Model 7153 High Voltage Low Current Matrix Card

Instruction Manual

Contains Operating and Servicing Information

KEITHLEY

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 7153 High Voltage Low Instruction Manual

Test Instrumentation Group

Cleveland, Ohio, U.S.A.
November 1990, First Printing
Document Number: 7153-901-Rev. A

SAFETY PRECAUTIONS

The following safety precautions should be observed before using the Model 7153 and the associated instruments.

This matrix card is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over this manual carefully before using the card.

ALWAYS remove power from the entire system (mainframe, test instruments, DUT, etc.) and discharge any capacitors before doing any of the following:

1. Installing or removing the matrix card from the mainframe.
2. Connecting or disconnecting cables from the matrix card.

Exercise extreme caution when a shock hazard is present at the test fixture. User-supplied lethal voltages may be present on the fixture or the connector jack. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS or 42.4V peak are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Do not exceed 1300V between any two pins or between any pin and chassis ground.

Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the test fixture, test cables or any instruments while power is applied to the circuit under test.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground.

Do not exceed the maximum signal levels of the test fixture, as defined in the specifications and operation section of this manual.

Do not connect the matrix card (or any other instrumentation) to humans.

Do not connect the matrix card directly to unlimited power circuits. This product is intended to be used with impedance limited sources. NEVER connect the matrix card directly to AC mains.

When connecting sources, install protective devices to limit fault current and voltage to the card.

The chassis connections must only be used as shield connections for measuring circuits; NOT as safety earth ground connections.

The outer shields (including the triax connector shells) of the Model 7153-TRX are not connected to safety earth ground. NEVER apply more than 30V to these shields.

To prevent voltages from being exposed or connections from shorting together, make sure cables are properly connected before applying voltage. Do not apply power to cables that are not connected.

Model 7153 Specifications

MATRIX CONFIGURATION: 4 rows by 5 columns.
CROSSPOINT CONFIGURATION (Signal and Guard): 2-pole Form A.
CONNECTOR TYPE: Miniature coax, M-Series Receptacle.
RELAY DRIVE CURRENT: 40mA (per crosspoint).
MAXIMUM SIGNAL LEVEL:
- 1A carry / 0.5A switched.
- 10VA peak (resistive load).
- **Maximum Between Any 2 Pins or Chassis:** 1300V.
- **Maximum Between Signal and Guard:** 200V.

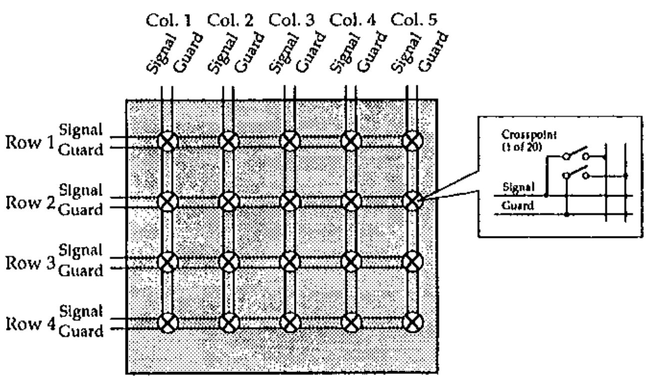
CONTACT LIFE:
- **Cold Switching:** 10^8 closures.
- **Maximum Signal Level:** 10^5 closures.

PATH RESISTANCE: <1Ω per contact to rated life.
ACTUATION TIME: <2ms exclusive of mainframe.
ISOLATION:
- **Path to Path:** $>10^{13}\Omega$ and <1pF.
- **Differential (Signal to Guard):** $>10^{11}\Omega$ and <100pF.
- **Common Mode (Signal and Guard to Chassis):** $>10^{9}\Omega$ and <300pF.

CROSSTALK (Adjacent Path to Path): <-50dB at 1MHz, 50 Ω load.
INSERTION LOSS (1 MHz, 50Ω Source, 50Ω Load): 0.1 dB typical.
3dB BANDWIDTH (50Ω Load): 60 MHz typical.
OFFSET CURRENT (Signal to Guard): <1pA (10fA typical).
CONTACT POTENTIAL (Signal to Guard): <50µV typical.
ENVIRONMENT:
- **Isolation and Offset Current Specifications:** 23°C, <60% R.H.
- **Operating:** 0° to 50°C, up to 35°C at 70% R.H.
- **Storage:** -25° to 65°C.

