connections are shown in (A) with LO and HI routed to two separate jacks on the Model 7174A. The common LO connections in (Figure 2-5B) should be used only for non-critical applications because the performance of the GUARD pathway is not specified.

WARNING

Hazardous voltage from other guard sources may be present on LO or the DUT if other crosspoints are closed.

4-wire DMM connections are shown in Figure 2-5(C). In this case, a total of four jacks are required; HI, LO, SENSE HI, and SENSE LO.

Electrometer connections

Typical electrometer connections are shown in Figure 2-5(D) through (G). The unguarded volts connections in (D) show the HI signal path routed through one jack, and the LO path goes through the other connector. Both GUARD pathways are connected to electrometer LO. For guarded voltage (E), Model 7174A GUARD is connected to electrometer GUARD.

The connections for electrometer fast amps and resistance measurements are shown in Figure 2-5(F) and (G). These configurations are essentially the same as those discussed above. For the case of fast amps, both GUARD paths are connected to electrometer LO, while in the case of guarded resistance, one GUARD path is connected to electrometer GUARD, and the other GUARD path is connected to electrometer LO.

Source connections

Voltage and current source connections are shown in Figure 2-5(H) through (J). The HI and LO paths of the voltage source (H) are routed through two jacks, with both card GUARD pathways connected to voltage source LO. For the unguarded current source connections (I), card GUARD is again connected to source LO, with source HI and LO routed through two pathways. In the case of the guarded current source in (J), card GUARD of the HI signal path is connected to source GUARD, and the other GUARD path is connected to source LO.

Source/measure unit connections

Figure 2-5(K) shows typical connections for a source/measure unit (SMU). In this instance, a remote-sensing type of a SMU is shown, requiring a total of four signal pathways to the DUT. For critical measurements, both source and sense HI pathways would be guarded as shown, with two of the four card GUARD pathways connected to SMU GUARD terminals. As with other instrument connections, the LO card GUARD pathways are connected to SMU LO terminals.

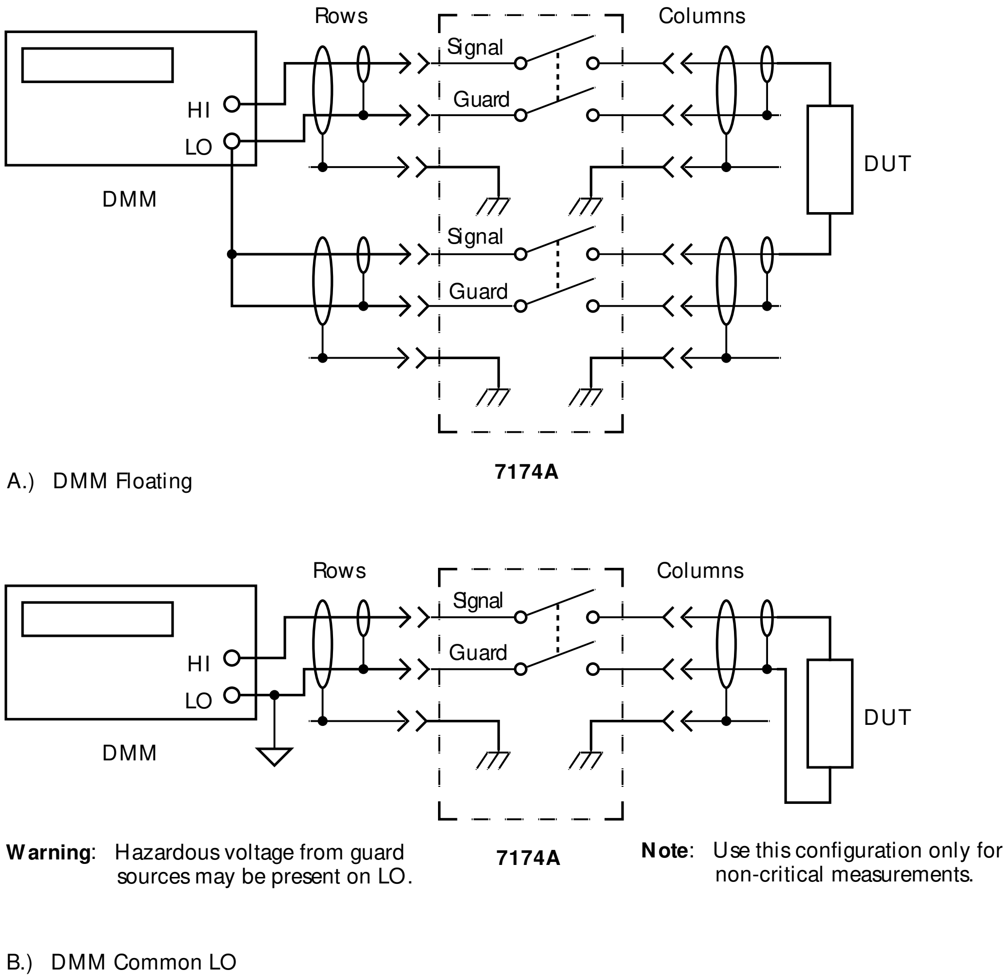
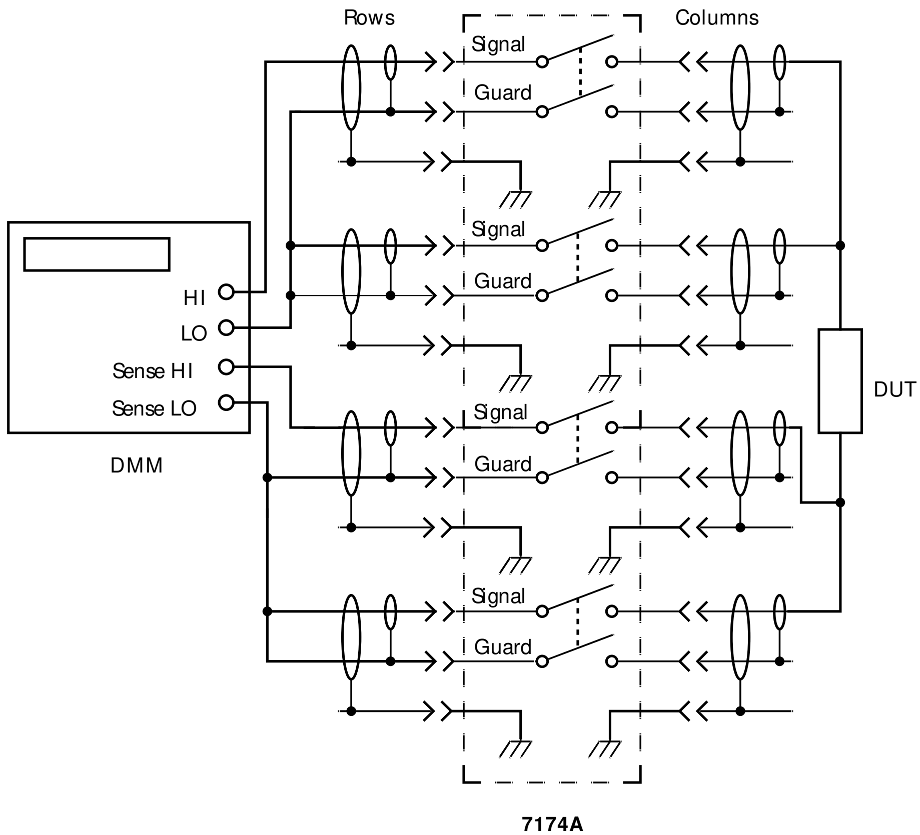
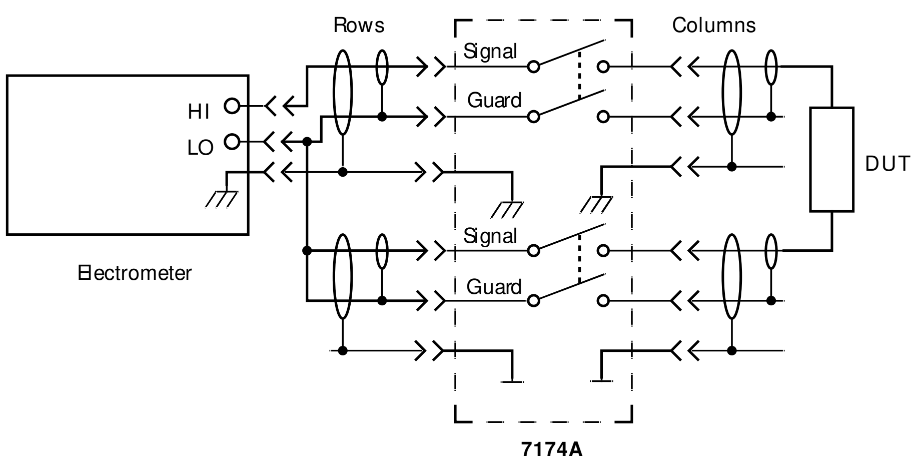


Figure 2-5
General instrument connections

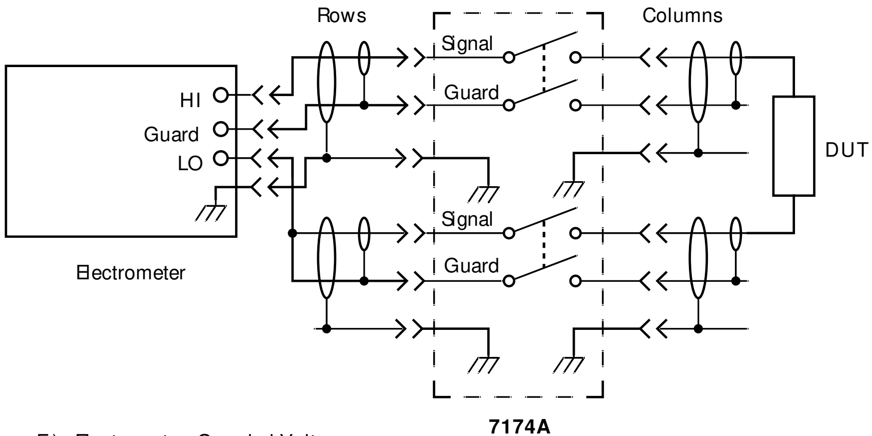


C.) DMM 4-Wire

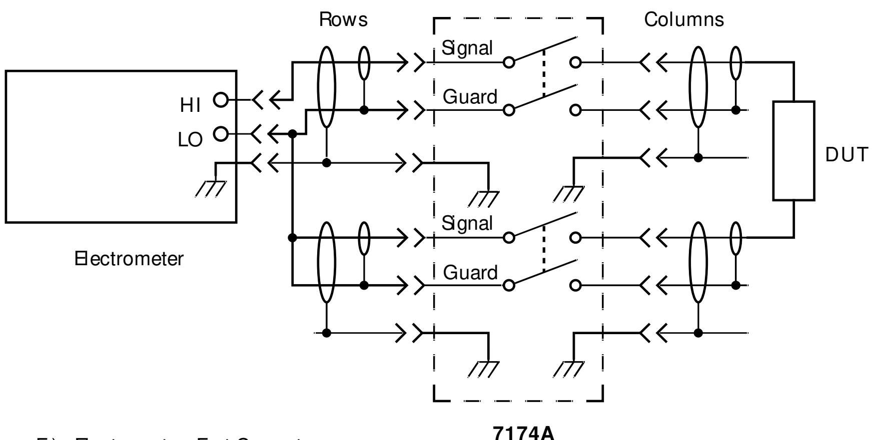


D.) Electrometer, Unguarded Volts

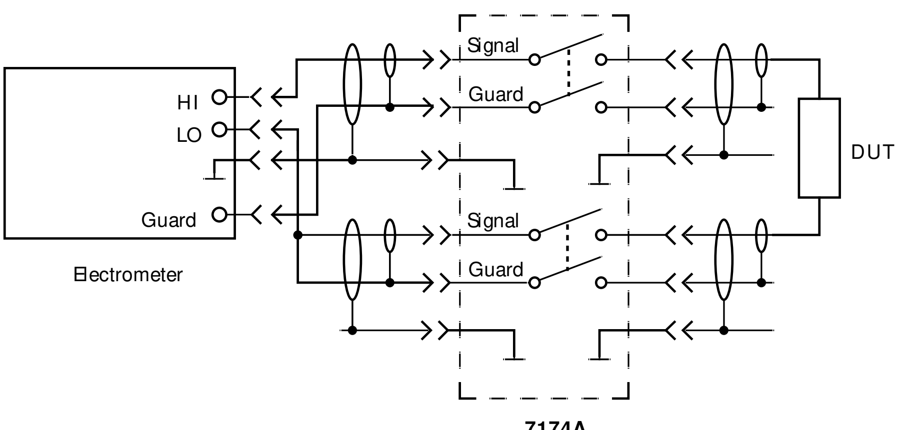
Figure 2-5
General instrument connections (cont.)



E.) Electrometer, Guarded Volts



F.) Electrometer, Fast Current



G.) Electrometer, Resistance (Guarded)

Figure 2-5
General instrument connections (cont.)

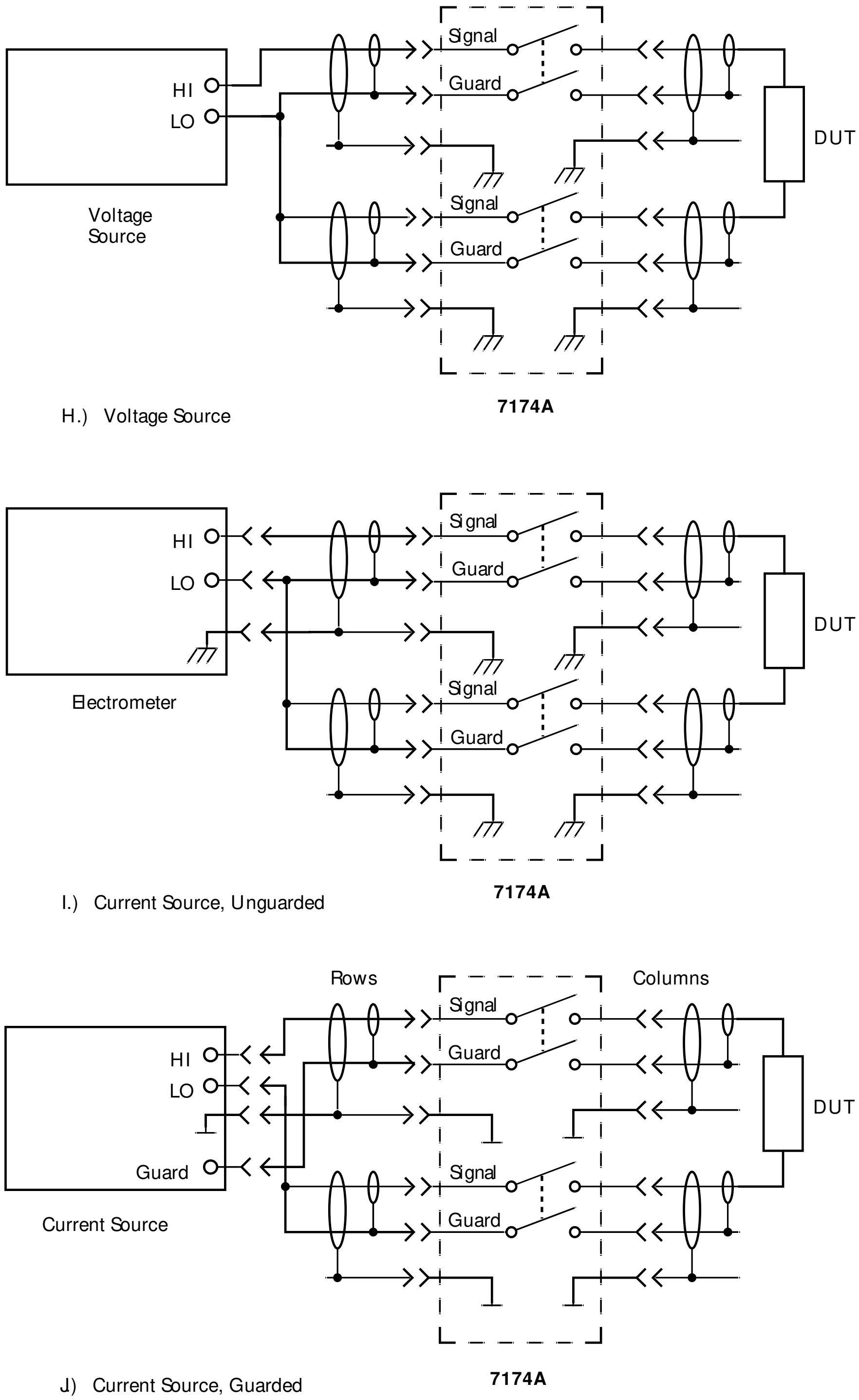
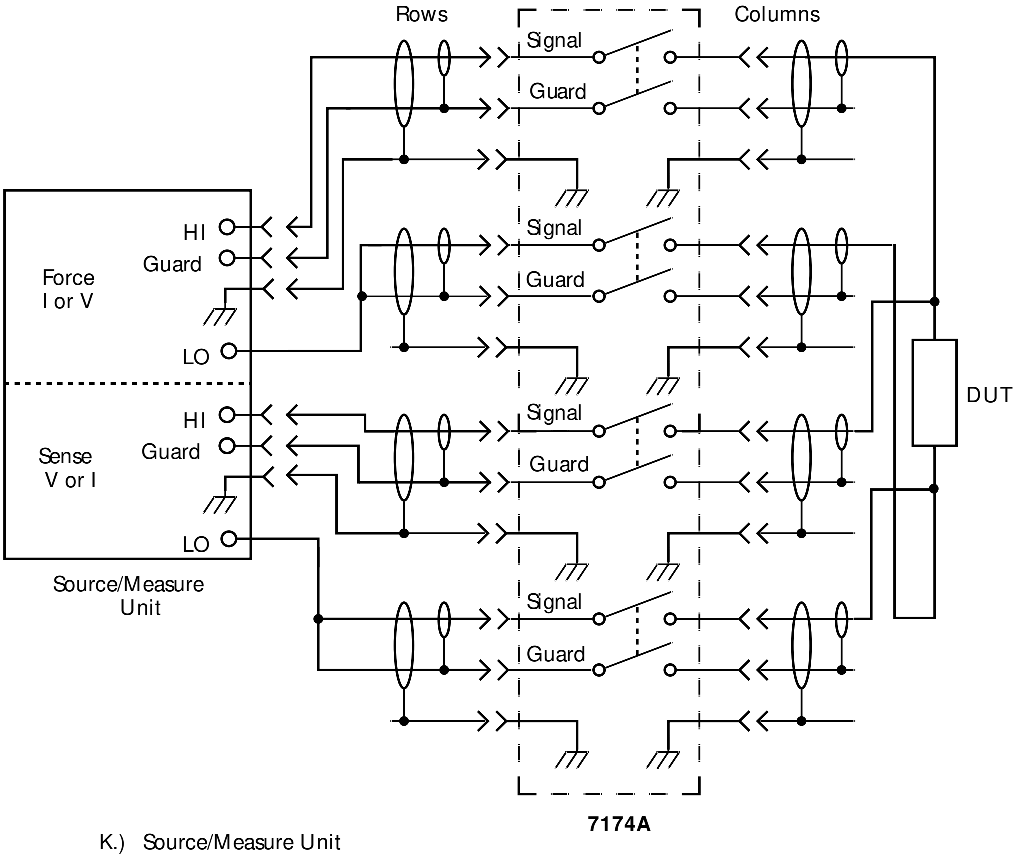


Figure 2-5
General instrument connections (cont.)



Note: DUT shielding/guarding not shown. See Figures 2-20 and 2-21.

Figure 2-5
General instrument connections (cont.)

2.5.5 Keithley instrument connections

The following paragraphs outline connecting typical Keithley instruments to the Model 7174A 8 × 12 Low Current Matrix Card. Other similar instruments can be connected using the same cabling as long as their input/output configurations are the same. Instrument connections covered include:

- Model 617 Electrometer/Source
- Model 196 DMM
- Model 230 Programmable Voltage Source
- Model 220 Programmable Current Source
- Model 590 CV Analyzer
- Model 236/237/238 Source Measure Unit

Model 617 electrometer connections

Connections for the Model 617 Electrometer are shown in Figure 2-6. The electrometer INPUT and COM can be connected to any row. Figure 2-6 shows connections to rows A and B.

1. Connect one end of a Model 7078-TRX- (3, 10, or 20) 3-lug triaxial cable to row A of the Model 7174A.
2. Connect the other end of the triax cable to the Model 617 INPUT connector using a Model 6172 adapter.
3. Connect the triax end of a triax/banana cable to row B of the Model 7174A.
4. Connect the banana plug end of the triax/banana cable to the COM terminal of the Model 617. The shorting link between COM and chassis ground should be removed for this application.
5. Place the GUARD switch in the OFF position.
6. To connect the voltage source to the Model 7174A, connect the V-SOURCE HI and LO connector of the Model 617 to the desired row connectors on the matrix card. Figure 2-6 shows connections to rows C and D.