DIMENSIONS, WEIGHT: 30mm high x 114mm wide x 288mm long (1.18 in. x 4.5 in. x 11.34 in.). Net weight 0.60 kg (20.0 oz.).
ACCESSORY SUPPLIED: Instruction manual.

Specifications subject to change without notice.



7153

SECTION 1
General Information

Contains information on Model 7153 features, specifications, and accessories.

SECTION 2
Operation

Details installation of the Model 7153 High Voltage Low Current Matrix Card within the Model 705 and 706 scanners, covers card connections, and also discusses matrix mainframe programming and measurement considerations.

SECTION 3
Applications

Gives three typical applications for the Model 7153, including semiconductor switching matrix, van der Pauw resistivity measurements, and semiconductor parameter analysis using the HP 4145B.

SECTION 4
Service Information

Contains Matrix card cleaning and performance verification procedures for the matrix card.

SECTION 5
Replaceable Parts

Lists replacement parts, and also includes component layout and schematic drawing for the Model 7153

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SECTION 1
General Information

1.1 INTRODUCTION

This section contains general information about the Model 7153 High Voltage Low Current Matrix Card and is arranged as follows:

1.2 Features

1.3 Warranty Information

1.4 Manual Addenda

1.5 Safety Symbols and Terms

1.6 Specifications

1.7 Unpacking and Inspection

1.8 Repacking for Shipment

1.9 Optional Accessories

1.2 FEATURES

Key features of the Model 7153 High Voltage Low Current Matrix Card include:

- 4 × 5 (four row by five column) switching matrix.
- Low offset current for low-current measurements.

1.3 WARRANTY INFORMATION

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7153 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the matrix card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

1.4 MANUAL ADDENDA

Any improvements or changes concerning the matrix card or manual will be explained in an addendum included with the 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 1kV or greater may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information 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 7153 specifications are located at the front of this manual. These specifications are exclusive of the mainframe specifications, which are located in their respective instruction manuals.

1.7 UNPACKING AND INSPECTION

1.7.1 Inspection for Damage

Upon receiving the Model 7153, 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 7153 order:

- Model 7153 High Voltage Low Current Matrix Card.
- Model 7153 Instruction Manual.
- Additional accessories as ordered.

1.7.3 Additional Instruction Manual

If an additional instruction manual is required, order the manual package, Keithley part number 7153-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 REPACKING FOR SHIPMENT

Should it become necessary to return the Model 7153 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Advise as to the warranty status of the 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 CABLE ASSEMBLY

The following cable assembly is available to make connections to the Model 7153.

Model 7153-TRX — This 2-meter cable assembly is made up of five individual triax cables. One end of the cable assembly is terminated with a miniature, multiple-contact plug that will mate to the matrix card receptacles. The other end of the cable assembly is terminated with five 3-slot male triax connectors.

NOTE

Adapters that are available from Keithley are listed in Table 2-1.

SECTION 2
Operation

2.1 INTRODUCTION

This section contains information on aspects of matrix card operation and is arranged as follows:

2.2 Handling Precautions: Details precautions that should be observed when handling the matrix card to ensure that its performance is not degraded due to contamination.

2.3 Environmental Considerations: Outlines environmental aspects of using the Model 7153.

2.4 Equivalent Circuit: Provides the simplified matrix card circuit for the Model 7153.

2.5 Card Installation and Removal: Covers the basic procedures for installing and removing the matrix card from the Model 705 or 706 mainframe.

2.6 Connections: Discusses card connectors, cables and adapters, and typical connections to other instrumentation and DUT test fixtures.

2.7 Matrix Expansion: Shows how to expand the matrix by connecting two or more matrix cards together.

2.8 Mainframe Control of Matrix Card: Covers the operating aspects specific to the Model 7153.

2.9 Measurement Considerations: Reviews a number of considerations when making low-level measurements.

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 resistances, degrading performance.

To avoid possible contamination, always grasp the card by the side edges. Do not touch the edge connectors of the card and do not touch board surfaces or components. When not installed in a mainframe, keep the card in the bag and store in the original packing carton.

Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the mainframe and matrix card only in a clean environment.

If the card should become contaminated, it should be thoroughly cleaned as explained in paragraph 4.2.

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. Note that current offset and path isolation values are specified within a lower range of limits than the general operating environment.

2.4 EQUIVALENT CIRCUIT

A simplified schematic of the Model 7153 4 × 5 matrix card is shown in Figure 2-1. Each of the 20 crosspoints is made up of a two-pole switch. In this simple configuration any row can be connected to any column by closing the appropriate crosspoint. Mainframe control of matrix crosspoints is covered in paragraph 2.8.

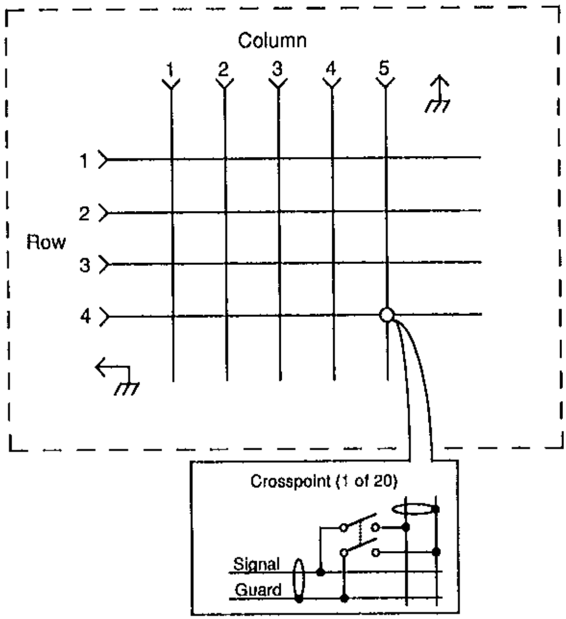


Figure 2-1. Schematic of Model 7153

NOTE

A diagram of the Model 7153 is provided in Appendix A. This system configuration worksheet makes it convenient to plan a matrix system. Additional space is provided for drawings and notes.

2.5 CARD INSTALLATION AND REMOVAL

The following procedures explain how to install and remove the Model 7153 matrix card from the Models 705 and 706 mainframes.

WARNING

To prevent electrical shock which could result in injury or death, turn off the mainframe power and disconnect the line cord before installing or removing matrix cards. If there are

cables connected to the card, also remove power from those circuits before proceeding.

CAUTION
Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the side edges. Do not touch the board surfaces or components.

2.5.1 Matrix Card Installation

Perform the following procedure to install the Model 7153 matrix card in either the Model 705 or Model 706 mainframe. Refer to Figure 2-2 to install the card in the Model 705 and refer to Figure 2-3 to install the card in the Model 706.

1. Slide the card into the desired slot as shown in the appropriate illustration. Make sure the card edges of the bottom shield board are properly aligned with the grooves in the receptacle.
2. Once the card is almost all the way in the slot, and you encounter resistance, push firmly on the edge of the card to seat it in the edge connector.
3. Once the card is fully seated, lock the card in place by placing the latches in the locked position.