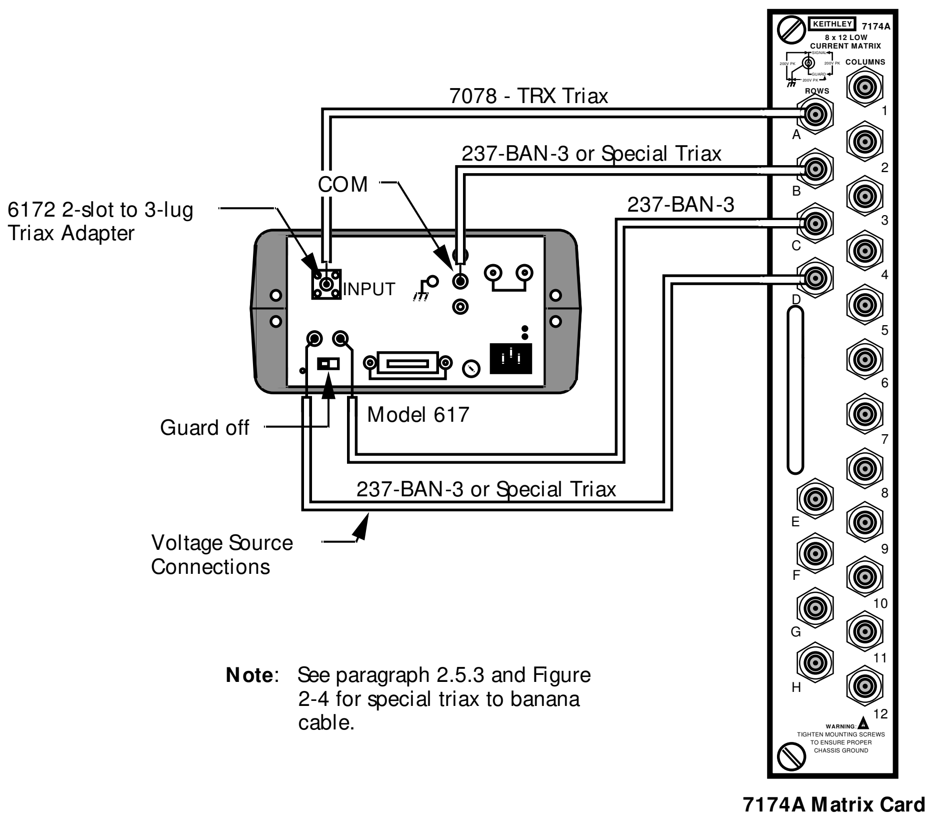


Figure 2-6
Model 617 electrometer connections

Model 196 DMM connections

Connect the Model 196 or other similar DMM to the matrix card using the general configuration shown in Figure 2-7. The VOLTS OHMS HI and LO terminals should be connected to the desired rows using triax/banana cables. For 4-wire ohms measurements, the OHMS SENSE HI and LO terminals should be connected to two additional rows using the same type of cables.

NOTE

For low-level voltage measurements, connect the inner shield of the HI cable to VOLT OHMS LO to minimize noise.

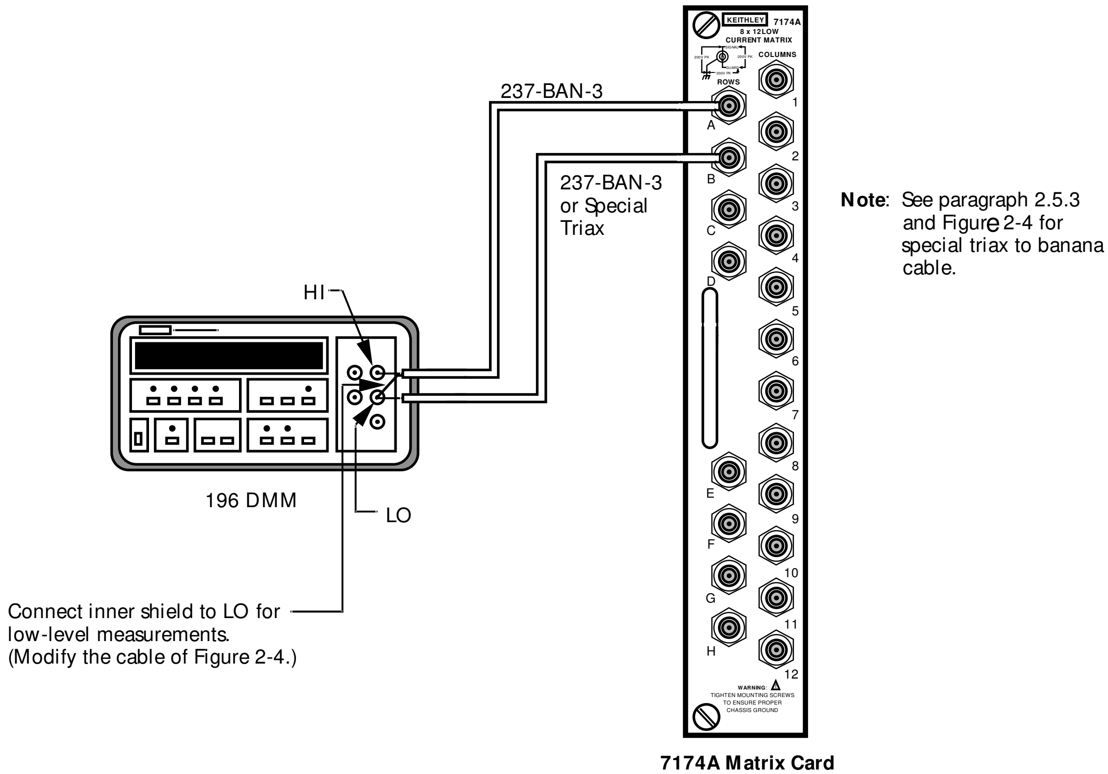


Figure 2-7
Model 196 DMM connections

Model 230 voltage source connections

Connect the Model 230 OUTPUT and COMMON terminal to the desired rows using triax/banana plug cables, as shown in Figure 2-8. For remote sensing applications, the SENSE OUTPUT and SENSE COMMON connectors can be routed through two additional rows using similar cables.

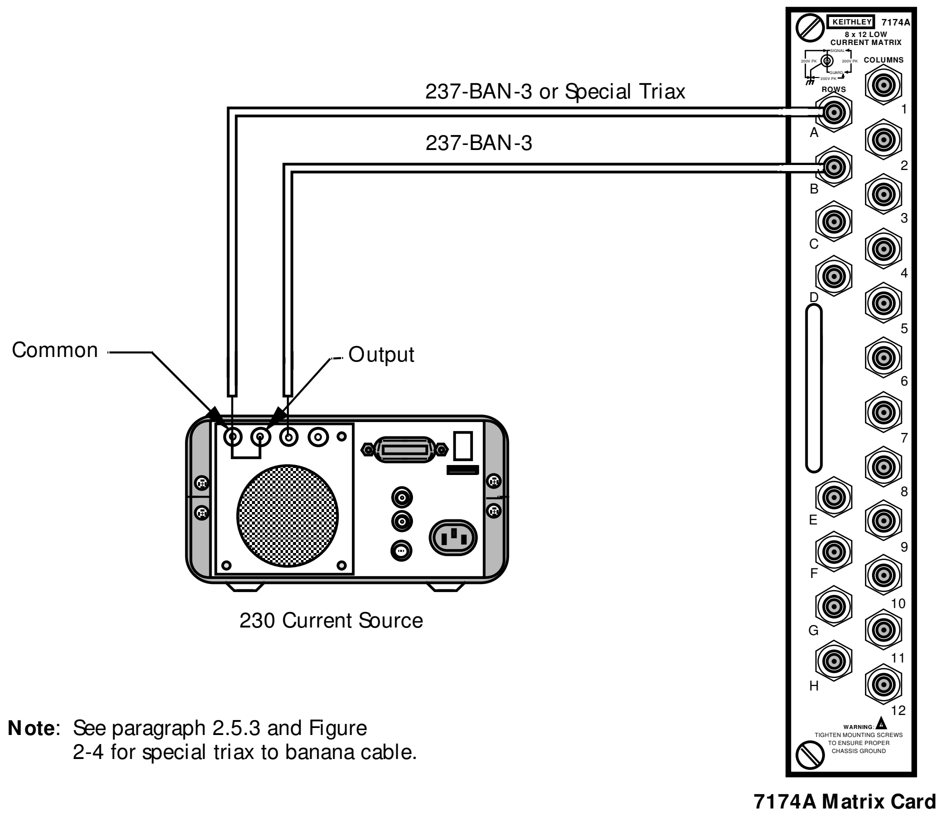


Figure 2-8
Model 230 voltage source connections

Model 590 CV analyzer connections

The Model 590 CV analyzer can be connected to any row or any column as shown in Figure 2-9. The BNC cables that are supplied with the Model 590 can be used; however, Model 7078-TRX-BNC adapters must be used at the Model 7174A end.

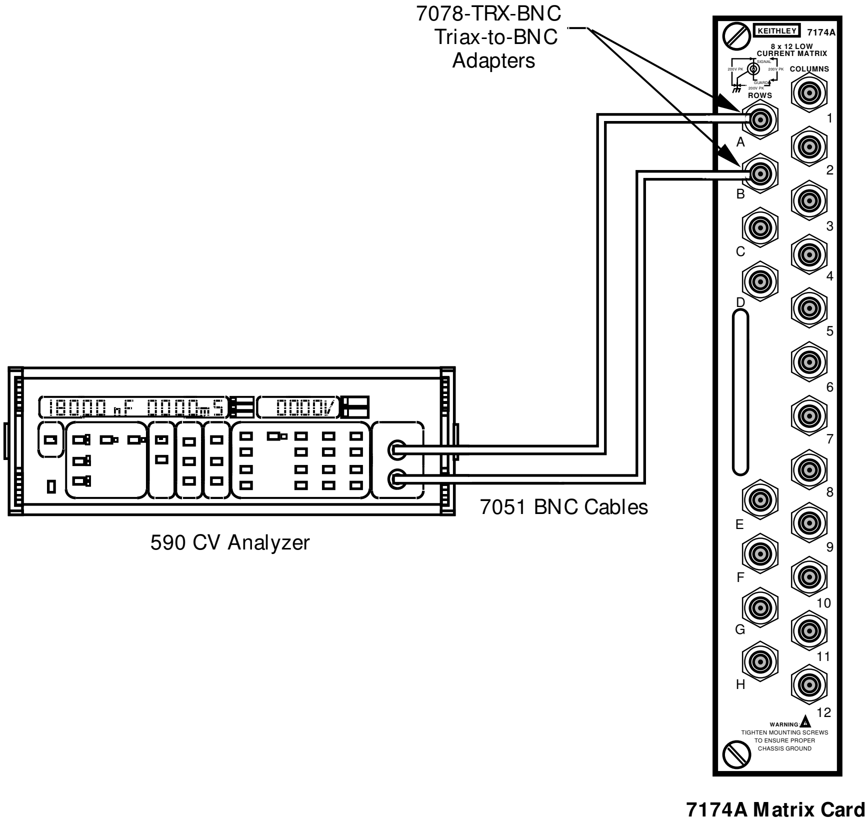


Figure 2-9
Model 590 CV analyzer connections

Model 220 current source connections

The Model 220 current source can be connected to the matrix card using the Model 6167 Guarded Adapter, as shown in Figure 2-10. This configuration guards the output signal to minimize the effects of distributed capacitance and leakage current.

NOTE

The Model 6167 adapter must be modified by internally disconnecting the inner shield connection of the input jack from the GUARDED/UNGUARDED selection switch. Otherwise, instrument LO will be connected to chassis ground through the adapter.

1. Connect the Model 6167 adapter to the Model 220 OUTPUT jack.
2. Connect a Model 7078-TRX-(3, 10 or 20) triax cable between the guarded adapter and the desired row of the Model 7174A.
3. Connect the Model 220 GUARD output to GUARD INPUT terminal of the adapter.
4. Connect the triax end of a triax/banana cable to the desired row on the Model 7174A.
5. Connect the banana plug end of the triax/banana cable to the OUTPUT COMMON jack of the Model 220.

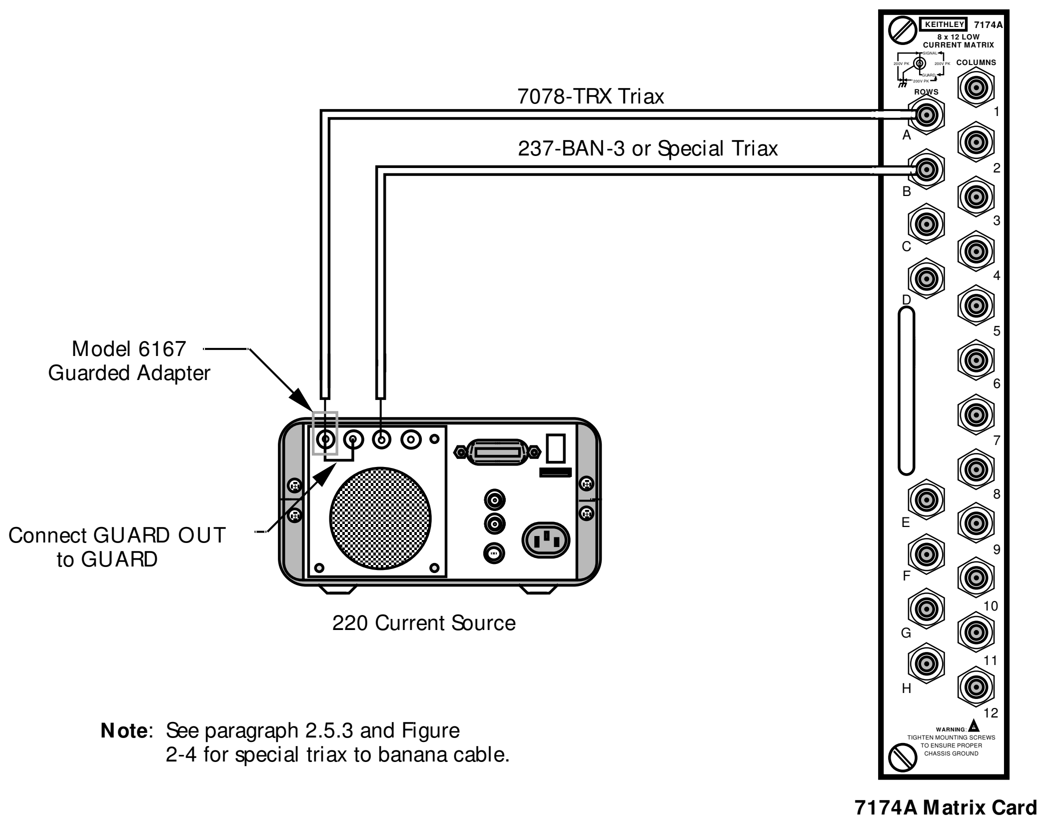


Figure 2-10
Model 220 current source connections

Model 236/237/238 source measure unit connections

Source measure units are connected to the matrix card using Model 7078-TRX cables. A Model 237-BAN-3 triax/banana cable can also be used to connect the output low binding post on the source measure unit to the matrix. Figure 2-11 shows connections for remote and local sensing applications.

CAUTION

Models 237 and 238 source measure units can only be used within the specified maximum signal levels of the Model 7174A (200V, 2A).

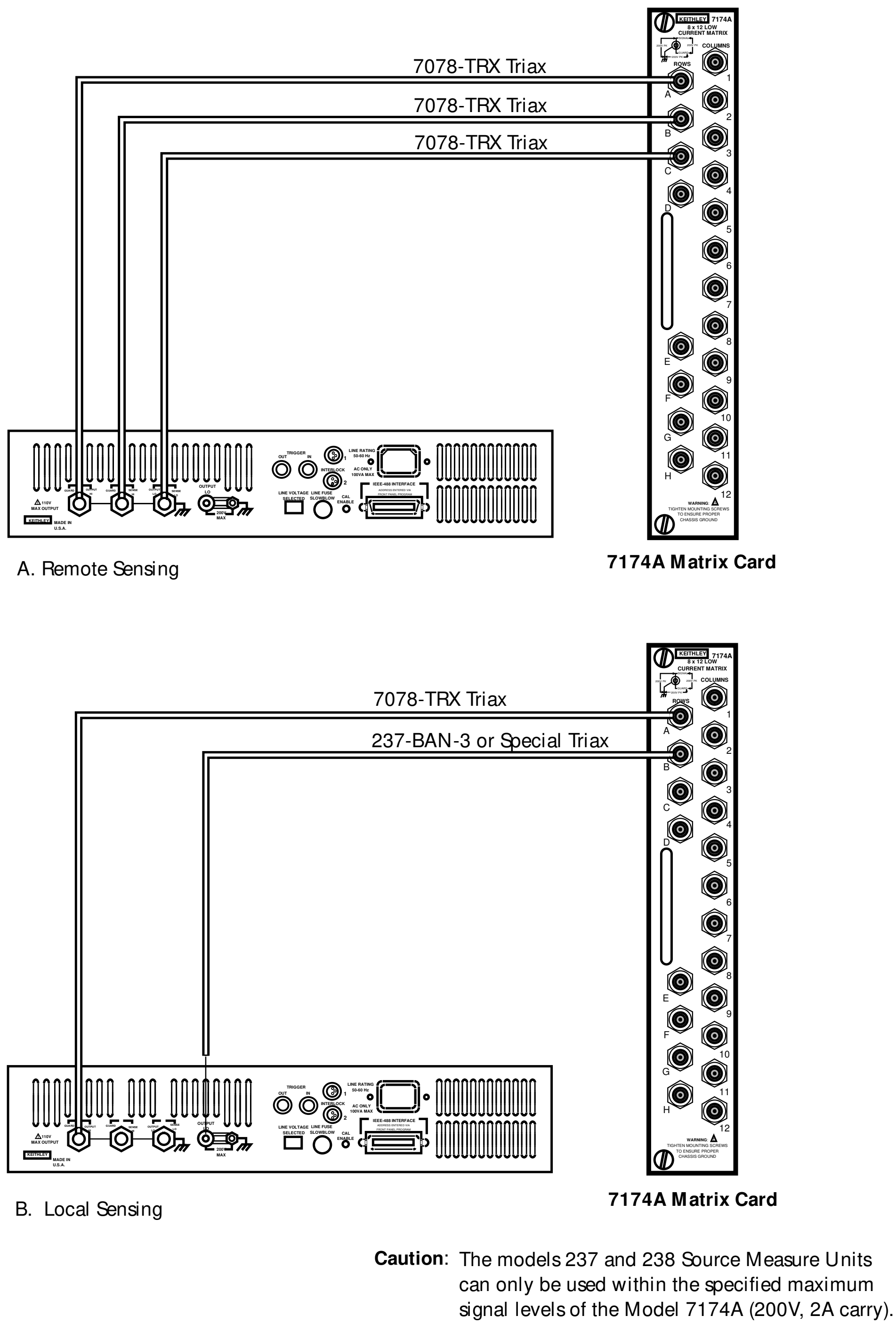


Figure 2-11
Model 236/237/238 source measure unit connections

2.5.6 Typical test fixture connections

Typically, one or more test fixtures will be connected to desired columns of the Model 7174A. Typically, the test fixtures will be equipped with card-edge connectors with wires soldered to them. In some cases, the test fixture will be equipped with triax connectors; for those types, Keithley Model 7078-TRX-(3, 10, or 20) cables can be used, as shown in Figure 2-12.

WARNING

Do not use BNC cables and adapters in cases where hazardous voltages from guard sources could be present on the BNC cable shields.

Internally, the test fixture should be wired as shown in the equivalent circuit of Figure 2-13. SIGNAL should be connected to the probe or other device contact points, while GUARD should be carried through as close to the device as possible. If coaxial probes are to be used, connect GUARD to the probe shield if the probe shield is insulated from the fixture shield.

Usually, the chassis ground terminal of the triax connector will automatically make contact with the fixture shield by virtue of the mounting method. However, ground integrity should be checked to ensure continued protection against hazardous guard voltages.

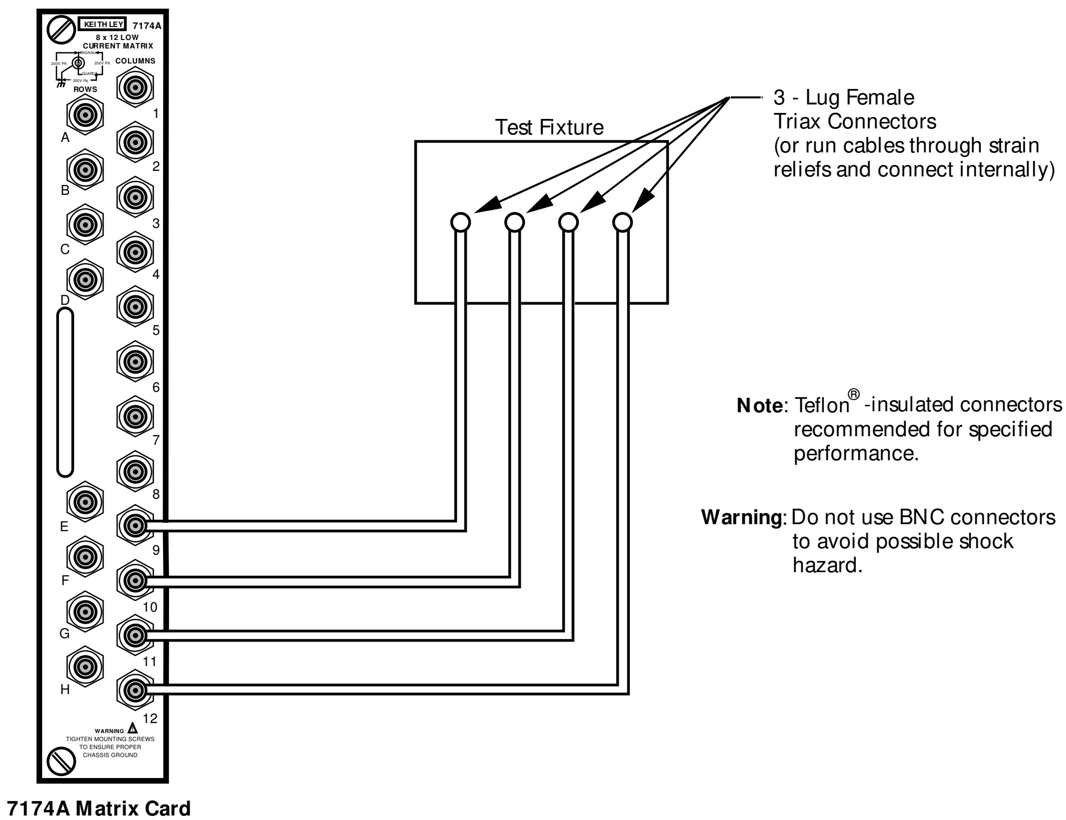


Figure 2-12
Typical test fixture connections

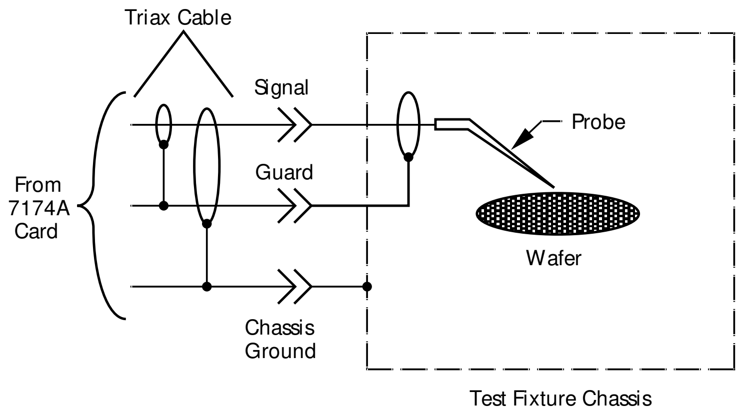


Figure 2-13
Equivalent circuit of test fixture connections

2.6 Matrix configuration

This section describes the matrix configuration of the Model 7174A. It also explains ways to expand the matrix by installing and connecting additional matrix cards in the Model 707A Switching Matrix.