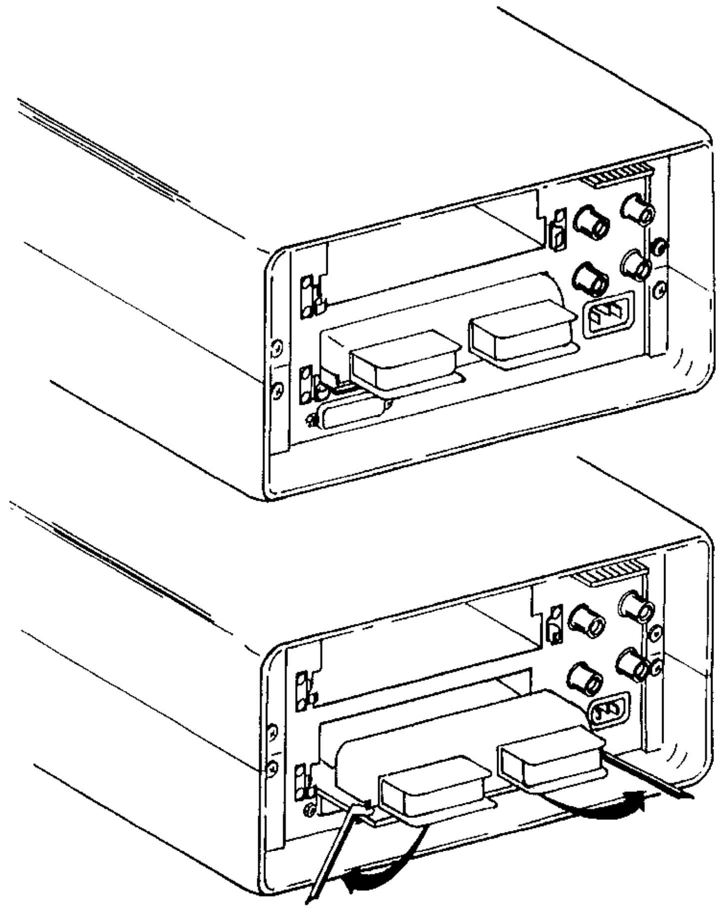


Figure 2-2. Card Installation in a Model 705

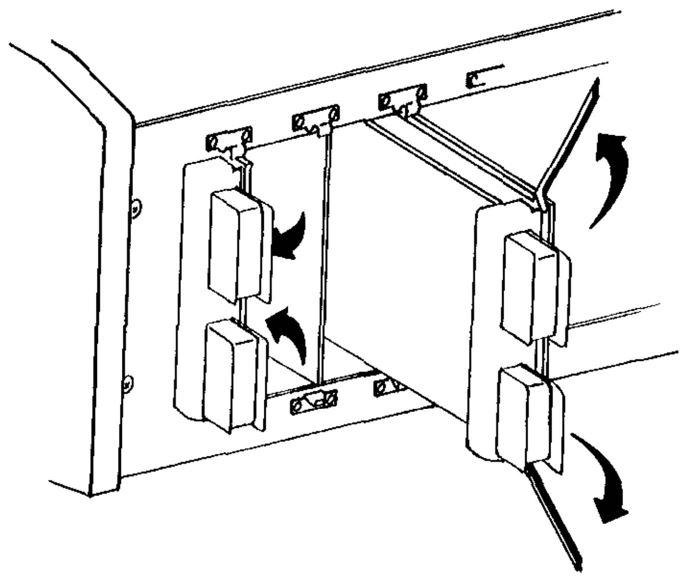


Figure 2-3. Card Installation in a Model 706

2.5.2 Matrix Card Removal

To remove the matrix card, first unlock it by pulling the latches outward, then grasp the end of the card at the edges, and pull the card out of the mainframe.

2.6 INSTRUMENT AND DUT CONNECTIONS

The information in the following paragraph explains how to connect the matrix card to external test circuitry (instruments and DUT).

CAUTION
Do not connect the matrix card to unlimited power circuits. This product is intended for use with impedance limited sources. Do not connect directly to AC mains.

When connecting an impedance limited source, install appropriate protection (such as a fuse or a clamping circuit) to limit potentially damaging fault currents to the matrix card.

CAUTION
Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the side edges. Do not touch the board surfaces or components.

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

2.6.1 Card Connectors

The card connectors are shown in Figure 2-4. There are two miniature coaxial, multiple contact receptacles. One of the receptacles is used for row connections and the other is used for column connections. Row and column number designations are included in the illustration. Notice that one contact of each receptacle is reserved for chassis ground. For each coaxial connector, as shown in Figure 2-5, the center conductor is SIGNAL, and the outer shell (shield)is GUARD.

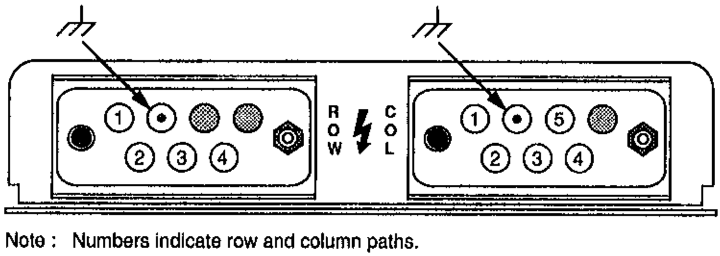


Figure 2-4. Model 7153 Connectors

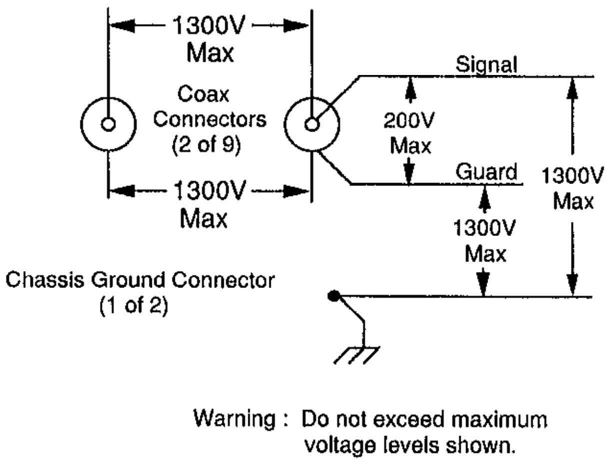


Figure 2-5. Miniature Connector Configuration

WARNING
Do not exceed 200V between SIGNAL and GUARD, or 1300V between SIGNAL and chassis ground, or between GUARD and chassis ground or between paths (see Figure 2-5). Also, do not exceed 1A carry/500mA switched, 10VA peak (resistive load).

CAUTION
To prevent damage to the matrix card and other equipment, do not connect equipment such that they short out on the same row or column.

2.6.2 Recommended Cables and Adapters

Table 2-1 summarizes the cables and adapters recommended for use with the Model 7153.

NOTE
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 adapters may degrade the integrity of the measurements made using the matrix card. See paragraph 2.9 for a discussion of measurement considerations.

The following discussion provides additional information about the recommended Keithley cable; Model 7153-TRX cable.

Table 2-1. Recommended Cables and Adapters

Item	Manufac-turer	Model or Part No.	Description	Applications
1	Keithley	7153-TRX	Matrix to triax cable	7153 input/output connections
2	Keithley	6172	2-slot male to 3-lug female triax adapter	Connect 3-slot triax cable to 2-lug triax connector
3	Keithley	237-TRX-BAR	3-lug female to female triax barrel	Connect male triax cable to male triax cable
4	Keithley	237-TRX-T	3-slot male to dual 3-lug female	Dual connections for 7153-TRX
5	Keithley	237-BAN-3	3-slot triax to male banana plug	Banana plug cable

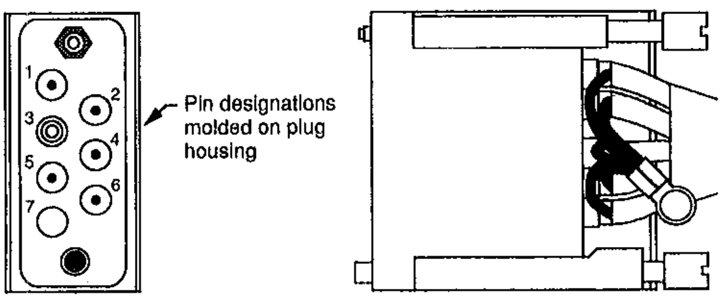
*6172 is for use in low voltage (≤500Vrms) applications only.

Model 7153-TRX Low Noise Matrix to Triax Cable

The Model 7153-TRX is a 2-meter cable assembly that is terminated with a miniature coaxial, multiple contact plug at one end, and five 3-slot male triax connectors at the other end. The plug end of the cable will mate to the ROW and COL receptacles of the matrix card. The triax connectors will mate to standard 3-lug female triax connectors. Each triax cable is labeled and corresponds to a ROW or COL as follows:

Triax #1 = Row 1 or Column 1
Triax #2 = Row 2 or Column 2
Triax #3 = Row 3 or Column 3
Triax #4 = Row 4 or Column 4
Triax #5 = Column 5

On each triax connector, as shown in Figure 2-7, the center conductor is SIGNAL, the inner shield is GUARD, and the connector shell is connected to the outer shield of the cable. Note that this outer shield is connected to chassis of the Model 7153.



Pin Designation	Matrix Card Row or Column
1	Row 1 or Col 1
2	Row 2 or Col 2
3	Chassis Ground
4	Row 3 or Col 3
5	Row 4 or Col 4
6	Col 5

Note : Pin designations 1, 2, 4, 5 and 6 are coaxial connectors. Pin 3 is a single pin connector for chassis ground.