2.6.1 Switching matrix

As shown in Figure 2-14, the Model 7174A is organized as an 8 × 12 (8 rows by 12 columns) matrix. The rows on the card are labeled A through H while the columns are numbered 1 through 12. The actual column number to use when programming depends on the slot and unit number (Table 2-3). For example, card column number 2 on a card in slot 5 of unit 1 is accessed as matrix column 50.

Each intersecting point in the matrix is called a crosspoint that can be individually closed or opened by programming the Model 707A mainframe. By closing the appropriate crosspoint, required pathways and pins may be connected. All crosspoints are configured for 2-pole switching, as shown in Figure 2-14. SIGNAL and GUARD are switched separately to any of the 12 columns on the card.

2.6.2 Path isolators

The path isolator relay switches shown in Figure 2-14 serve to isolate a given path from the rest of the matrix when no crosspoint (relay) is closed in that pathway. This topology minimizes leakage current and capacitance to pathways which are active. These isolators close automatically when any crosspoint on the path is closed and open automatically when all crosspoints on the path are opened.

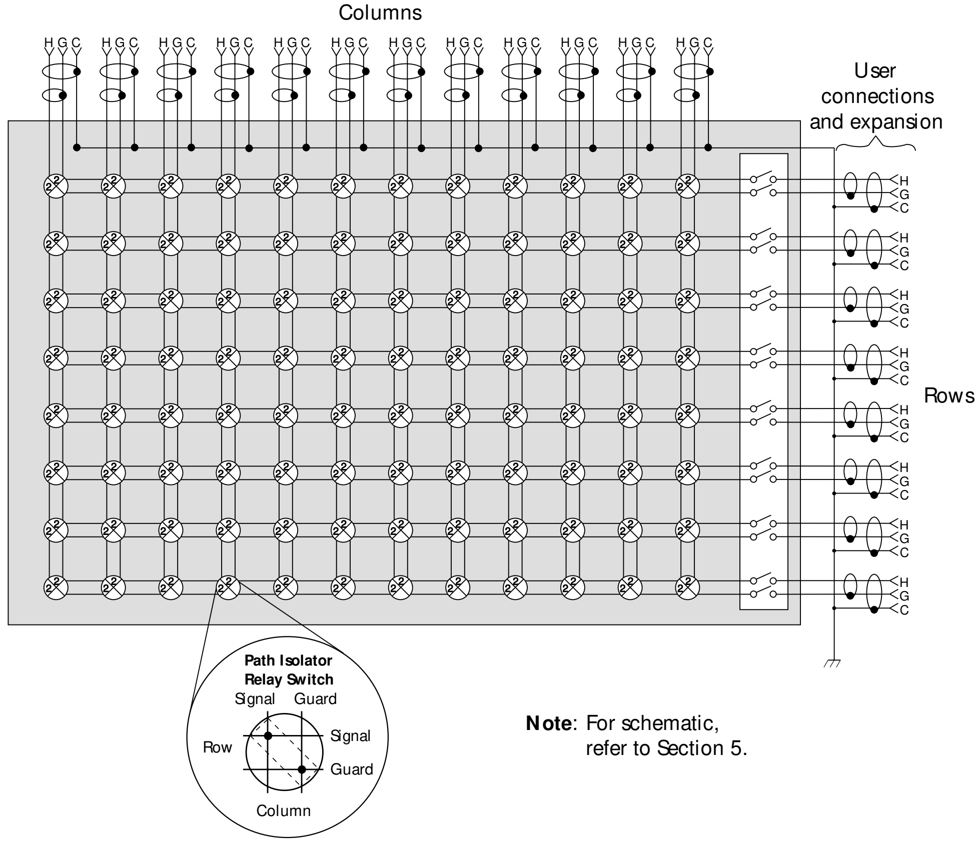


Figure 2-14
Matrix configuration

Table 2-3
Column numbering by slot and unit

Unit	Slot	Columns (1 through 12)											
1	1	1	2	3	4	5	6	7	8	9	10	11	12
	2	13	14	15	16	17	18	19	20	21	22	23	24
	3	25	26	27	28	29	30	31	32	33	34	35	36
	4	37	38	39	40	41	42	43	44	45	46	47	48
	5	49	50	51	52	53	54	55	56	57	58	59	60
	6	61	62	63	64	65	66	67	68	69	70	71	72
2	1	73	74	75	76	77	78	79	80	81	82	83	84
	2	85	86	87	88	89	90	91	92	93	94	95	96
	3	97	98	99	100	101	102	103	104	105	106	107	108
	4	109	110	111	112	113	114	115	116	117	118	119	120
	5	121	122	123	124	125	126	127	128	129	130	131	132
	6	133	134	135	136	137	138	139	140	141	142	143	144
3	1	145	146	147	148	149	150	151	152	153	154	155	156
	2	157	158	159	160	161	162	163	164	165	166	167	168
	3	169	170	171	172	173	174	175	176	177	178	179	180
	4	181	182	183	184	185	186	187	188	189	190	191	192
	5	193	194	195	196	197	198	199	200	201	202	203	204
	6	205	206	207	208	209	210	211	212	213	214	215	216
4	1	217	218	219	220	221	222	223	224	225	226	227	228
	2	229	230	231	232	233	234	235	236	237	238	239	240
	3	241	242	243	244	245	2446	247	248	249	250	251	252
	4	253	254	255	256	257	258	259	260	261	262	263	264
	5	265	266	267	268	269	270	271	272	273	274	275	276
	6	277	278	279	280	281	282	283	284	285	286	287	288
5	1	289	290	291	292	293	294	295	296	297	298	299	300
	2	301	302	303	304	305	306	307	308	309	310	311	312
	3	313	314	315	316	317	318	319	320	321	322	323	324
	4	325	326	327	328	329	330	331	332	333	334	335	336
	5	337	338	339	340	341	342	343	344	345	346	347	348
	6	349	350	351	352	353	354	355	356	357	358	359	360

2.6.3 Internal matrix expansion

Two to six Model 7174A cards can be connected together within the mainframe to yield an 8 × N matrix, where N depends on the number of cards. Figure 2-15 shows an internally expanded matrix with three cards, resulting in an 8 × 36 (eight row by 36 column) matrix. As summarized in Table 2-3, the actual column number used when programming the unit is determined by the slot.

WARNING

The shells of the row jumpers are at guard potential. To avoid a possible shock hazard, always disconnect all cables from the row and column jacks before removing or installing jumpers.

Because of critical signal paths, rows A-H are not jumpered through the backplane. Instead, install the supplied coaxial jumpers between appropriate connectors on Model 7174A cards (for more critical signal paths, rows can be isolated from other cards by not installing these cables). Each card has two coaxial connectors for each row, allowing daisy chaining of card rows. These connectors can be reached by lifting the access door on the top of the mainframe; do not remove cards to install the jumpers. This expansion is shown schematically in Figure 2-15 for cards located in slots 1, 2 and 3.

Figure 2-16 shows the location of the connectors used for this expansion. These connectors can be reached by lifting the access door on the top of the Model 707A Switching Matrix. The jumpers must be installed and removed before installing or removing a Model 7174A from the 707A Switching Matrix. Figure 2-17 shows how two cards can be daisy chained together using the coaxial jumpers.

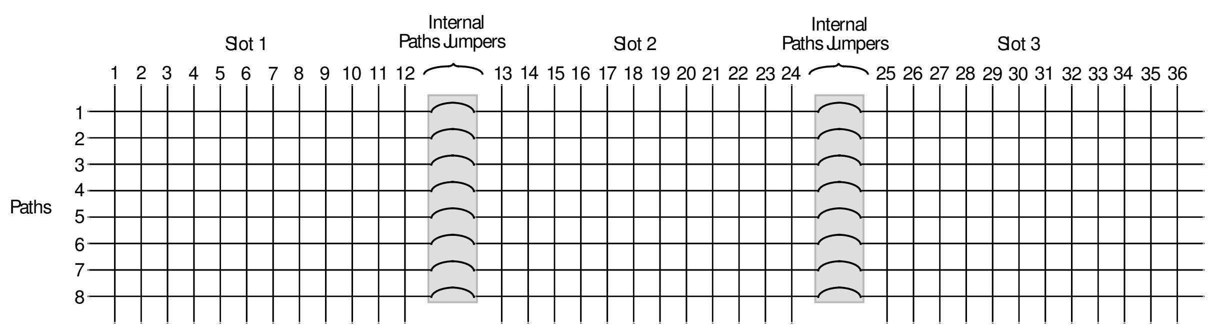


Figure 2-15
Connecting three cards for an 8 × 36 matrix

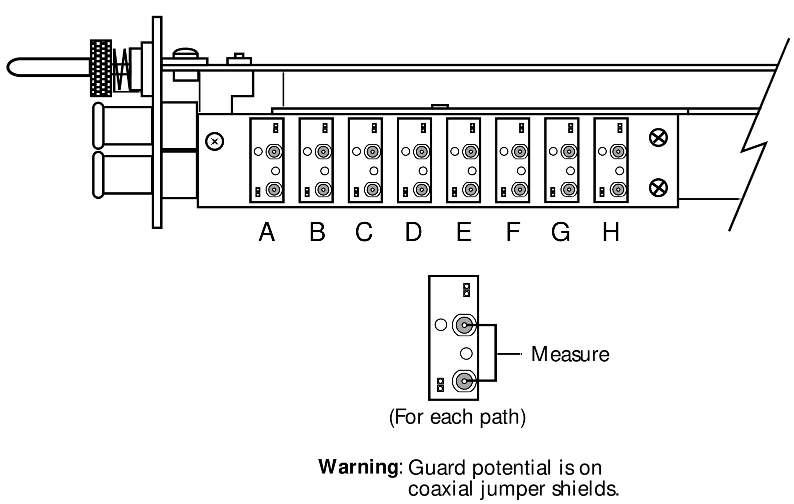


Figure 2-16
Jumper connector locations

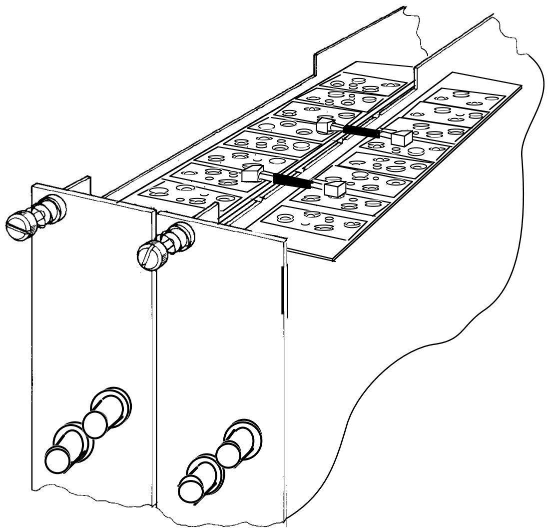


Figure 2-17
Two cards in daisy chain configuration

2.7 Measurement considerations

Most measurements made with the Model 7174A concern low-level signals. Such measurements are subject to various types of noise that can seriously affect low-level measurement accuracy. The following paragraphs discuss possible noise sources that might affect these measurements.

2.7.1 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 matrix 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.

Two ways to reduce these effects are: (1) reduce the lengths of the test leads, and (2) minimize the exposed circuit area. In extreme cases, magnetic shielding may be required. Special metals with high permeability at low flux densities (such as mu metal) are 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 also 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.

2.7.2 Electromagnetic Interference (EMI)

The electromagnetic interference characteristics of the Model 7174A comply with the electromagnetic compatibility (EMC) requirements of the European Union (EU) directives as denoted by the CE mark. However, it is still possible for sensitive signals to be affected by external sources. In these instances, special precautions may be required in the test setup.

Sources of EMI include:

- Radio and TV broadcast transmitters.
- Communications transmitters, including cellular phones and handheld radios.
- Devices incorporating microprocessors and high-speed digital circuits.
- Impulse sources as in the case of arcing in high-voltage environments.

The Model 7174A, signal source, measuring instrument, and signal leads should be kept as far away as possible from any EMI sources. Additional shielding of the card, signal leads, sources, and measuring instruments will often reduce EMI 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 EMI effects in some situations. In other cases, additional external filtering may be required. Keep in mind, however, that filtering may have detrimental effects, such as increased settling time, on the measurement.

2.7.3 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 2-18, the resulting ground loop causes unwanted signals 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.

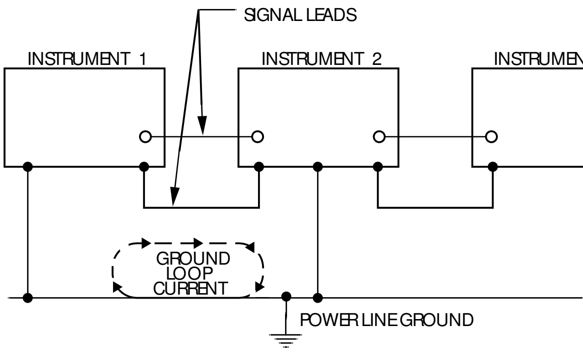


Figure 2-18
Power line ground loops

Figure 2-19 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, there is only one connection to power line ground.

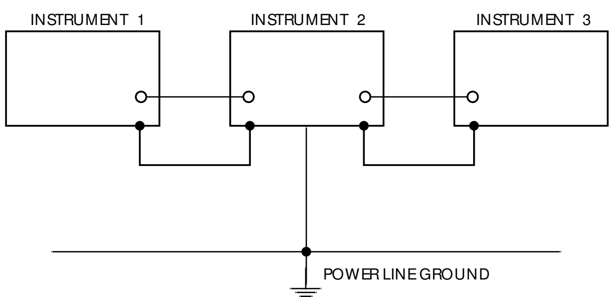


Figure 2-19
Eliminating ground loops

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 each instrument in the test setup.

2.7.4 Keeping connectors clean

As is the case with any high-resistance device, the integrity of connectors can be damaged if they are not handled properly. If the 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 matrix 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 or an HCFC. 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.

2.7.5 Noise currents caused by cable flexing

Noise currents can be generated by bending or flexing coaxial, triaxial, or quadraxial cables. Such currents, known as triboelectric currents, are generated by charges created between a conductor and insulator caused by friction.

Low-noise cable can be used to minimize these effects. Such cables have a special graphite coating under the shield to provide lubrication and to provide a conduction path to equalize charges.

Even low-noise cable generates some noise current when flexed or subjected to vibration. To minimize these effects, keep the cables as short as possible, and do not subject them to temperature variations that could cause expansion or contraction. Tie down offending cables securely to avoid movement, and isolate or remove vibration sources such as motors or pumps.

2.7.6 Shielding

Proper shielding of all unguarded signal paths and devices under test is important to minimize noise pickup in virtually any switching matrix system. Otherwise, interference from such noise sources as line frequency and RF fields can seriously corrupt a measurement.

In order for shielding to be effective, the shield must completely surround the source, measure and guard signals. It must also have a low impedance path to chassis ground. This is shown pictorially in Figure 2-20. The shield also functions as a safety shield since it is connected to chassis ground.

WARNING

Hazardous voltage may be present if LO on any instrument is floated above ground potential.

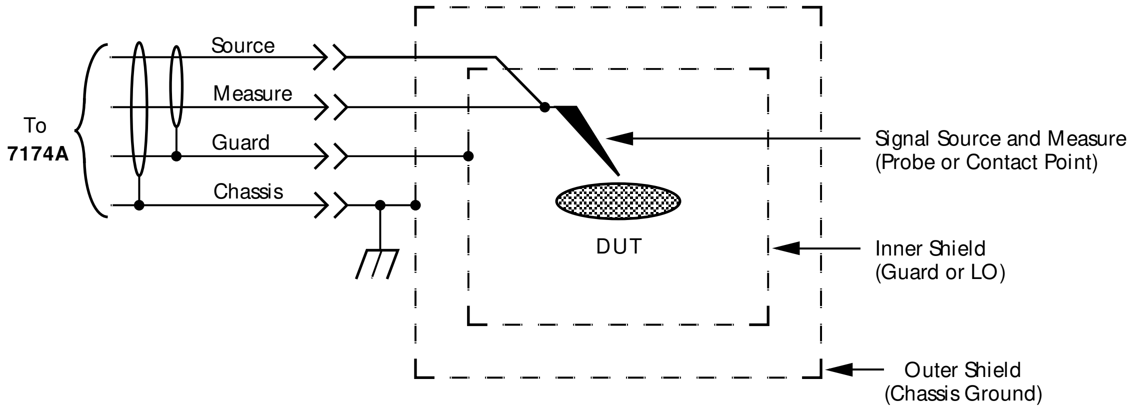


Figure 2-20
Shielded and guarded

2.7.7 Guarding

Guarding is important in high-impedance circuits where leakage resistance and capacitance could have degrading effects on the measurement. Guarding consists of using a shield surrounding a conductor that is carrying the high impedance signal. This shield is driven by a low-impedance amplifier to maintain the shield at signal potential.

Guarding minimizes leakage resistance effects by driving the cable shield with a unity gain amplifier, as shown in Figure 2-21. Since the amplifier has a high input impedance, it minimizes loading on the high-impedance signal lead. Also, the low output impedance ensures that the shield remains at signal potential, so that virtually no leakage current flows through the leakage resistance, R_L. Leakage between inner and outer shields may be considerable, but that leakage is of little consequence because that current is supplied by the buffer amplifier rather than the signal itself.

In a similar manner, guarding also reduces the effective cable capacitance, resulting in much faster measurements on high-impedance circuits. Because any distributed capacitance is charged through the low impedance of the buffer amplifier rather than by the source, settling times are shortened considerably by guarding.

In order to use guarding effectively with the Model 7174A, the guard path of the matrix card should be connected to the guard output of the sourcing or measuring instrument. Figure 2-20 shows typical connections. Guard should be properly carried through the inner shield to the device under test to be completely effective. The shielded, guarded test fixture arrangement shown in Figure 2-20 is also recommended for safety purposes (guard voltage may be hazardous with some instruments).

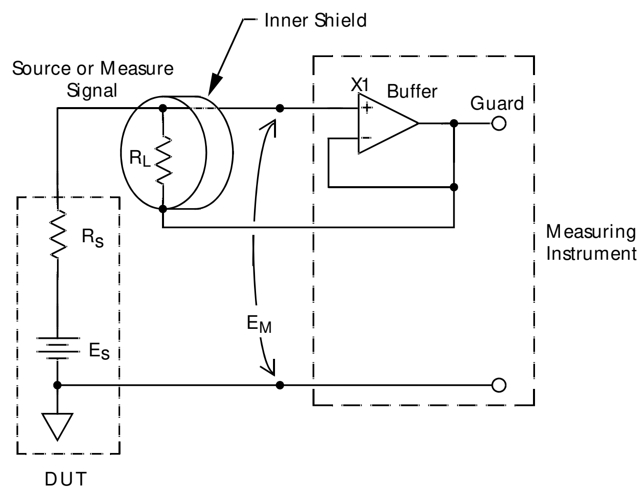


Figure 2-21
Guarded circuit

2.7.8 Matrix expansion effects on card specifications

Specifications such as those given for path isolation and offset current are with a single Model 7174A card installed in the mainframe. Expanding the matrix by internally connecting two or more Model 7174A cards together will degrade system performance specifications (other types of cards do not affect the specifications because they use different pathways in the mainframe backplane). The extent depends on how many cards are used, as well as the amount of cabling used to connect them together.

With internal pathway expansion, isolation among paths is increased, and offset current is decreased, although the isolator relays on the card do help to minimize these effects.

2.8 Coaxial jumper access

To gain access to jumpers, lift jumper across cover (Figure 2-22).

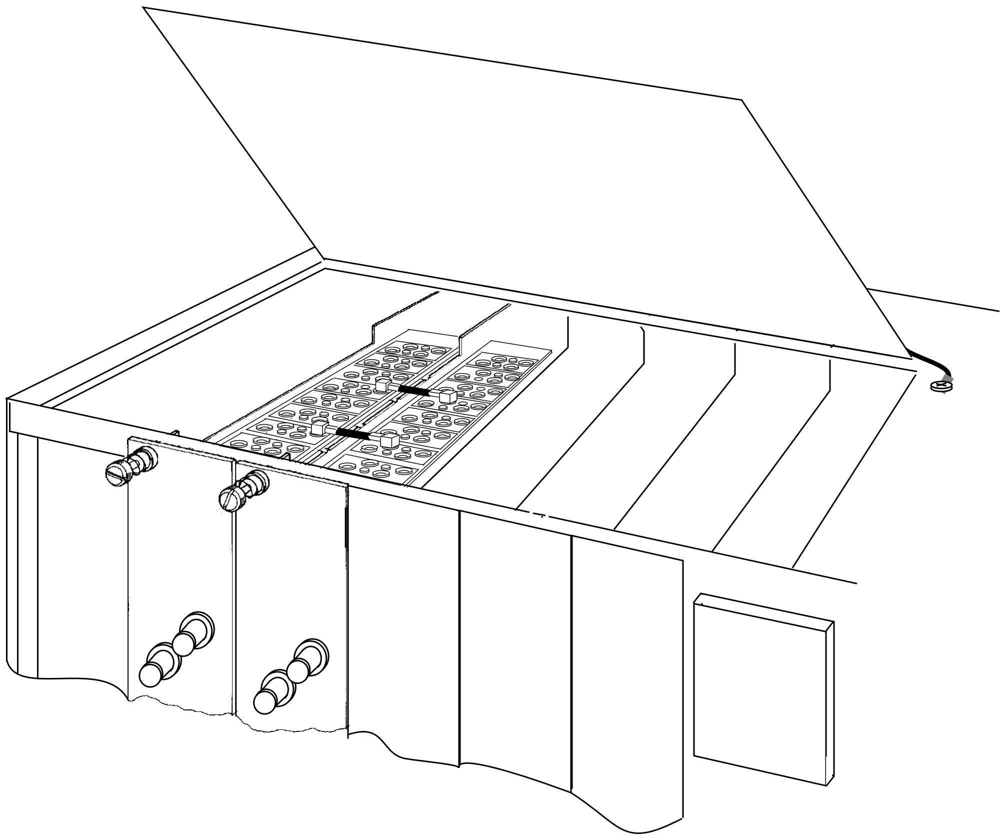


Figure 2-22
Coaxial jumper access

3
Applications

3.1 Introduction

This section covers typical applications for the Model 7174A 8×12 Low Current Matrix Card and is organized as follows:

3.2 CV measurements — Outlines the test configuration and procedure for making quasistatic and high-frequency CV measurements.

3.3 Semiconductor test matrix — Details a semiconductor test matrix that can be used to perform a variety of different tests on semiconductors such as FETs.

3.4 Resistivity measurements— Covers methods to measure the resistivity of semiconductor samples using the van der Pauw method.

3.5 Semiconductor IV characterization — Covers the basic scheme and connections used to generate an IV curve of a bipolar or MOS transistor.

3.2 CV measurements

The Model 7174A can be used in conjunction with the Keithley Model 590 CV Analyzer, and the Keithley Model 595 Quasistatic CV Meter to perform quasistatic and high-frequency CV (capacitance vs. voltage) test on semiconductors. The resulting CV curves can be used to calculate important semiconductor parameters such as doping profile, band bending, and mobile ion concentration.

3.2.1 Stand alone system configuration

The stand alone system shown in Figure 3-1 can be used to make CV measurements without the aid of a computer. System components perform the following functions.

Model 590 CV Analyzer: Measures CV data at 100kHz and 1MHz and sends the resulting data to the plotter for graphing.

Model 595 Quasistatic CV Meter: Measures quasistatic CV data and sends the data to the plotter for graphing in real time.

Model 707A Switching Matrix: Controls the semiconductor matrix card to close and open the desired crosspoints at the proper time.

Model 7174A 8×12 Low Current Matrix Card: Switches the signa pathways to the six devices under test.

HP-GL Plotter: Plots CV and other curves directly from the Models 590 and 595.

3.2.2 Computerized system configuration

Figure 3-2 shows a computerized version of the CV matrix test system. The addition of a computer allows greater system versatility and easier instrument control. Also, analysis functions such as doping profile and ion concentration can be added to the software to expand CV analysis capabilities.

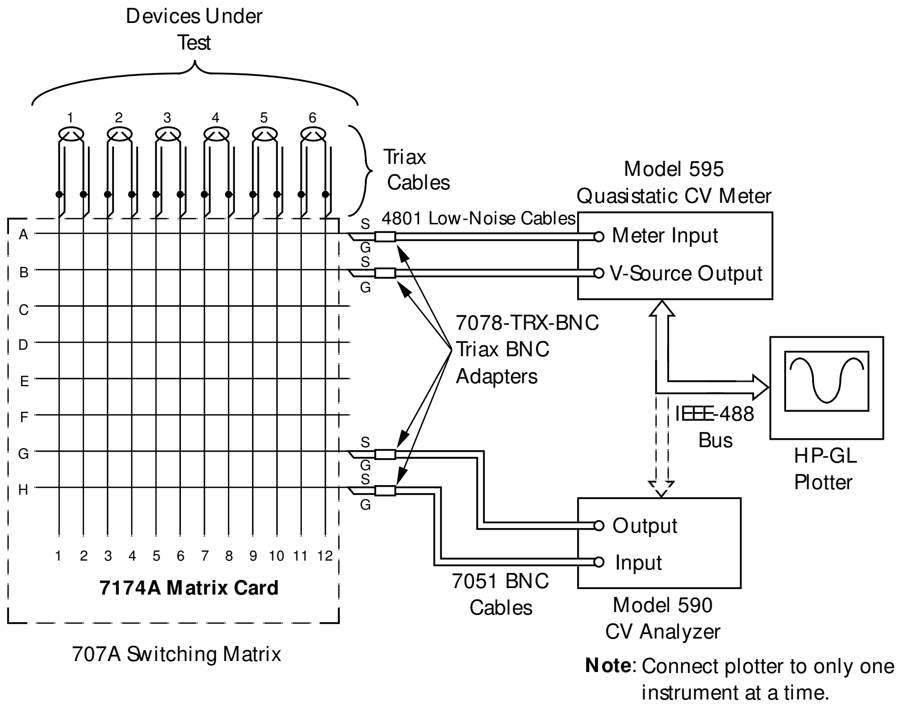


Figure 3-1
Stand alone CV system configuration

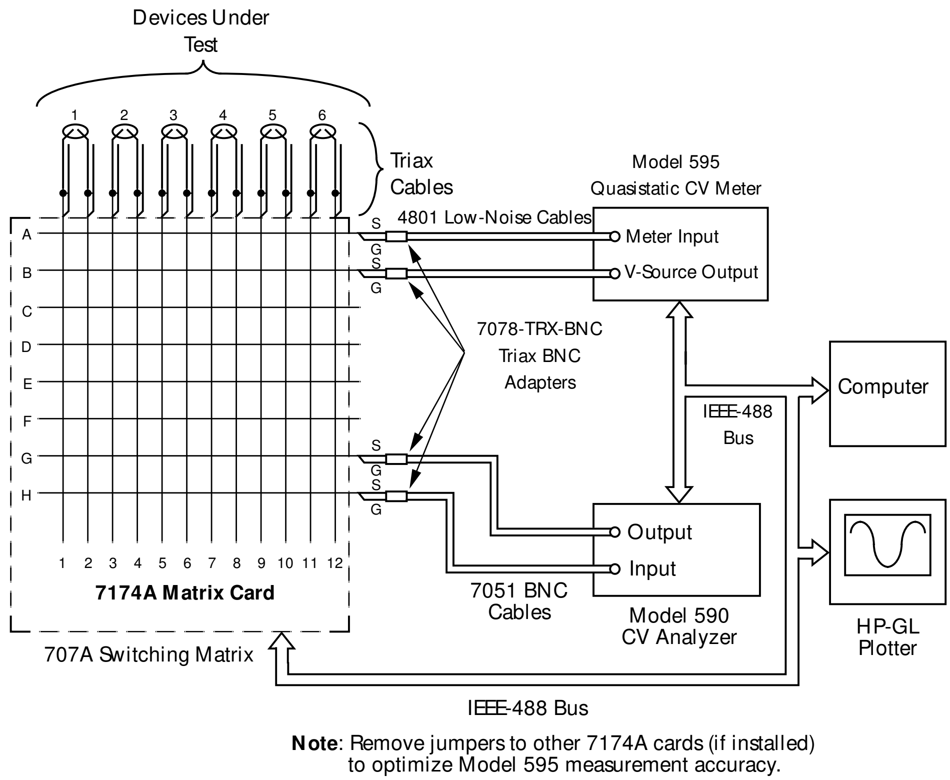


Figure 3-2
Computerized CV system configuration

3.2.3 Optimizing CV measurement accuracy

For accurate CV measurements, each Model 590 CV measurement pathway must be corrected using the procedure outlined in the Model 590 Instruction Manual. The pathways to each DUT must be cable corrected separately.

Also, for best quasistatic CV results, the corrected capacitance feature of the Model 595 should be used. Corrected capacitance compensates for any leakage currents present in the cables, switching matrix, or test fixture. However, care must be taken when using corrected capacitance to ensure that the device remains in equilibrium throughout the test sweep to avoid distorting the CV curves.

In order to minimize the effects of the switching network on quasistatic CV measurements, cables to the Model 595 and DUT should be kept as short as possible.

3.2.4 Basic CV test procedure

The fundamental CV test procedure is outlined below. Keep in mind that this procedure does not address many considerations and aspects of CV testing, which is fairly complex. The procedure given is for the stand alone system in Figure 3-1. Detailed instrument operating information may be found in the pertinent instruction manuals.

1. Connect the HP-GL plotter to the IEEE-488 bus connector of the Model 595 only.
2. Set up the Model 595 for the expected CV sweep.
3. Close the crosspoints necessary to connect the Model 595 to the device under test, as summarized in Table 3-1. For example, to test device #1, close A1 and B2.
4. Place the probes down on the wafer test dots.
5. Run a quasistatic sweep on the selected device and generate a CV curve.
6. Open the crosspoints that are presently closed.
7. Set up the Model 590 for the expected CV sweep.
8. Close the crosspoints necessary to connect the Model 590 to the device under test. For example, to test device #1, close G1 and H2.
9. Run a high-frequency test sweep on the device to store the CV data in the Model 590 buffer.
10. Disconnect the plotter from the Model 595 and connect it to the Model 590.
11. Generate a plot from the data in the Model 590 buffer.
12. Repeat steps 2 through 11 for the remaining devices, as required.

Table 3-1
CV test crosspoint summary

Wafer #	Closed crosspoints	
	Quasistatic (595)	**High frequency (590)**
1	A1, B2	G1, H2
2	A3, B4	G3, H4
3	A5, B6	G5, H6
4	A7, B8	G7, H8
5	A9, B10	G9, H10
6	A11, B12	G11, H12

3.2.5 Typical CV curves

Figure 3-3 and Figure 3-4 shows typical CV curves as generated by the Model 595 and 590 respectively. The quasistatic curve shows a fair amount of symmetry, while the high-frequency curve is highly asymmetrical. The asymmetrical nature of the high-frequency curve results from the inability of minority carries to follow the high-frequency test signal.

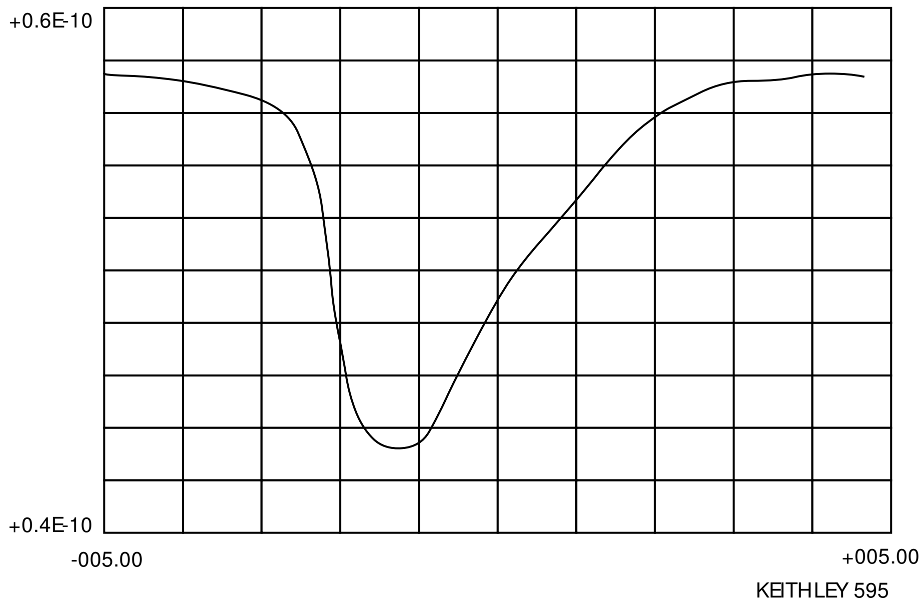


Figure 3-3
Typical quasistatic CV curve generated by Model 595

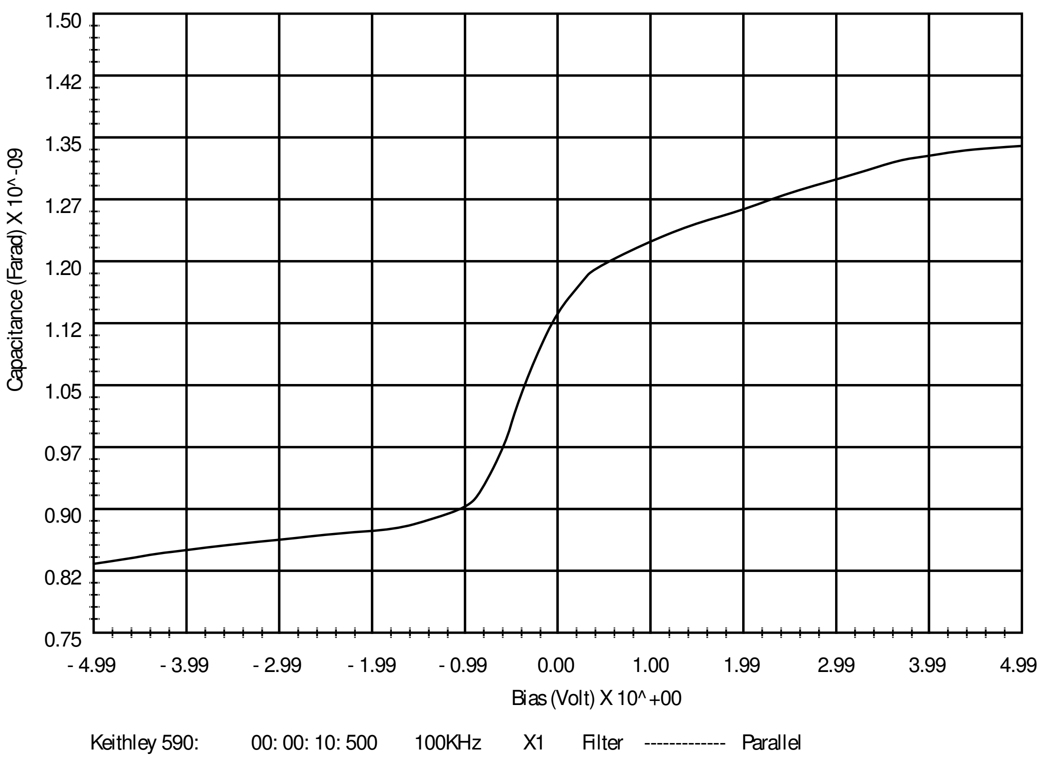


Figure 3-4
Typical high-frequency CV curve generated by Model 590

3.3 Semiconductor test matrix

Two important advantages of a matrix switching system are the ability to connect a variety of instruments to the device or devices under test, as well as the ability to connect any instrument terminal to any device test node. The following paragraphs discuss a typical semiconductor matrix test system and how to use that system to perform a typical test: common-source characteristic testing of a typical JFET.

3.3.1 System configuration

Figure 3-5 shows the configuration for a typical multipurpose semiconductor test matrix. Instruments in the system perform the following functions.

Model 617 Electrometer/Source: Measures current, and also could be used to measure voltages up to ±200VDC. The DC voltage source can supply a maximum of ±100V at currents up to 2mA.

Model 230 Voltage Source: Sources DC voltages up to ±101V at a maximum current of 100mA.

Model 590 CV Analyzer: Adds CV sweep measurement capability to the system.

Model 220 Current Source: Used to source currents up to a maximum of 101mA with a maximum compliance voltage of 105V.

Model 196 DMM: Measure DC voltages in the range of 100nV to 300V. The Model 196 could also be used to measure resistance in certain applications.

Device Under Test: A three-terminal picture for testing such devices as bipolar transistors and FETs. Additional connections could easily be added to test more complex devices, as required.

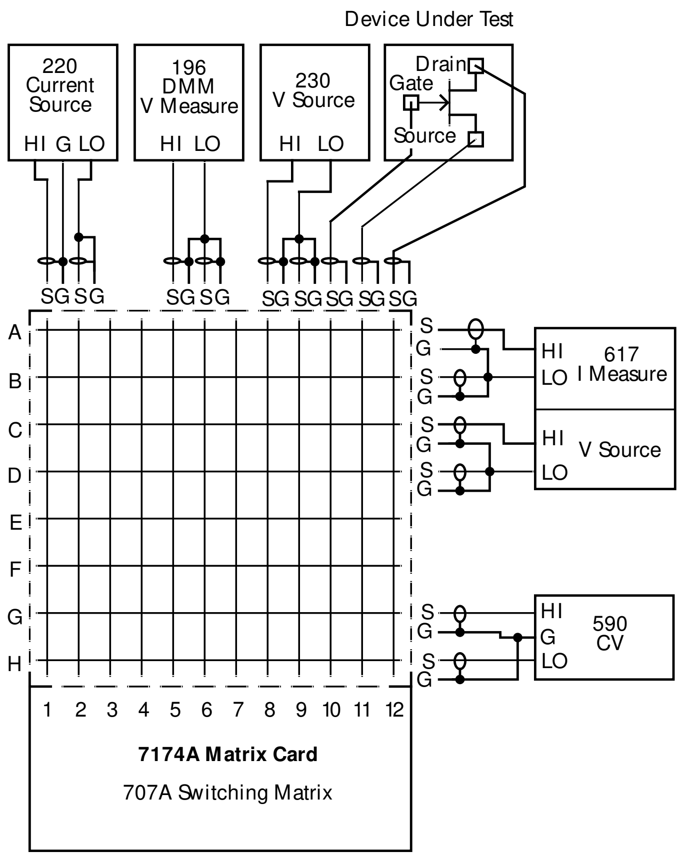


Figure 3-5
Semiconductor test matrix

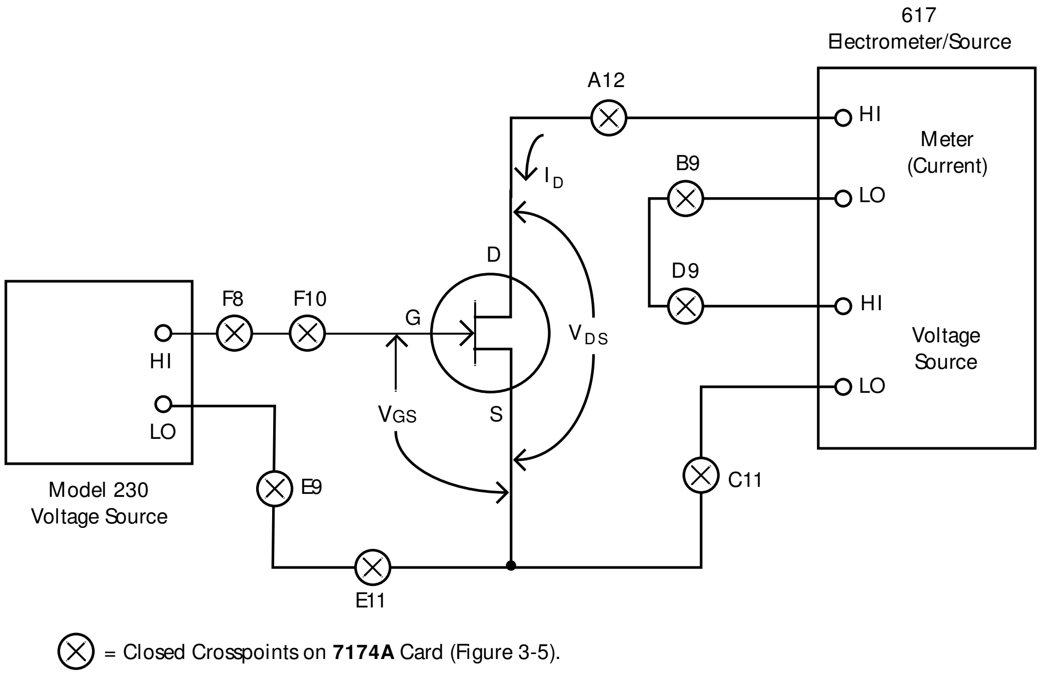


Figure 3-6
System configuration for measuring common-emitter characteristics

3.3.2 Testing common-source characteristic of FETs

The system shown in Figure 3-5 could be used to test a variety of characteristics including I_{GSS}, $I_{D[OFF]}$, $I_{G[ON]}$, I_{DSS}, and $V_{DS[OFF]}$. To demonstrate a practical use for the system, we will show how it can be used to generate common source characteristic curves of a particular JFET.

In order to generate these curves, the instrument must be connected to the JFET under test, as shown in Figure 3-6. The advantage of using the matrix is, of course, that it is a simple matter of closing specific crosspoints. The crosspoints that must be closed are also indicated on the diagram.

To run the test, V_{GS} is set to specific values, for example in increments of 0.25V. At each V_{GS} value, the drain-source voltage (V_{DS}) is stepped across the desired range, and the drain current, I_D, is measured at each value of V_{DS}. Once all data are compiled, it is a simple matter to generate the common-source IV curves, an example of which is shown in Figure 3-7. If the system is connected to a computer, the test and graphing could all be done automatically.

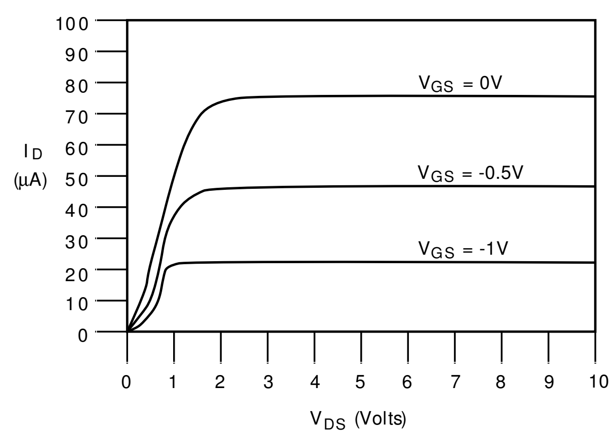


Figure 3-7
Typical common-source FET IV characteristics

3.4 Resistivity measurements

The Model 7174A 8×12 Low Current Matrix Card can be used in conjunction with a Model 220 Current Source and a Model 196 DMM to perform resistivity measurements on semiconductors. Such measurements can yield such important information as doping concentration.