Figure 2-6. Model 7153-TRX Pin Identification

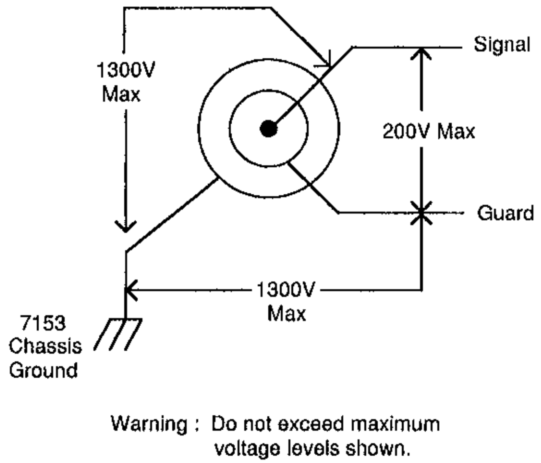


Figure 2-7. Triax Connector Configuration (Model 7153-TRX)

2.6.3 General Instrument Connections

The following paragraphs discuss connecting the Model 7153 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.

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

Figure 2-8 shows the general instrument connections for the discussions below. Note that DUT guarding or shielding is not indicated here; see Figure 2-18 and Figure 2-21 for shielding and guarding information. As shown, all figures assume instruments are connected to rows, and the DUT is connected to columns.

DMM Connections

General DMM connections are shown in Figure 2-8(A), (B), and (C). Floating connections are shown in (A), with LO and HI routed to two separate rows on the Model 7153. The common LO connections in (B) should be used only for non-critical applications because the performance (isolation) of the GUARD pathway is not as good as a SIGNAL pathway.

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

Four-wire DMM connections are shown in Figure 2-8(C). In this case, a total of four rows are required; one row for HI, one for LO, one for SENSE HI, and one for SENSE LO.

Electrometer Connections

Typical electrometer connections are shown in Figure 2-8(D) through (G). The unguarded volts connections in (D) show the HI signal path routed to one row, and the LO path goes to a another row. Both GUARD pathways are connected to electrometer LO. For guarded voltage (E), Model 7153 GUARD is connected to electrometer GUARD.

The connections for electrometer fast amps and resistance measurements are shown in Figure 2-8(F) and (G). These configurations are essentially the same as those discussed above. In 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.

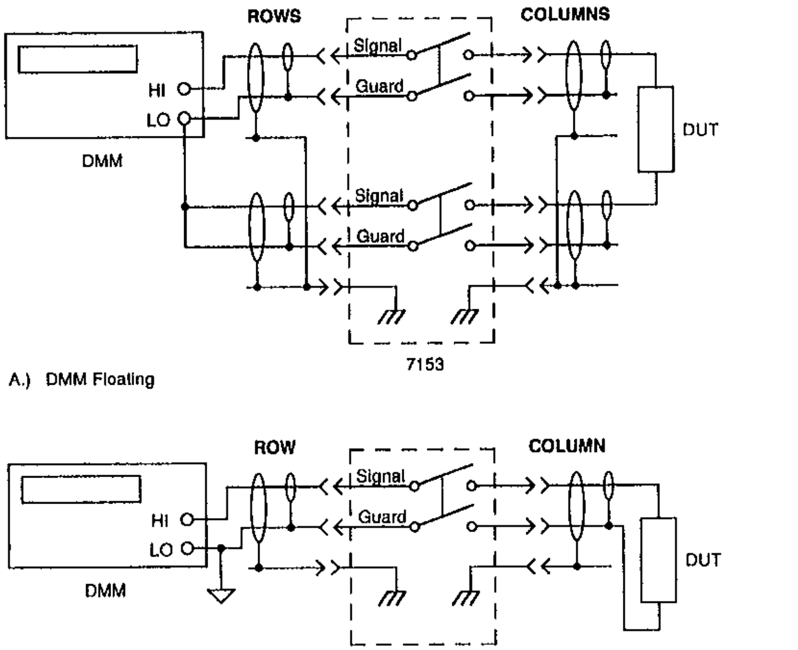
Source Connections

Voltage and current source connections are shown in Figure 2-8(H) through (J). The HI and LO paths of the voltage source (H) are routed through two rows, 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 rows. 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 2-8(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.