3.4.1 Test configuration

Figure 3-8 shows the basic test configuration to make resistivity measurements on van der Pauw samples. The Model 220 sources current through the samples, while the Model 196 measures the voltage developed across the samples. The matrix card, of course, switches the signal paths as necessary. In order to minimize sample loading, which will reduce accuracy, the Model 196 DMM should be used only on the 300mV or 3V ranges. Also, this configuration is not recommended for resistance measurements above 1MΩ due to the accuracy-degrading effects of DMM loading.

3.4.2 Test procedure

In order to make van der Pauw resistivity measurements, four terminals of a sample of arbitrary shape are measured. A current (from the Model 220) is applied to two terminals, while the voltage is measured (by the Model 196) across the two opposite terminals, as shown in Figure 3-9. A total of eight such measurements on each sample are required, with each possible terminal and current convention. The resulting voltages are designated V1 through V8.

In order to source current into and measure the voltage across the sample, specific crosspoints must be closed. Table 3-2 summarizes the crosspoints to close for each voltage measurement on all three samples from the test configuration shown in Figure 3-8.

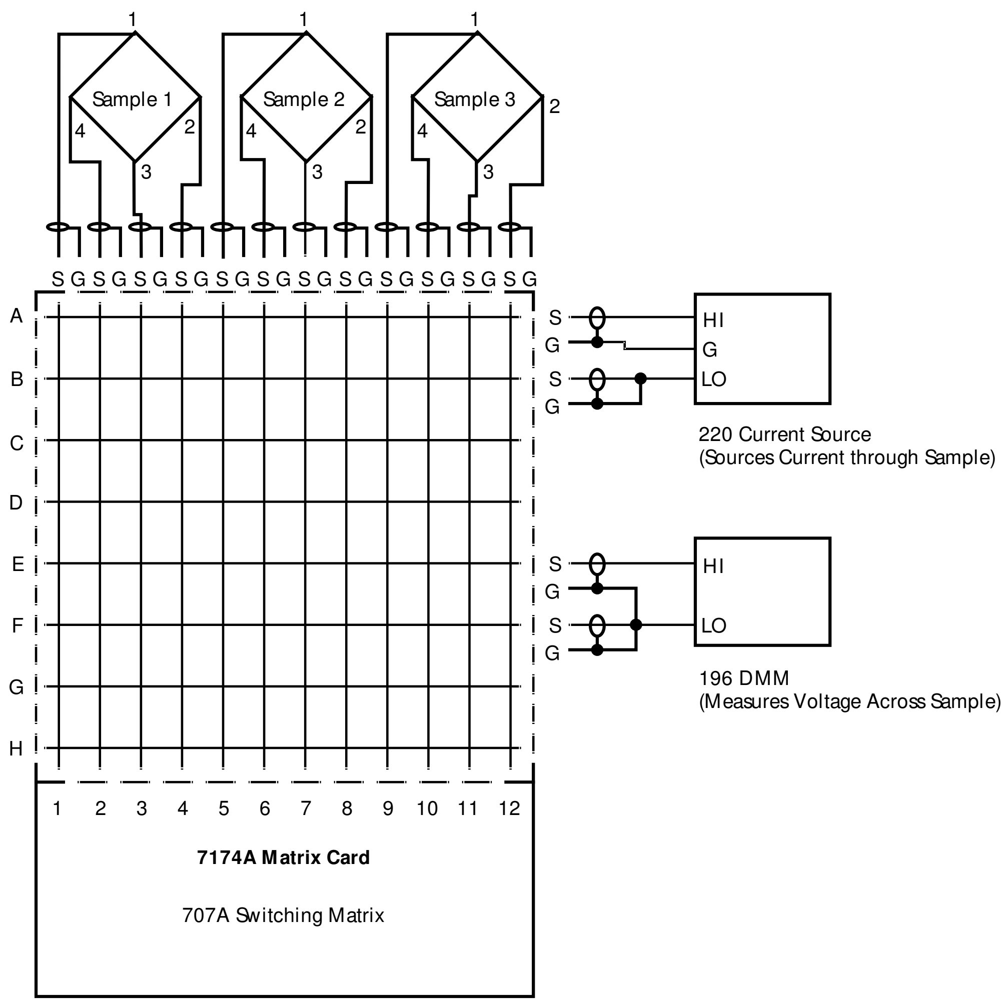


Figure 3-8
Resistivity test configuration

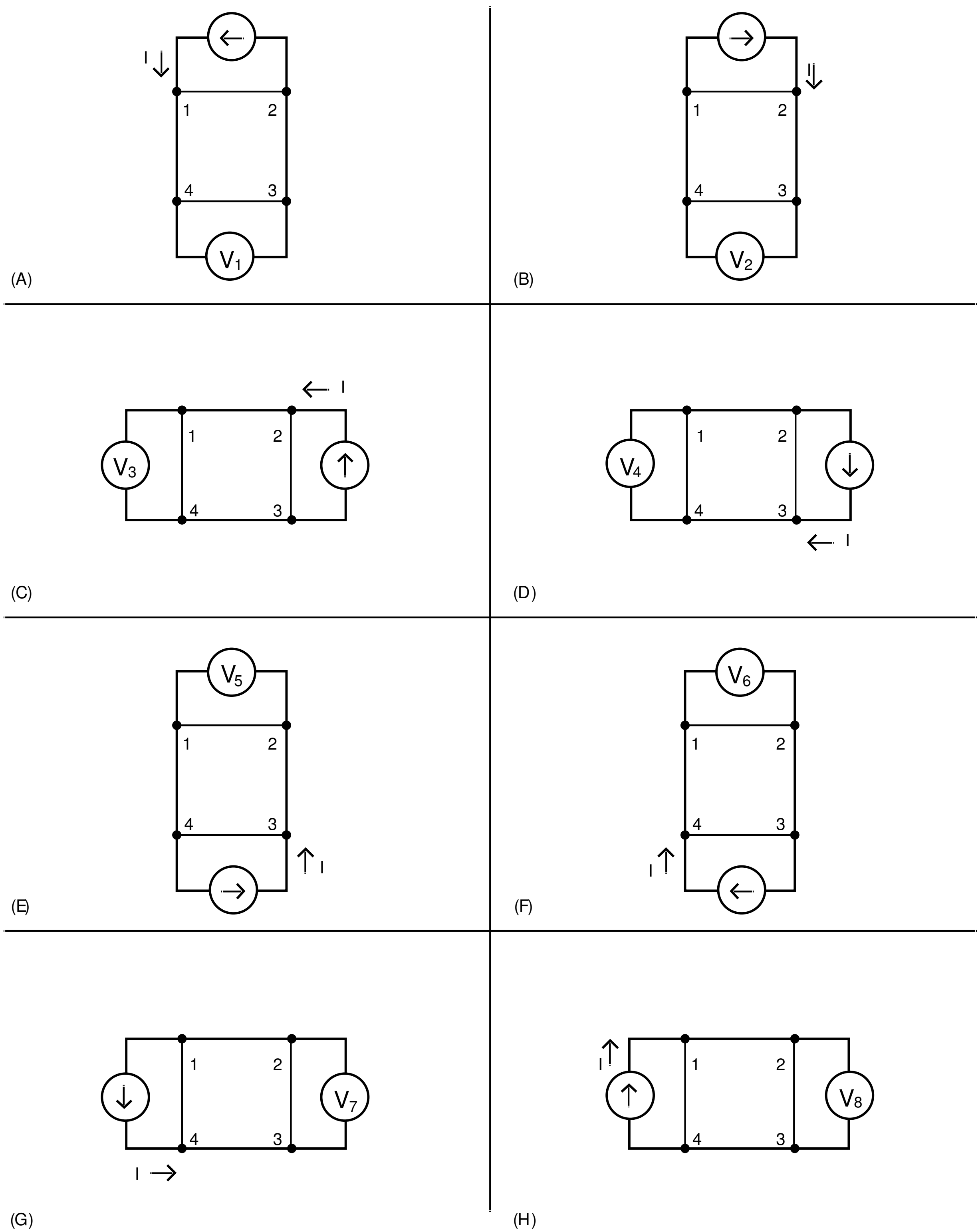


Figure 3-9
Resistivity measurement conventions

Table 3-2
Crosspoint summary for resistivity measurements

Voltage	Crosspoint closed												Current between	Voltage between
	Sample #1				Sample #2				Sample #2					
V_1	A1	B4	E3	F2	A5	B9	E7	F6	A9	B12	E11	F10	1-2	3-4
V_2	A4	B1	E3	F2	A8	B5	E7	F6	A12	B9	E11	F10	2-1	3-4
V_3	A4	B3	E2	F1	A8	B7	E6	F5	A12	B11	E10	F9	2-3	4-1
V_4	A3	B4	E2	F1	A7	B8	E6	F5	A11	B12	E10	F9	3-2	4-1
V_5	A3	B2	E1	F4	A7	B6	E5	F8	A11	B10	E9	F12	3-4	1-2
V_6	A2	B3	E1	F4	A6	B7	E5	F8	A10	B11	E9	F12	4-3	1-2
V_7	A2	B1	E4	F3	A6	B5	E8	F7	A10	B9	E12	F11	4-1	2-3
V_8	A1	B2	E4	F3	A5	B6	E8	F7	A9	B10	E12	F11	1-4	2-3

3.4.3 Resistivity calculations

Once the eight voltage measurements are known, the resistivity can be calculated. Two values of resistivity, ρ_A and ρ_B are initially computed as follows:

$$\rho_A = \frac{1.1331\ f_A t_S (V_2 + V_4 - V_1 - V_3)}{I}$$

$$\rho_B = \frac{1.1331\ f_B t_S (V_6 + V_8 - V_5 - V_7)}{I}$$

Where: ρ_A and ρ_B are the resistivities in Ω-cm
t_S is the sample thickness in cm
V_1 through V_8 are the voltages measured by the Model 196
I is the current through the sample in amperes
f_A and f_B are geometrical factors based on sample symmetry (f_A=f_B=1 for perfect symmetry).

Once ρ_A and ρ_B are known, the average resistivity, ρ_{AVG}, can be determined as follows:

$$\rho_{AVG} = \frac{\rho_A + \rho_B}{2}$$

3.5 Semiconductor IV characterization

A source measure unit such as the Model 236, 237, or 238 is used to test and characterize many types of devices. One of these is semiconductor devices. The following paragraphs explain the basic scheme and connections used to generate an IV curve of a bipolar or MOS transistor. Figure 3-10 shows FET devices connected in a test fixture.

3.5.1 Test configuration

Rows A and B are used to switch the Model 237 Source Measure Unit; rows C and D are used for the Model 236.

CAUTION

To prevent card damage, do not exceed the 200 volt maximum rating of the Model 7174A when switching the Model 237, which is capable of sourcing up to 1100 volts.

At the test fixture, the drain and source leads of the FETs are connected in a 4-wire sensing configuration. This connection scheme allows the Model 237 to use remote sensing to accurately apply Vds to the FETs. The Model 236 uses local sensing and is used to supply the bias to the gates of the FETs. Since the gates are low current, remote sensing is not necessary.

If more DUT pins are needed, the system is easily expanded by adding more Model 7174A matrix cards. Each additional card will add 12 columns to the system.

3.5.2 Cable connections

Source Measure Unit and test fixture connections to the matrix card are accomplished using Model 7078-TRX. These are three slot triax cables. On each Source Measure Unit, the banana jack (5-way binding post) is used to access OUTPUT LO. This connection is made using a Model 237-BAN-3 or the special cable constructed using the information in Figure 2-4. This allows OUTPUT LO to be applied to a signal pathway and independently switched. The guard pathways of the matrix cards are used exclusively to extend the driven guards of the Source Measure Units to the DUT to eliminate the effects of leakage current.

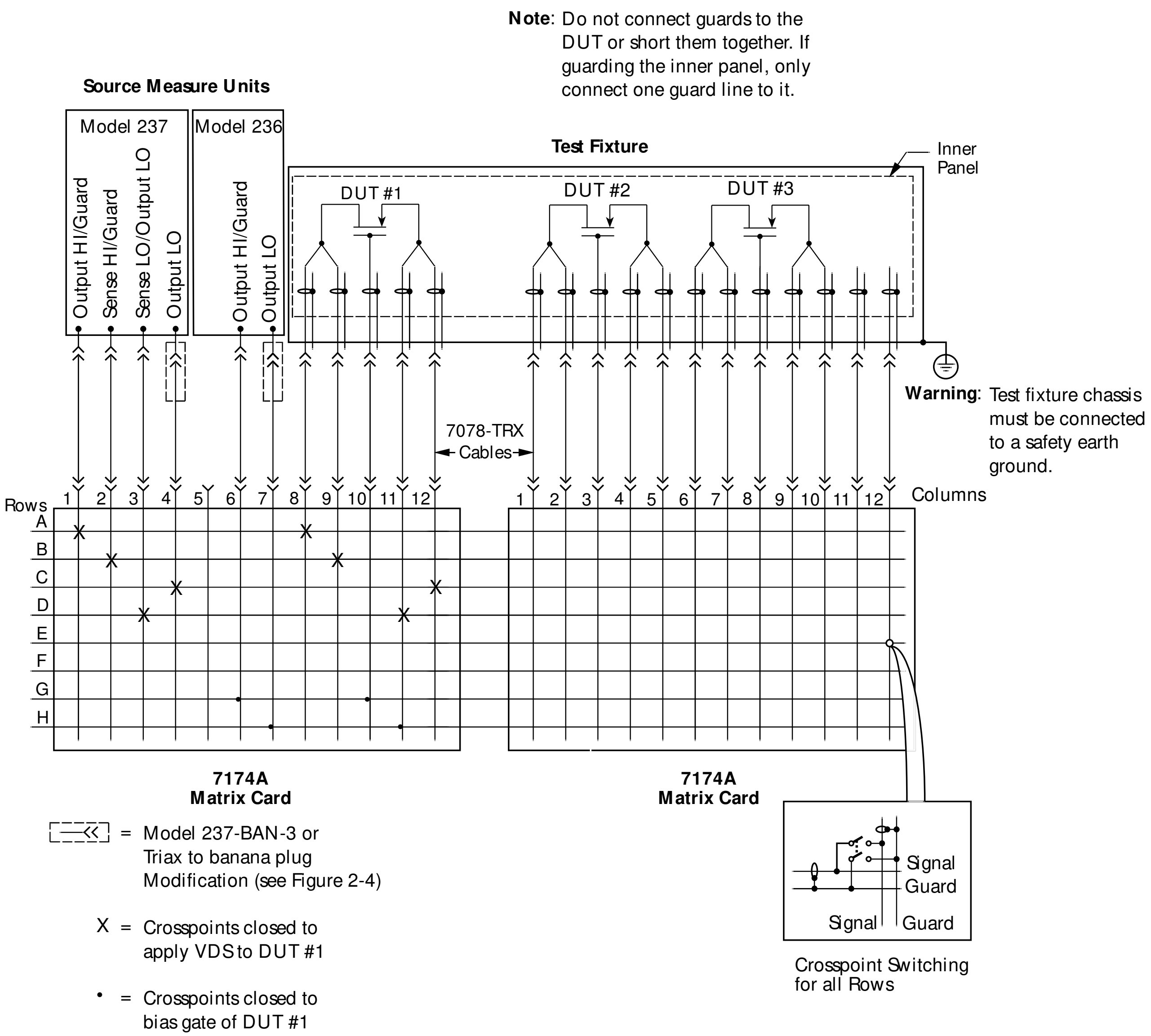


Figure 3-10
Multi unit test system using Models 236 and 237 source measure units

4
Service Information

4.1 Introduction

WARNING

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

This section contains information necessary to service the Model 7174A Low Current Matrix Card and is arranged as follows:

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

4.3 Principles of operation — Briefly discusses circuit operation.

4.4 Troubleshooting — Presents some troubleshooting tips for the Model 7174A.

4.5 Special handling of static-sensitive devices — Reviews precautions necessary when handling static-sensitive devices.

4.6 Performance verification — Describes conditions and provides references to determine if the card is operating properly.

4.7 Reed pack replacement — Provides a procedure for replacing faulty reed packs.

4.2 Handling and cleaning precautions

Because of the high-impedance circuits on the Model 7174A, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be taken when servicing the card.

1. Handle the card only by the edges and handle (do not touch the edge connectors). Do not touch any board surfaces or components not associated with the repair.
2. 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.
3. When making repairs on the circuit board, use aqua core solder and OA-based (organic activated) flux. Use warm deionized 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, blow dry the board with dry nitrogen gas.

NOTE

Removal of skin oils and other non-organic contaminants can be done with methanol or an HCFC.

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

4.3 Principles of operation

The following paragraphs discuss the basic operating principles for the Model 7174A. A schematic diagram of the matrix card may be found in drawings 9174-106 (mother board) and 9174-126 (air matrix relay board) located at the end of Section 5.

4.3.1 Block diagram

Figure 4-1 shows a simplified block diagram of the Model 7174A. Key elements include the buffer (U410), ID data circuits (U406, U408, and U410), relay drivers (U101 through U113), relays (K101-K204), and the power-on safe guard (U409). The major elements are discussed below.

4.3.2 ID data circuits

At power up, the card identification data information from each card is read by the mainframe. This ID data includes such information as card ID, hardware settling time for the card, and a relay configuration table, which tells the mainframe which relays to close for a specific crosspoint. This configuration table is necessary because some cards (such as the Model 7174A) require the closing of more than one relay to close a specific crosspoint.

ID Data is contained within an on-card ROM, U406. In order to read this information, the sequence below is performed upon power up. Figure 4-2 shows the general timing of this sequence.

1. The CARDSEL line is brought low, enabling the ROM outputs. This line remains low throughout the ID data transmission sequence.
2. The CLRADDR line is pulsed clearing the address counter to zero. At this point, a ROM address of zero is selected. This pulse occurs only once.
3. The NEXTADDR line is set low. NEXTADDR going low increments the counter and enables parallel loading of the parallel-to-serial converter. NEXTADDR is kept low long enough for the counter to increment and the ROM outputs to stabilize. This sequence functions because the load input of the parallel-to-serial converter is level sensitive rather than edge sensitive. The first ROM address is location 1, not 0.
4. The CLK line clocks the parallel-to-serial converter to shift all eight data bits from the converter to the mainframe via the IDDATA line.

The process in steps 3 and 4 repeats until all the necessary ROM locations have been read. A total of 498 bytes of information are read by the mainframe during the card ID sequence.

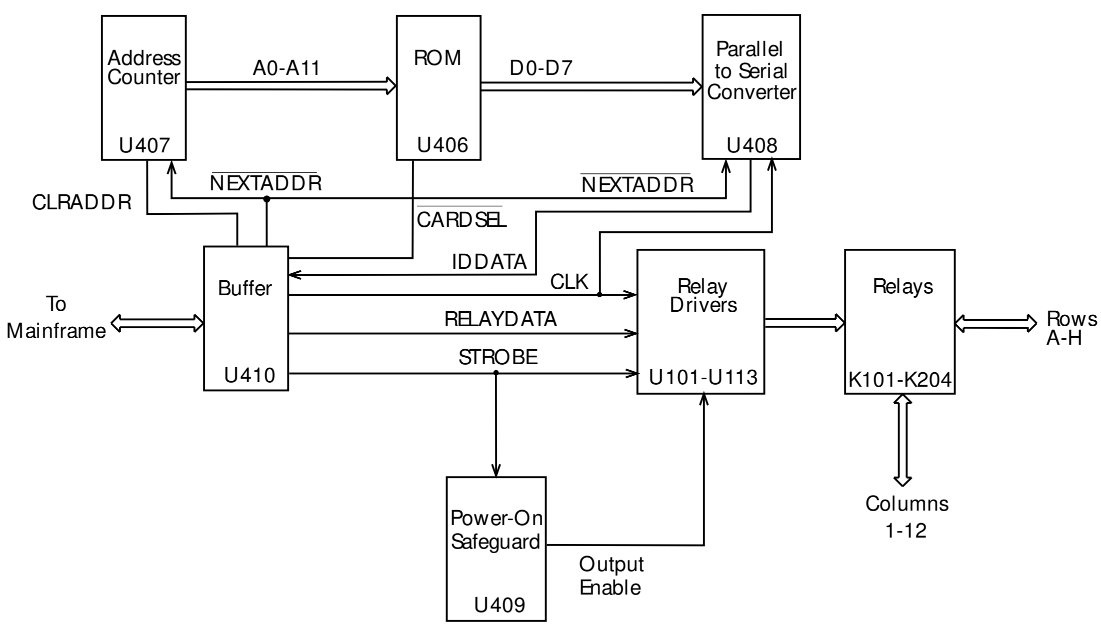
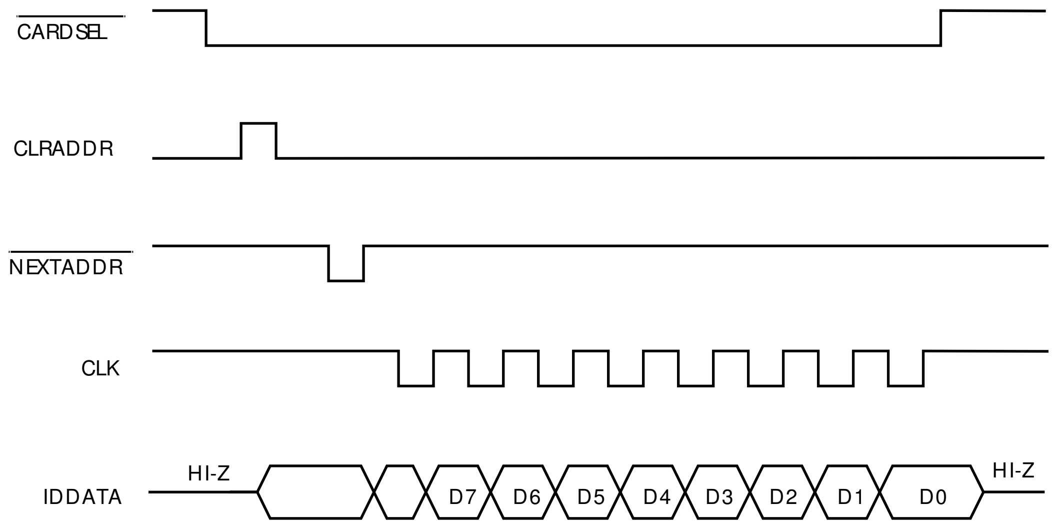


Figure 4-1
Model 7174A block diagram



Note: ID data sequence occurs on power-up only.
CLRADDR pulse occurs only once.

Figure 4-2
ID data timing

4.3.3 Relay control

The relays are controlled by serial data transmitted via the RELAY DATA line. A total of 16 bytes for each card are shifted in serial fashion into latches located in the 16 relay drivers, (U101 through U113). The serial data is fed in through the DATA lines under control of the CLK signal. As data overflows one register, it is fed out the Q's line of that register to the next IC down the chain.

Once all 16 bytes have been shifted into each card in the mainframe, 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 (assuming the driver outputs are enabled, as discussed below). Logic convention is such that the corresponding relay driver output must be low to energize the associated relay, while the output is high when the relay is de-energized. For example, if the Q1 output of U113 is low, relay K197 will be energized.

4.3.4 Power-on sequence

A power-on safeguard circuit, made up of U409 and associated components, ensures that relays do not randomly energize upon power-up. The two ANG gates, U409, make up an R-S flip-flop. Initially, the Q output of the flip-flop (pin 3 of U409) is set high upon power up. Since the OEN terminals of the relay drivers (U101 through U113) are held high, their outputs are disabled, and all relays remain de-energized regardless of the relay data information preset at that time.

The first STROBE pulse that comes along (in order to load relay data) clears the R-S flip-flop, setting the OEN lines of the relay drivers low to enable their outputs. This action allows the relays to be controlled by the transmitted relay data information.

A hold-off period of approximately 470msec is included in the safeguard circuit to guard against premature enabling of the relays. The time constant of the hold-off period is determined by the relative values of R419 and C419.

4.3.5 Isolator relays

Row isolator relays are necessary in addition to the crosspoint relays in order to ensure the integrity of signal pathways. Path isolator relays include K198-K204. The necessary isolator relay is closed in addition to the selected crosspoint to complete the entire pathway. For example, if crosspoint C10 (Row C, Column 10) is closed, relays K199 and K183 would be energized.

4.4 Troubleshooting

4.4.1 Recommended equipment

Table 4-1 summarizes the recommended equipment for general troubleshooting.

Table 4-1
Recommended troubleshooting equipment

Description	Manufacturer and model	Application
5½ digit DMM	Keithley 199	Measure DC voltages
Oscilloscope	TEK 2243	View logic waveforms
Extender card	Keithley 7070	Allow circuit access

4.4.2 Gaining circuit access

In order to gain access to the test points and other circuitry on the Model 7174A, the card must be plugged into the Model 7070 Extender Card, which, in turn, must be plugged into the desired slot of the mainframe. The Model 7070 must be configured as an extender card by placing the configuration jumper in the EXTEND position. See the documentation supplied with the Model 7070 for complete details on using the card.

NOTE

Do not use the Model 7070 for performing verification tests because its presence will affect the results.

4.4.3 Troubleshooting procedure

Table 4-2 summarizes the troubleshooting procedure for the Model 7174A Low Current Matrix Card. Some of the troubleshooting steps refer to the ID data timing diagram shown in Figure 4-2. Refer to paragraph 4.3 for an overview of operating principles.

Table 4-2
Troubleshooting procedure

Step	Test point/component	Required condition	Comments
1	DGND		All voltages referenced to DGND (digital common)
2	+6V	+6VDC	Relay voltage
3	+5V	+5VDC	Logic voltage
4	NXTADR	NEXT ADDR pulses	Power up only (Fig. 4-2)
5	CLRADR	CLR ADDR pulse	Power up only (Fig. 4-2)
6	IDDATA	ID data pulses	Power up only (Fig. 4-2)
7	STRB	STROBE pulse	End of relay data sequence
8	RLDAT	Relay data (128 bits)	Present when updating relays
9	CLK	CLK pulses	Present during relay data or ID data (Fig. 4-2)
10	OE	High on power up until first STROBE sets low.	Power on safe guard
11	U101-U113 pins 10-18	Low with relay energized, high with relay de-energized.	Relay driver outputs

4.5 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 work station. 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.

4.6 Performance verification

The following paragraphs discuss performance verification procedures for the Model 7174A, including relay testing, contact resistance, contact potential, path isolation, and leakage current.

4.6.1 Environment conditions

All verification measurements except for path isolation and offset current should be made at an ambient temperature of 21°C-25°C and a relative humidity of less than 0% R.H. Path isolation and offset current verification must be performed at an ambient temperature of 23°C and a relative humidity of less than 60% R.H. If the card has been subjected to temperatures or humidities outside of this range for even a short time, allow it to stabilize within these ranges for at least one hour before performing any tests.

4.6.2 Recommended test equipment

Table 4-3 summarizes the equipment necessary to make the performance verification tests, along with the application for each item.

Table 4-3
Recommended verification equipment

Qty.	Description	Application
1	Model 617 Electrometer	Offset current; path isolation
1	Model 196 6½ Digit DMM	Path resistance; electrometer
1	Model 707A Switching Matrix	All tests
4	Model 7078-TRX-10 triax cables*	Offset current; path resistance
2	Model 7078-TRX-3 triax cables	Path isolation; offset current; electrometer
1	Model 6172 2-slot male to 3-lug female triaxial adapter	Offset current; electrometer
3	Model 7078-TRX-T triax tee adapter	Path resistance
5	Banana plugs (part #BG-10-2*)	Path isolation and resistance
1	Model 263 Calibrator/Source	Electrometer
1	BNC to Right-angle SMB Cable (part #CA-93-1)	Electrometer
1	BNC to Dual Banana Adapter (Pomona part #1269)	Electrometer

*These items are used to construct special cables; see text and Figure 4-9.

4.6.3 Offset current verification

Recommended equipment

- Model 707A Switching Matrix
- Model 617 Electrometer
- Model 7078-TRX-3 Triax Cable
- Model 6172 2-slot male to 3-lug female triaxial adapter

Test connections

Figure 4-3 shows the test connections for offset current verification. The Model 7174A row being tested is to be connected to the Model 617 Electrometer input through the triaxial cable and the triaxial adapter. Note that the electrometer ground strap is to be removed, and the electrometer should be operated in the unguarded mode.

Procedure

NOTE

The following procedure should be performed at an ambient temperature of 23°C and at a relative humidity of less than 60%.

1. Turn on the Model 617 power and allow it to warm up for two hours before beginning the verification procedure
2. With the power off, install the Model 7174A in the desired slot of the Model 707A Switching Matrix. Remove all other cards from the instrument, and install the slot covers.
3. After the prescribed warm up period, select the amps function and the 2pA range on the Model 617. Zero correct the instrument, and then select autoranging.
4. Connect the Model 617 to row A of the Model 7174A, as shown in Figure 4-4.
5. Close crosspoint A1 by using the Model 707A front panel controls.
6. Disable zero check on the Model 617, and allow the reading to settle.
7. Verify that the offset current reading is <500fA.
8. Enable zero check on the Model 617, and open crosspoint A1.
9. Repeat steps 5 through 8 for crosspoints A2 through A12. Only one crosspoint at a time should be closed.
10. Disconnect the triax cable from row A, and connect it instead to row B.
11. Repeat steps 5 through 8 for crosspoints B1 through B12. Only one crosspoint at a time should be closed.
12. Connect the triax cable to each succeeding row and repeat steps 5 through 8 for each of the row's crosspoints.

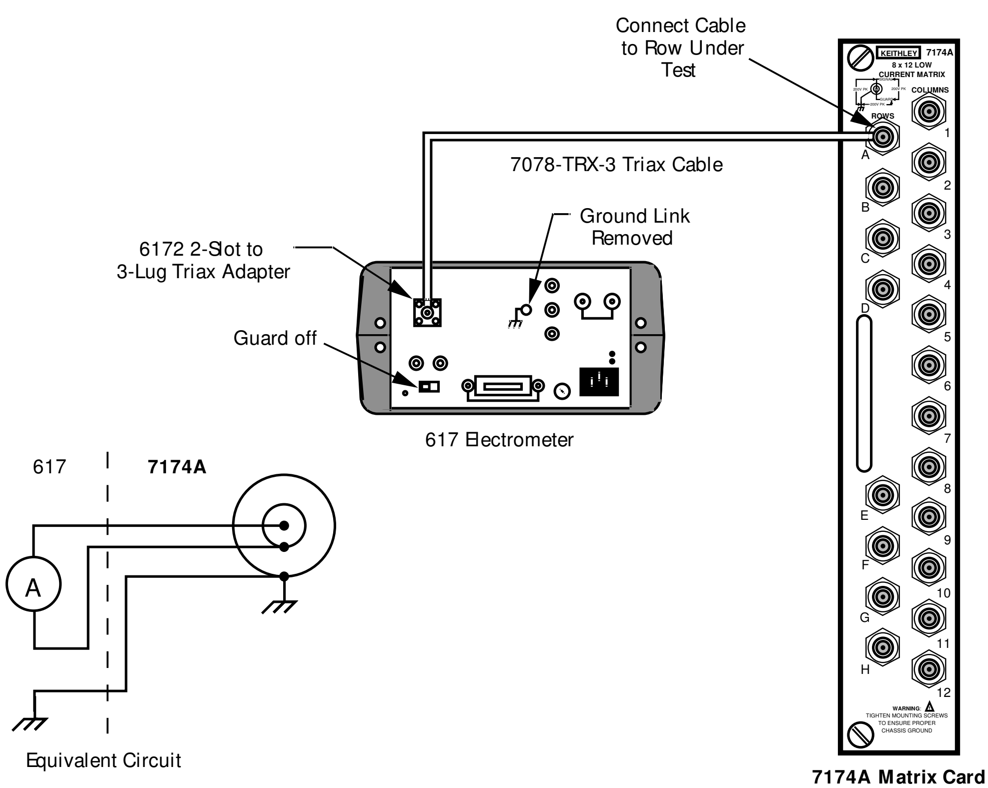


Figure 4-3
Offset verification test connections

4.6.4 Path isolation verification

The procedure for verifying path isolation is discussed below. Should the card fail any of the tests, clean it using the procedures outlined in paragraph 4.2.

Recommended equipment

- Model 707A Switching Matrix
- Model 617 Electrometer
- Model 7078-TRX-3 Triax Cable
- Unterminated 3-slot triaxial cable (cut connector off 7078-TRX-3)
- Banana plug (Keithley part #BG-10-2)
- #16-18AWG insulated stranded wire (6 in. length)

Test connections

Figure 4-4 shows the test connections for the path isolation tests. One row being tested is to be connected to the Model 617 Electrometer input through a Model 6172 2-slot female to 3-lug male triaxial adapter. The other row is to be connected to the voltage source HI terminal using a specially prepared 3-slot triax-to-banana plug cable, the construction of which is shown in Figure 4-5. Note that both the inner shield and the center conductor are to be connected to the banana plug as shown.

COM and LO terminal of the electrometer voltage source must be connected together as shown. Also, the ground link between COM and chassis must be removed, and the Model 617 guard must be turned off for current measurements.

Procedure

WARNING

Hazardous voltage from the electrometer voltage source will be used in the following steps. Take care not to contact live circuits, which could cause personal injury or death.

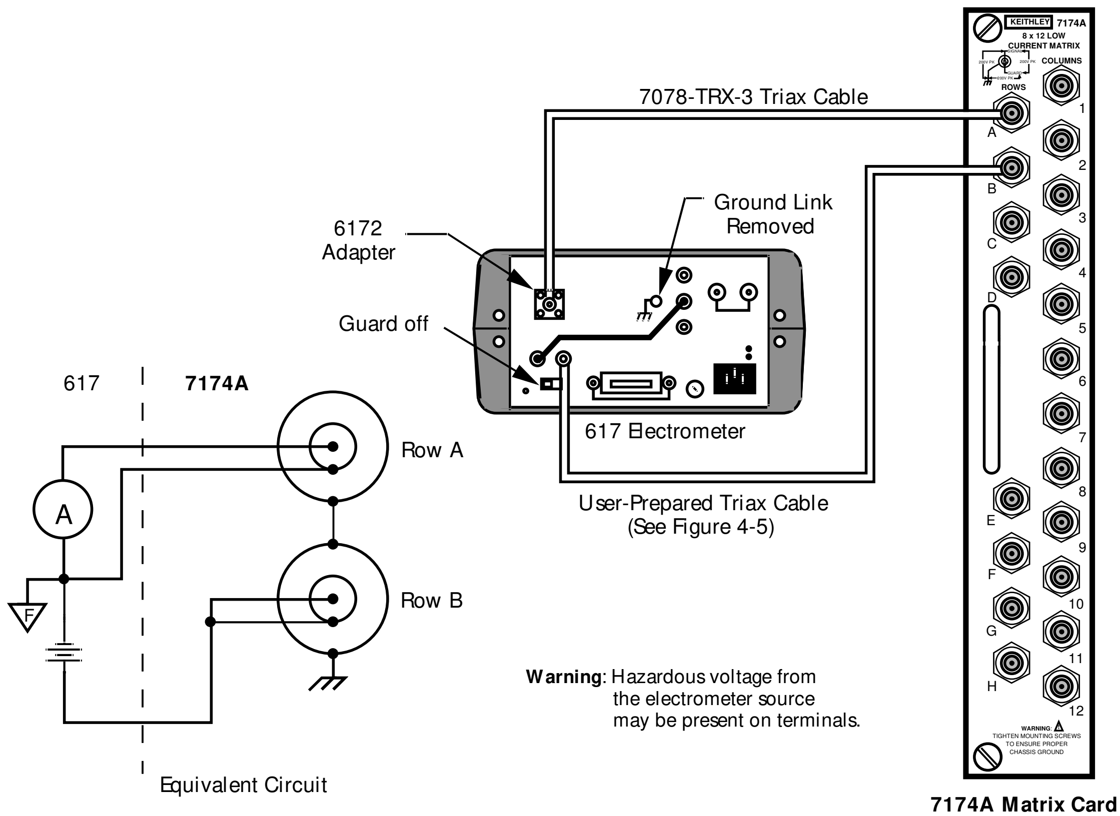


Figure 4-4
Connections for path isolation verification

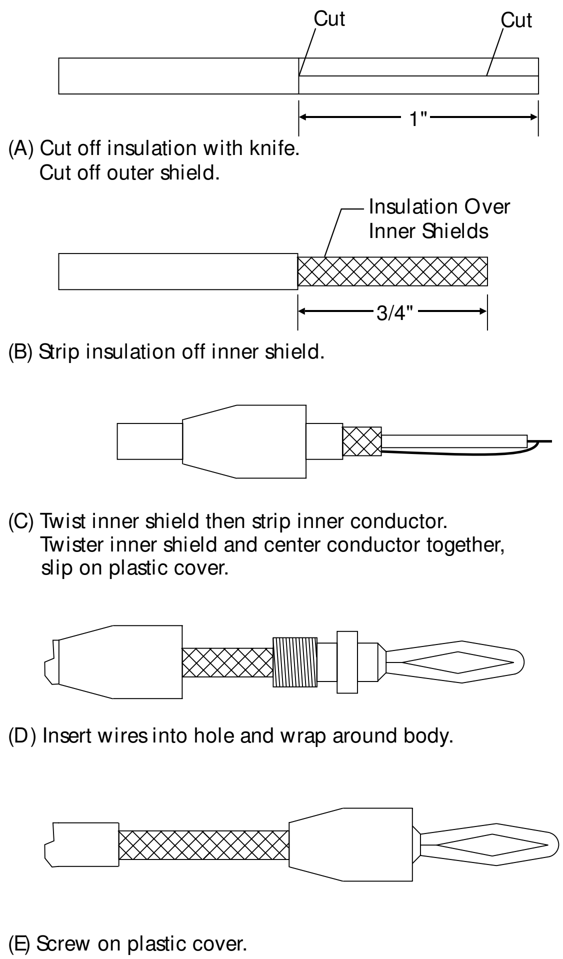


Figure 4-5
Triaxial cable preparation

NOTE

The following procedure must be performed at an ambient temperature of 23°C and at a relative humidity of less than 60%.

1. Turn on the Model 617 and allow it to warm up for two hours for rated accuracy.
2. With the mainframe power turned off, plug the Model 7174A into slot 1 of the mainframe. Remove all other cards from the mainframe, and install the slot covers.
3. After the prescribed warm up period, select the Model 617 amps function, and enable zero check. Select the 2pA range, and zero correct the instrument.
4. Connect the Model 617 to rows A and B of the matrix card, as shown in Figure 4-4.
5. Program the Model 617 voltage source for a value of +100V, but do not yet turn on the voltage source output.
6. Close crosspoints A1 and B2 by using the switching matrix front panel controls.
7. With the Model 617 in amps, enable suppress after the reading has settled.
8. Turn on the Model 617 voltage source output, and enable the V/I ohms function on the electrometer.
9. After the reading has settled, verify that the resistance is >67TΩ ($6.7\times10^{13}\Omega$).
10. Turn off the voltage source, and enable zero check. Disable suppress, and select the amps function on the electrometer.
11. Open crosspoints A1 and B2, and close crosspoints A3 and B4.
12. Repeat steps 7 through 11 for A3 and B4.
13. Repeat steps 7 through 12 for crosspoint pairs A5 and B6, A7 and B8, A9 and B10, and A11 and B12.
14. Disconnect the electrometer from rows A and B, and connect it instead to rows C and D.
15. Repeat steps 7 through 13 for rows C and D. The path isolation for these rows should be 67TΩ ($6.7\times10^{3}\Omega$).
16. Repeat steps 7 through 14 for row pairs E and F, and G and H. For each row pair, step through the crosspoint pairs 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, and 11 and 12. The complete procedure outlined in steps 7 through 11 should be repeated for each crosspoint pair. Each resistance measurement for rows E through H should be 67TΩ ($6.7\times10^{13}\Omega$).

4.6.5 Path resistance verification

The following paragraphs discuss the equipment, connections, and procedure to check path resistance. Should a particular pathway fail the resistance test, the relay (or relays) for that particular crosspoint is probably defective. See the schematic diagram at the end of Section 5 to determine which relay is defective.

NOTE

The following procedure verifies the resistance of the HI signal path. To verify the resistance of the GUARD path, modify the cable of Figure 4-5 to connect the inner shield to the banana plug and have no connection to the triax center conductor.

Recommended equipment

- Model 196 DMM
- 7078-TRX-T triax tee adapters (3)
- 237-BAN-3 triax to banana cables (4)

Connections

Figure 4-6 shows the connections for the path resistance tests. The Model 196 is to be connected to the row and column jacks using Model 237-BAN-3 triax/banana cables. These cables differ from the one in Figure 4-5 in that the inner shield and center conductor are not connected together.

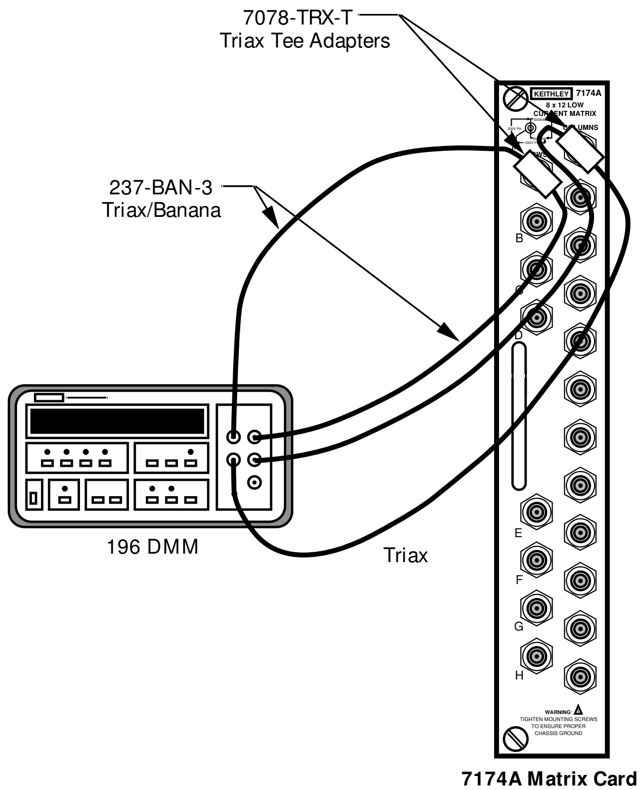


Figure 4-6
Connections for path resistance verification

Procedure

1. Turn on the Model 196 DMM and allow it to warm up for at least one hour before beginning the test.
2. With the power off, install the Model 7174A card in slot 1 of the mainframe.
3. Connect the four triaxial cables to the Model 196 and the two triax tee adapters (Figure 4-6), but do not yet connect the adapters to the Model 7174A.
4. Temporarily connect the two triax tee connectors together using a third triax tee adapter, as shown in Figure 4-7.
5. Select the ohms function, 300Ω range, and 6½ digit resolution on the Model 196.
6. After the reading settles, enable zero on the Model 196 DMM. Leave zero enabled for the remainder of the tests.
7. Disconnect the two triax tee adapters from the shorting adapter, and connect the two adapters with the cable to the row A and column 1 connectors on the Model 7174A (see Figure 4-6).
8. Close crosspoint A1, and allow the reading to settle.
9. Verify that the resistance reading is <1.5Ω.
10. Open the crosspoint, and disconnect the triax adapter from column 1. Connect the adapter to column 2.
11. Repeat steps 8 through 10 for columns 2 through 12. In each case, the column adapter must be connected to the column under test, and the crosspoint must be closed.
12. Disconnect the row adapter from row A, and connect it instead to row B.
13. Repeat steps 8 through 10 for row B. The crosspoints of interest here are B1 through B12. Also, the row adapter must be connected to the row being tested.
14. Repeat steps 8 through 13 for rows C through H. In each case, the crosspoint to close is the one corresponding to the row and column connections at that time. In all cases, the measured resistance should be <1.5Ω.

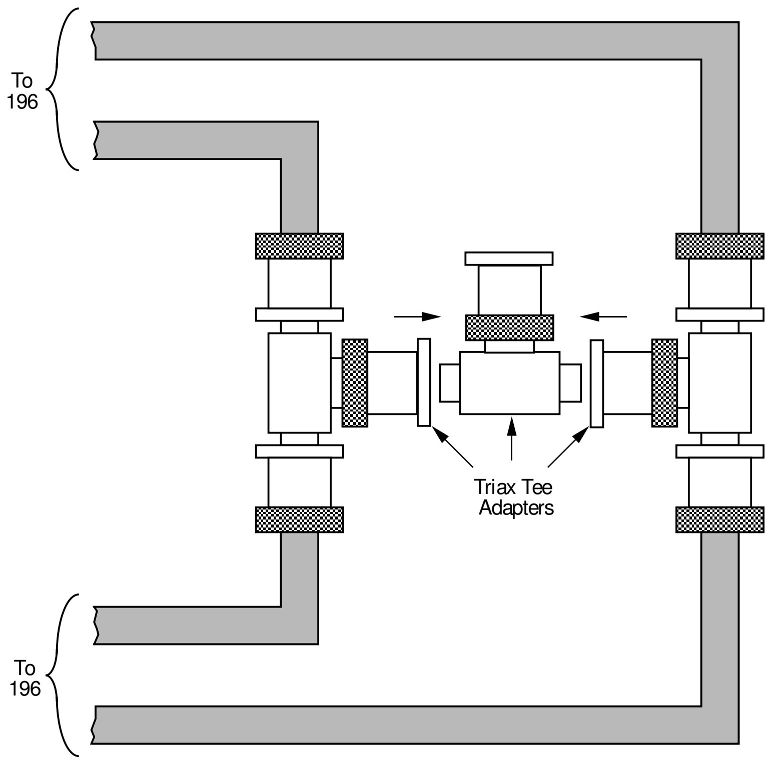


Figure 4-7
Shorting measurement paths using triax tee adapter

4.7 Reed pack replacement

If after performing troubleshooting or verification, a reed switch is thought to be faulty, it should be replaced. Note that reeds can only be replaced as a pack of three. The part number for a reed pack is RL-179. A reed pack maintenance kit, part number 9174-MK is also suggested.

Cross point relay

Use the following procedure and Figure 4-8 to replace cross point relay reed packs.

NOTE

Repairs should only be done from the component side of the board.

1. Remove the card and place on an anti-static surface.
2. Put on the gloves that came in the maintenance kit.
3. Carefully pry off the cover of the guard enclosure of the crossbar that includes the suspect reed. Take care not to break the wire that connects the cover to the front panel.
4. Carefully pry off the cross point interconnect board. Take care not to break the wires that connect the interconnect board to the front panel.
5. Using clean needle-noise pliers, carefully remove the reed pack in question.
6. Inspect the relay coil. If there is any debris or contamination, clean with methanol and blow out with dry nitrogen.

NOTE

When inserting reed pack, make sure long leads are inserted into relay coil (bobbin).

7. Using the reed pack insertion tool from the maintenance kit, install the new reed pack into bobbin making sure the long leads align with the holes at the base of the relay coil (bobbin).
8. Reinstall any reed packs that may have been removed when the cross point interconnect board was removed.
9. Reinstall the cross point interconnect board. Be sure that it is properly seated.
10. Reinstall the guard enclosure cover.
11. Allow the card to stabilize for one hour.
12. Retest the card to verify operation and specifications.

Isolator relay

Use the following procedure and Figure 4-9 to replace isolator relay reed packs.

NOTE

Repairs should only be done from the component side of the board.

1. Remove the card and place on an anti-static surface.
2. Put on the gloves that came in the maintenance kit.
3. Carefully pry off the cover of the guard enclosure. Take care not to break wires connecting the relay to the pathway interconnect board.
4. Using clean needle nose pliers, carefully disconnect the three wires that attach to the reed pack, taking note of the locations for each.
5. Remove the reed pack in question.
6. Inspect the reed pack socket. If there is any debris or contamination, clean with methanol and blow out with dry nitrogen.

NOTE

When inserting reed pack, make sure long leads are inserted into relay coil (bobbin).

7. Using the reed pack insertion tool from the maintenance kit, install the new reed pack into bobbin making sure the long leads align with the holes at the base of the relay coil (bobbin).
8. Reconnect the wires to the top of the reed pack.
9. Reinstall the guard enclosure cover.
10. Allow the card to stabilize for one hour.
11. Retest the card to verify operations and specifications.

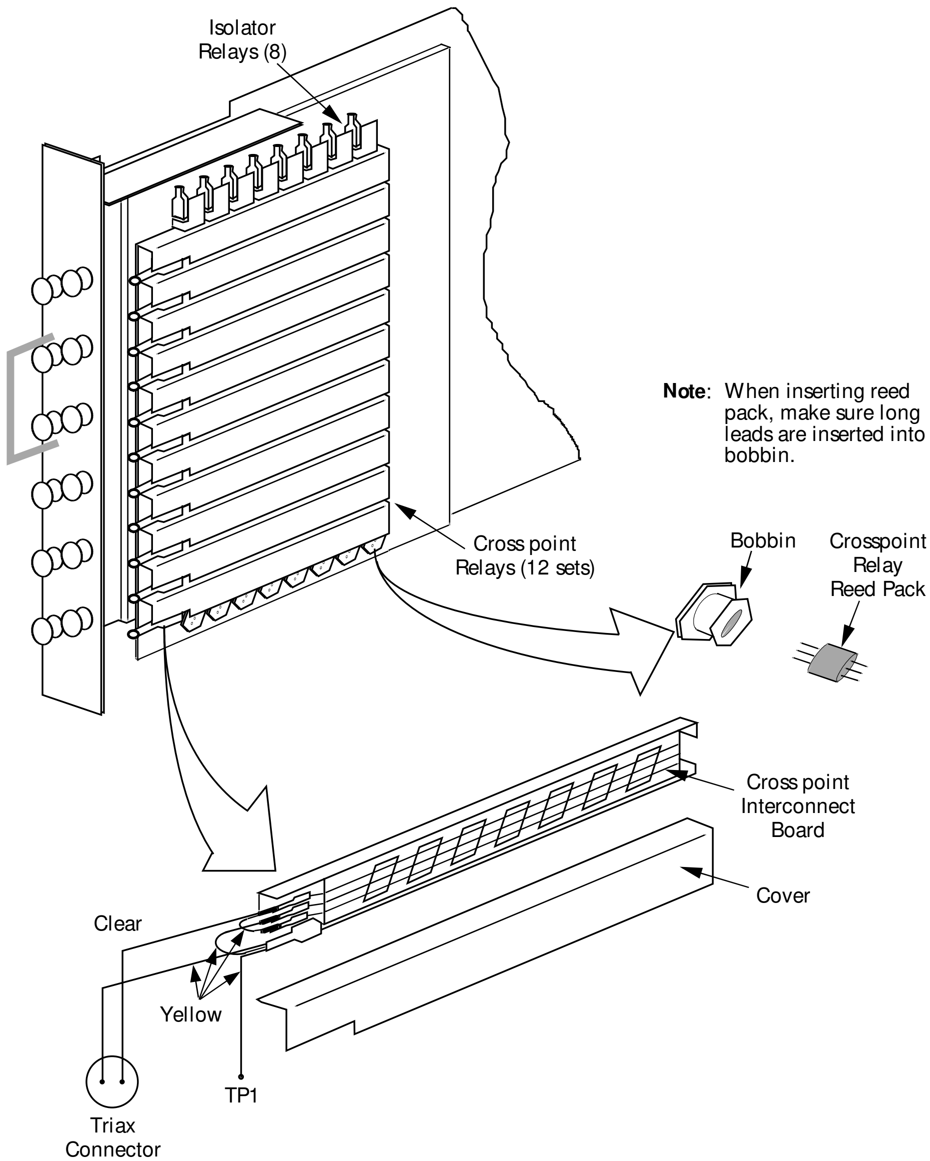


Figure 4-8
Cross point relays

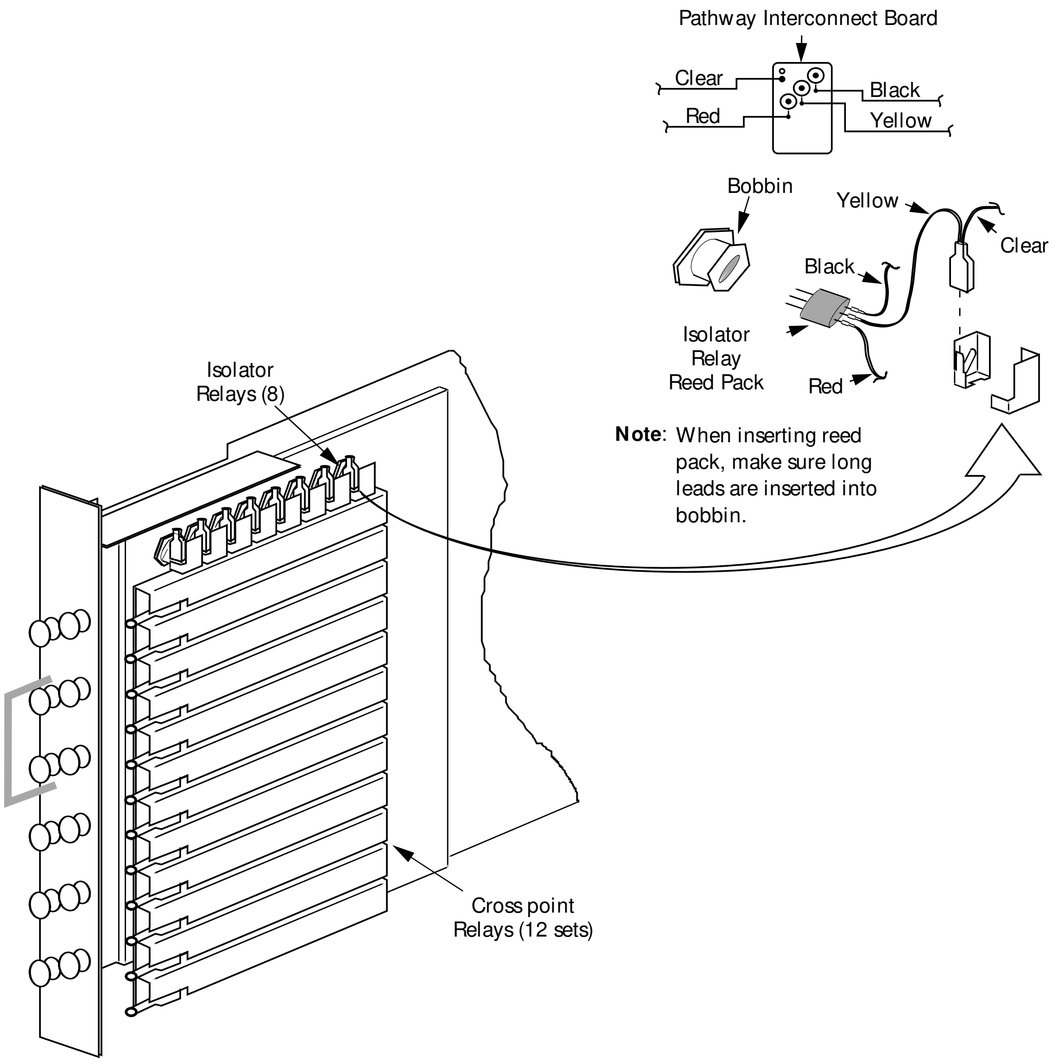


Figure 4-9
Isolator relays

5
Replaceable Parts

5.1 Introduction

This section contains a list of replaceable electrical and mechanical parts for the Model 7174A, as well as a component layout drawing and schematic diagram of the matrix card.

5.2 Parts list

Electrical parts are listed in order of circuit designation in Table 5-1. Table 5-2 summarizes mechanical parts.

5.3 Ordering information

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

1. Matrix card model number 7174A.
2. Card serial number
3. Part description
4. Circuit designation, if applicable
5. Keithley part number

5.4 Factory service

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

1. Call the Repair Department at 1-800-552-1115 for a Return Authorization (RMA) number.
2. Complete the service form located at the back of this manual, and include it with the unit.
3. Carefully pack the card in the original packing carton or the equivalent.
4. Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label. Note that it is not necessary to return the matrix mainframe with the card.

5.5 Component layout and schematic diagram

Mother board

- Component layout — 9174-100
- Schematic — 9174-106

Relay board

- Component layout — 9174-120
- Schematic — 9174-126 (sheets 1 and 4 only)

Pathway interconnect board

- Component layout — 7174-160
- Schematic — 7174-166

Table 5-1
Model 7174A electrical parts list

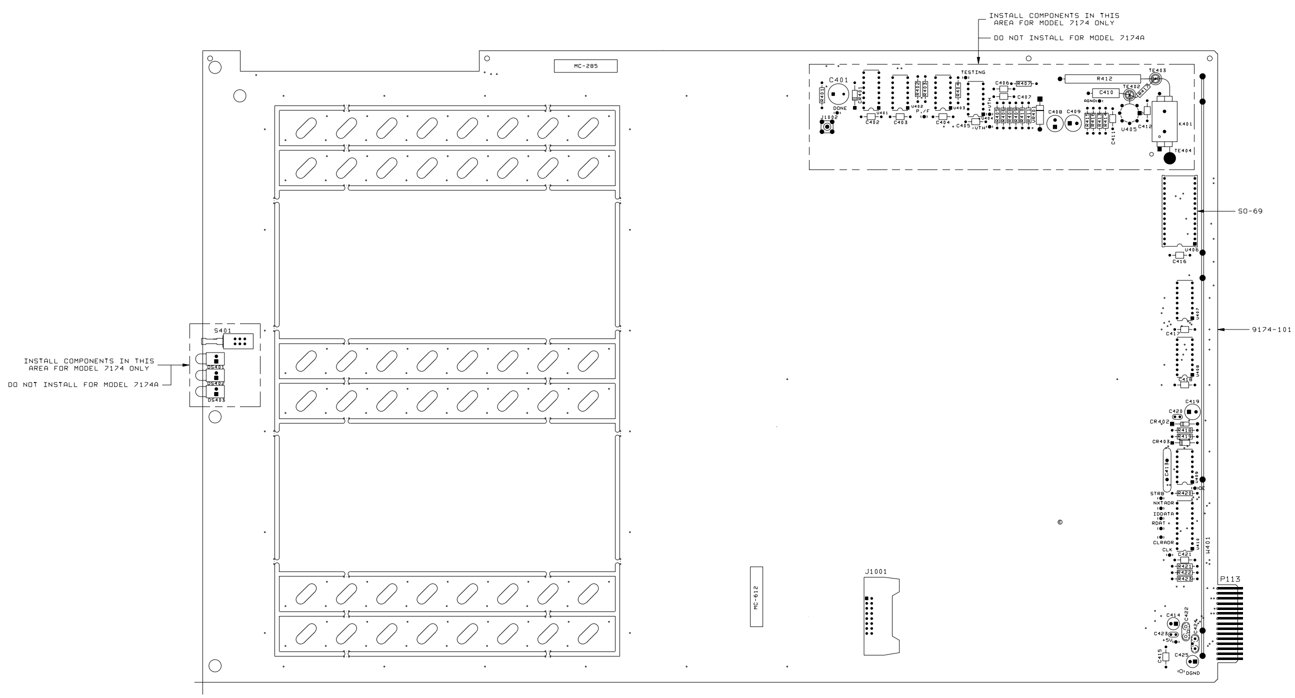
Circuit Desig.	Description	Keithley Part No.
C101-113	CAP, .1µF, 20%, 50V, CERAMIC	C-365-.1
C415-418, 421	CAP, .1µF, 20%, 50V, CERAMIC	C-365-.1
C413	CAP, .01µF, 10%, 1000V, CERAMIC	C-64-.01
C414, 425	CAP, 10µF, -20+100%, 25V, ALUM ELEC	C-314-10
C419	CAP, 47µF, 10%, 16V, ALUM ELEC	C-321-47
C420, 423	CAP, .01µF, 20%, 50V, CERAMIC	C-237-.01
C422, 424	CAP, 270pF, 20%, 100V, CERAMIC/FERRITE	C-386-270P
CR403	DIODE, SILICON, IN4148 (DO-35)	RF-28
CR402	DIODE, SCHOTTKY, IN5711	RF-69
J1001	CONNECTOR	CS-598
J1001-1003	CONNECTOR, MALE	CS-389-2
K101-204	REED PACK 3 FORM, DUAL GUARDED	RL-179
K101-204	RELAY, AIR MATRIX BOBBIN	RL-177
R101-128	RES, 22M, 5%, 1/4W, COMPOSITION OR FILM	R-76-22M
R417, 418	RES, 10K, 5%, 1/4W, COMPOSITION OR FILM	R-76-10K
R419	RES, 47K, 5%, 1/4W, COMPOSITION OR FILM	R-76-47K
R420	RES, 200, 5%, 1/4W, COMPOSITION OR FILM	R-76-200
R421	RES, 680, 5%, 1/4W, COMPOSITION OR FILM	R-76-680
R422	RES, 120K, 5%, 1/4W, COMPOSITION OR FILM	R-76-120K
R423	RES, 11K, 5%, 1/4W, COMPOSITION OR FILM	R-76-11K
U101-113	IC, 8-BIT SERIAL-IN LATCH DRIVER, 5841A	IC-536
U406	PROGRAM	7174-800A02*
U407	IC, 12 STAGE BINARY COUNTER, 74HCT4040	IC-545
U408	IC, 8-BIT PARALLEL TO SERIAL, 74HCT165	IC-548
U409	IC, QUAD 2 INPUT NAND, 74HCT00	IC-399
U410	IC, OCTAL BUFFER/LINE DRIVER, 74HC244	IC-489
W401	STIFFENER, BOARD	J-16

*Order present firmware revision level.

Table 5-2
Model 7174A mechanical parts list

Description	Keithley Part No.
#4-40X1/4 PHILLIPS PAN HD SEMS SCREW (9174-162 BOARD TO BRACKETS)	4-40X1/4PPHSEM
#6-32X3/8LG. PHIL FLAT HD SCR (HANDLE MTG)	6-32X3/8PFH
#6-32X5/16PHIL PAN HED SEMS SCR (R. PANEL TO MB; BRKT TO BD)	6-32X5/16PPHSEM
#6-32 PEM NUT	FA-135
8 POS INTERCONNECT	9174-315B
13 POS INTERCONNECT	9174-314B
BRACKET	9174-307A
BRACKET	9174-308A
CABLE	CA-121A
CABLE ASSEMBLY, 16 CONDUCTOR	CA-27-13C
CAP, PROTECTIVE	CAP-30-1
CONN, TEST POINT (DONE,IDDATA,NXTADR,OR,P,/F,RDAT,STRB)	CS-553
CONN, TEST POINT (+5V, +VTH, -VTH,AGND,CLK,CLRADR,DGND)	CS-553
CONNECTOR (ON SC-120-4)	CS-236
FASTENER	FA-257-1
FEMALE, BULKHEAD MOUNT RECEPTACLE	CS-824
GROUND CLIP	9174-313A
GUARD TUBE, BASE	9174-301A
GUARD TUBE, LID	9174-302A
GUARD TUBE, BASE	9174-303A
GUARD TUBE, LID	9174-304A
GUARD TUBE, BASE	9174-305A
GUARD TUBE, LID	9174-306A
HANDLE	HH-33-1
LOCKNUT (REL BD TO FASTENERS, BRKT TO BD)	FA-226-1
LUG (ON SC-83, SC-120-4)	LU-108-2
LUG (ON SC-120-4)	LU-108-2
REAR PANEL ASSEMBLY	7174A-301A
SOCKET (SOLDERED ON SC-83 AND SC-120-4)	SO-144
SOCKET, I.C. 28 PIN (FOR U406)	SO-69
SPACER, LID	9174-316A
STRIP TERMINAL (FOR SC-111)	CS-812
SUPPORT	9174-309A
TEFLON TWISTED PAIR SHLD	SC-83
TERMINAL, BIFURCATED (TEFLON)	TE-119
TEST PIN	TE-108
TRIAX CONNECTOR (FOR SC-111	CS-827
WIRE, SINGLE CONDUCTOR	SC-120-4

LTR.	ECO NO.	REVISION	ENG.	DATE
A	940725	RELEASED	SZ	7-25-94
B	16785	CHG'D ARTWORK FROM REV A TO B.	SZ	11-7-94
B1	20589	ADDED DO NOT INSTALL FOR MODEL 7174A		



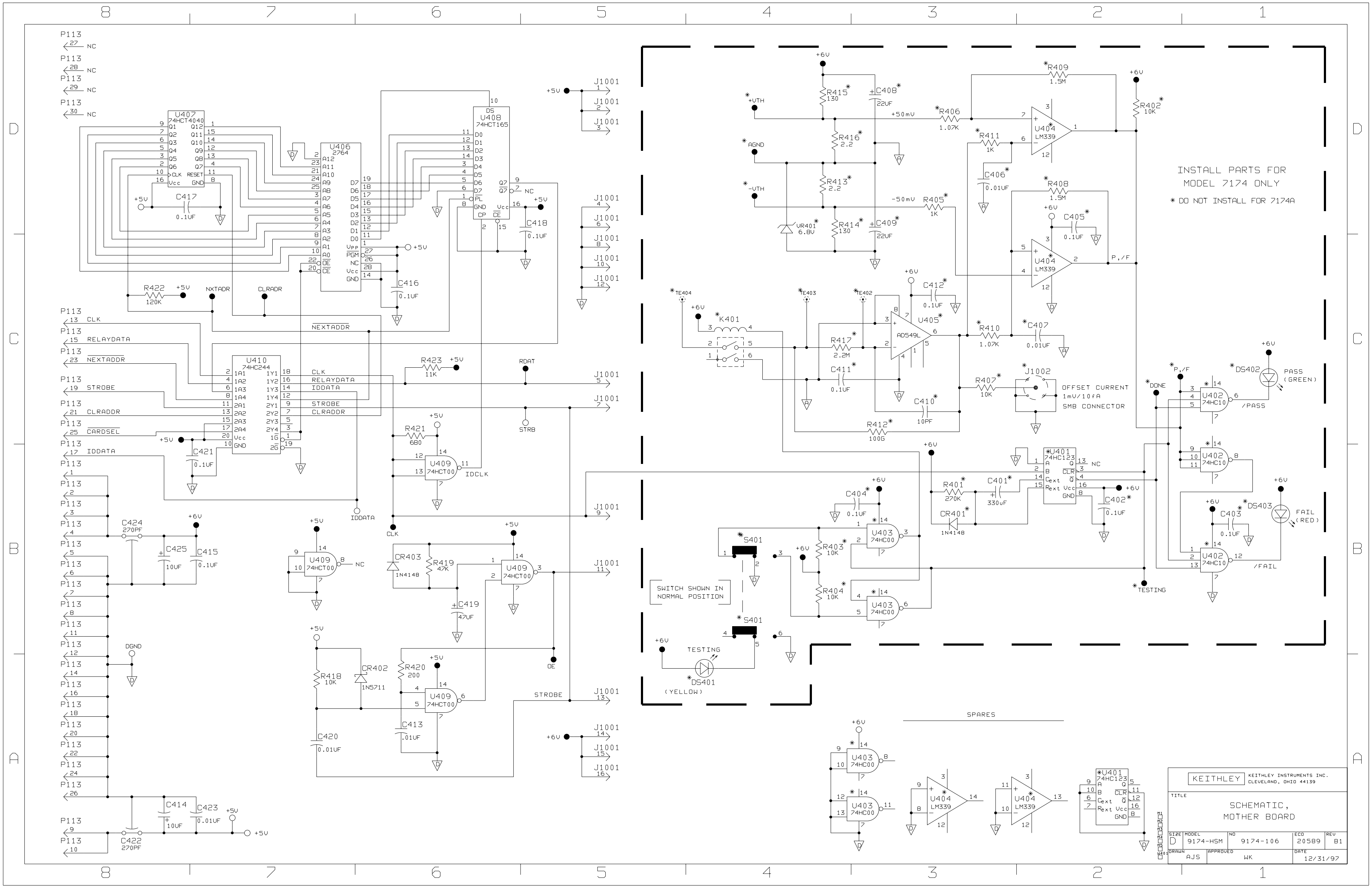
NOTE:
FOR COMPONENT INFORMATION REFER TO 9174-HSM, 9174-HSMI, AND 7174 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
9174-HSM		1
9174-HSMI		1
7174A		1

USED ON

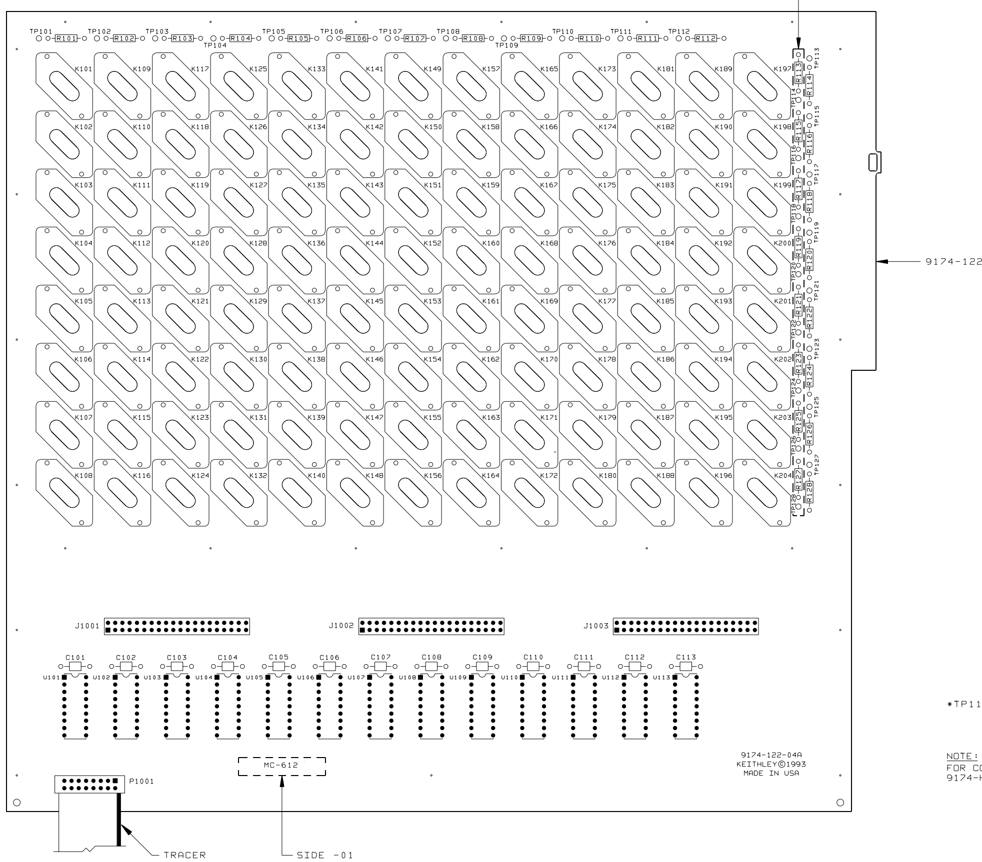
DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 6/9/94	SCALE 1:1	TITLE COMPONENT LAYOUT, MOTHER BOARD
	XX=±.015 ANG.=±1°	DRN. AJS	ENG. APPR. WK	
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XXX=±.005 FRAC.=±1/64	MATERIAL N/A		D NO. 9174-100
	SURFACE MAX.	FINISH N/A		

NO. 9174-100


INSTALL PARTS FOR
MODEL 7174 ONLY
* DO NOT INSTALL FOR 7174A
SWITCH SHOWN IN
NORMAL POSITION
OFFSET CURRENT
1mV/10fA
SMB CONNECTOR
SPARES
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC,
MOTHER BOARD
D 9174-HSM 9174-106 20589 B1
AJS WK 12/31/97

LTR.	ECO NO.	REVISION	ENG.	DATE
A	940919	RELEASED	SZ	9/19/94

INSTALL RESISTORS IN THIS ROW
FOR MODELS 9174-HSMI & 7174 ONLY



*TP113-TP128 NOT INSTALLED

NOTE:
FOR COMPONENT INFORMATION REFER TO 9174-HSM, 9174-HSMI, AND 7174 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
7174		1
9174-HSMI		1
9174-HSM		1

USED ON

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 8/17/94	SCALE 1:1
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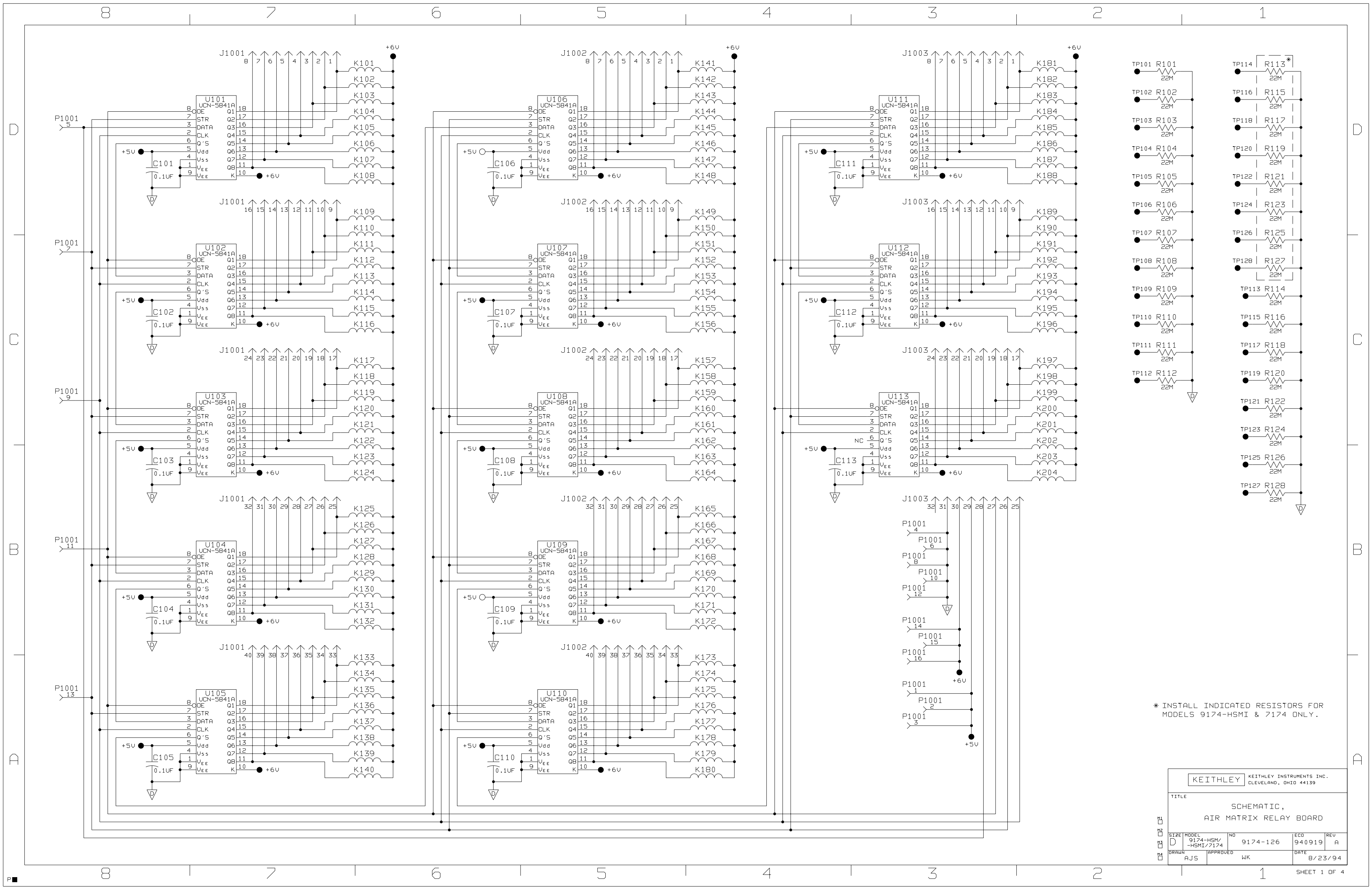
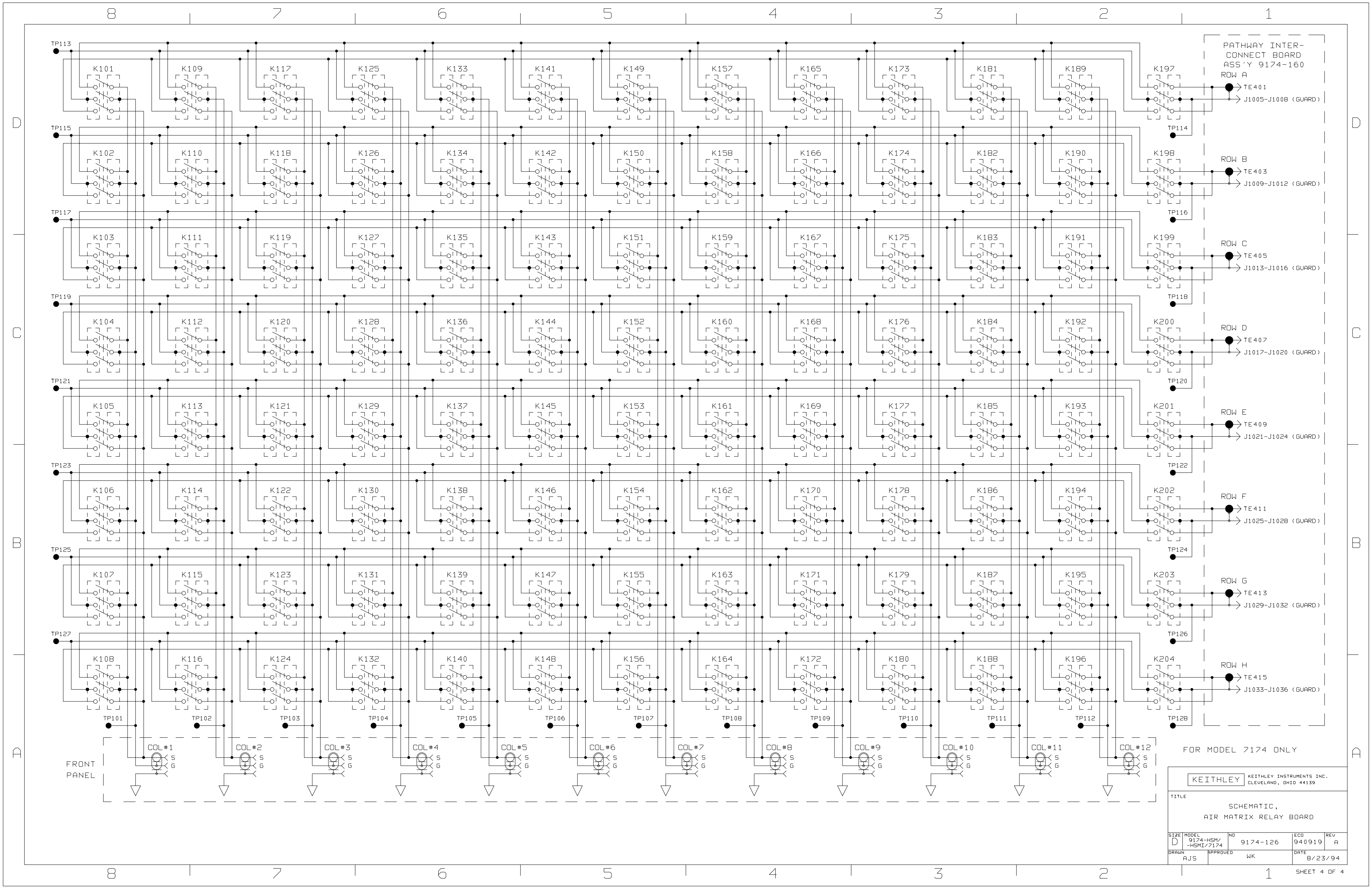
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XXX=±.005 FRAC.=±1/64	MATERIAL N/A	
	SURFACE MAX. 63	FINISH N/A	

TITLE COMPONENT LAYOUT, AIR MATRIX RELAY BOARD

C NO. 9174-120



* INSTALL INDICATED RESISTORS FOR
MODELS 9174-HSMI & 7174 ONLY.
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC,
AIR MATRIX RELAY BOARD
SIZE D
MODEL 9174-HSM/ -HSMI/7174
NO 9174-126
ECO 940919
REV A
DRAWN AJS
APPROVED WK
DATE 8/23/94
SHEET 1 OF 4


PATHWAY INTER-
CONNECT BOARD
ASS'Y 9174-160
ROW A
TE401
J1005-J1008 (GUARD)
ROW B
TE403
J1009-J1012 (GUARD)
ROW C
TE405
J1013-J1016 (GUARD)
ROW D
TE407
J1017-J1020 (GUARD)
ROW E
TE409
J1021-J1024 (GUARD)
ROW F
TE411
J1025-J1028 (GUARD)
ROW G
TE413
J1029-J1032 (GUARD)
ROW H
TE415
J1033-J1036 (GUARD)
FRONT
PANEL
COL#1
COL#2
COL#3
COL#4
COL#5
COL#6
COL#7
COL#8
COL#9
COL#10
COL#11
COL#12
FOR MODEL 7174 ONLY
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC,
AIR MATRIX RELAY BOARD
SIZE D
MODEL 9174-HSM/ -HSMI/7174
NO 9174-126
ECO 940919
REV A
DRAWN AJS
APPROVED WK
DATE 8/23/94
SHEET 4 OF 4

NO. 7174-160

LTR.	ECO NO.	REVISION	ENG.	DATE
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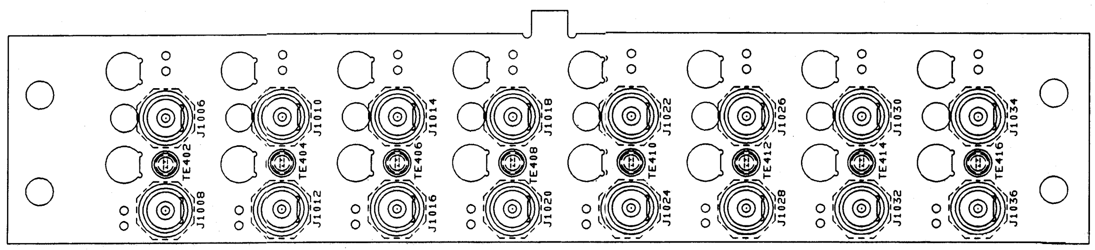

NOTE: FOR MORE COMPONENT INFORMATION REFER TO 7174 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

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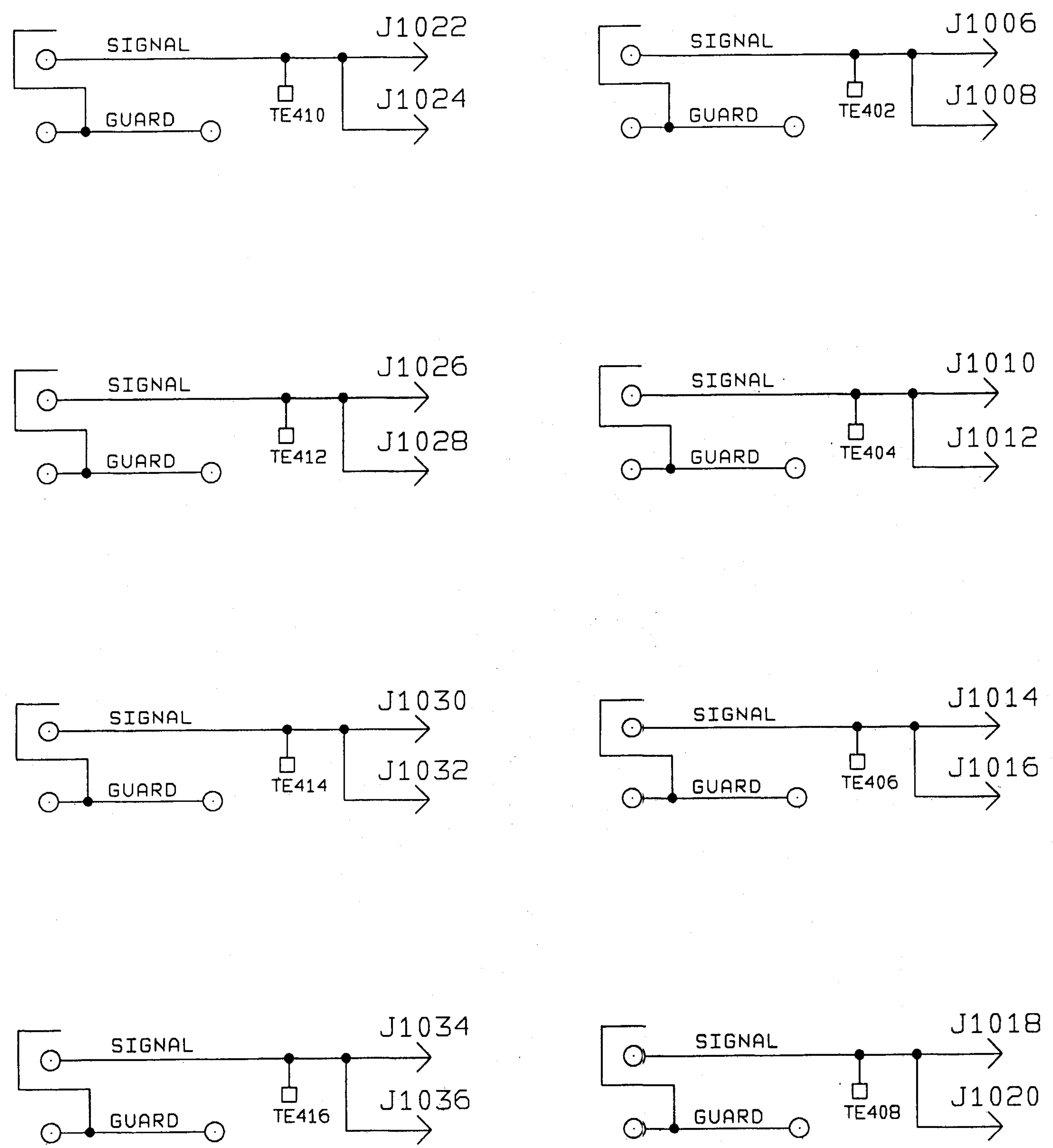
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO	XX=±.015 ANG.=±1°	DRN. MAH	ENG. APPR.	
	XXX=±.005 FRAC.=±1/64	MATERIAL —		C NO. 7174-160
	SURFACE MAX. 63	FINISH —		



KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

TITLE: SCHEMATIC, PATHWAY INTERCONNECT BD.

SIZE	MODEL	NO	ECO	REV
B	7174	7174-166	940602	A

DRAWN	APPROVED	DATE
MAH	M.K.	5/26/94

Index

U

W

KEITHLEY

Service Form

Model No. ____________________ **Serial No.** ____________________ **Date** ____________

Name and Telephone No. ____

Company ____

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

____

____

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

Display or output (check one)

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

- ❑ Calibration only
- ❑ Certificate of calibration required
- ❑ Data 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.

KEITHLEY

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

Printed in the U.S.A.