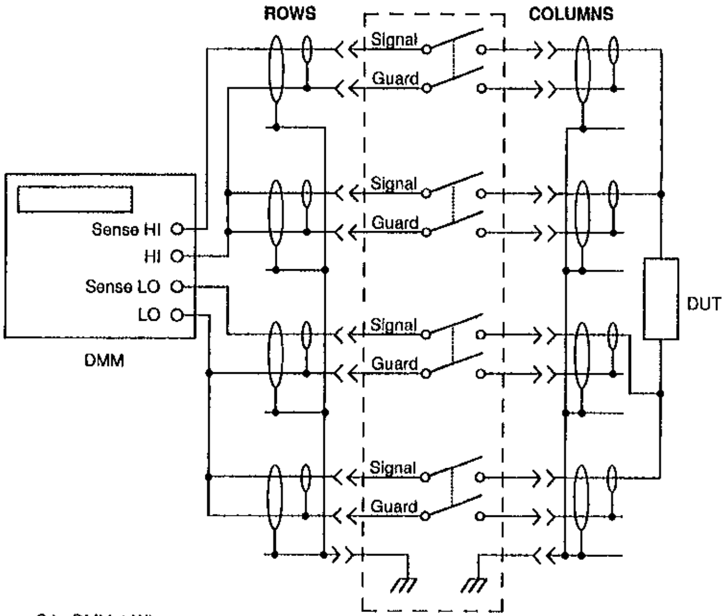


Warning : Hazardous voltage from guard sources may be present on LO.

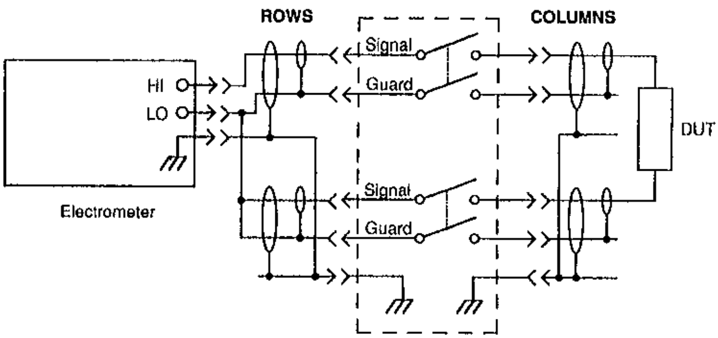
Note : Use this configuration only for non-critical measurements.

B.) DMM Common LO

Figure 2-8. General Instrument Connections

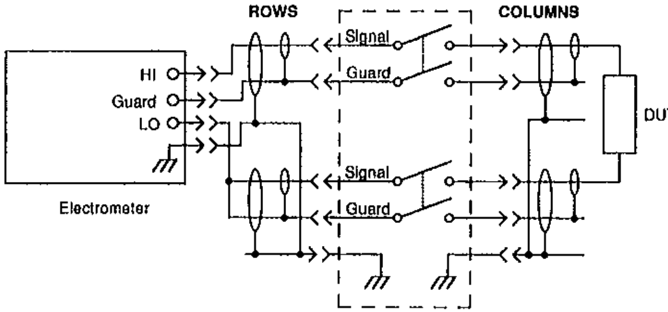


C.) DMM 4-Wire

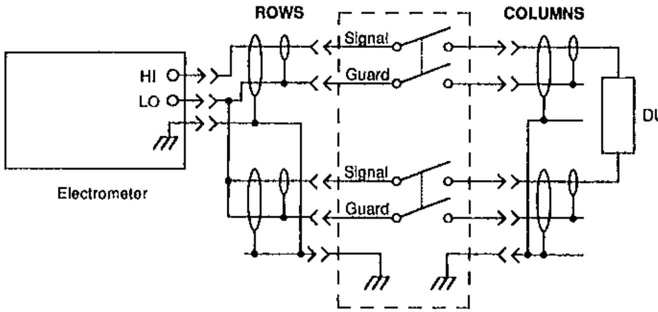


D.) Electrometer, Unguarded Volts

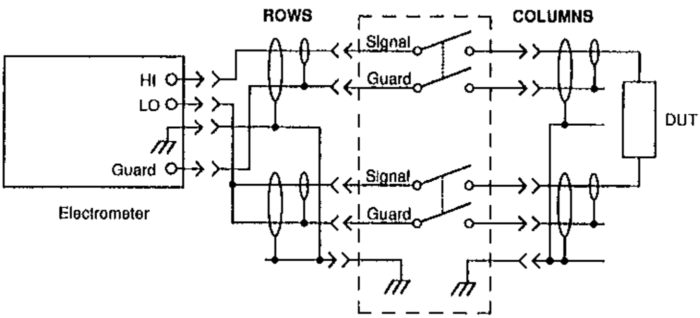
General Instrument Connections (Cont.)



E.) Electrometer, Guarded Volts

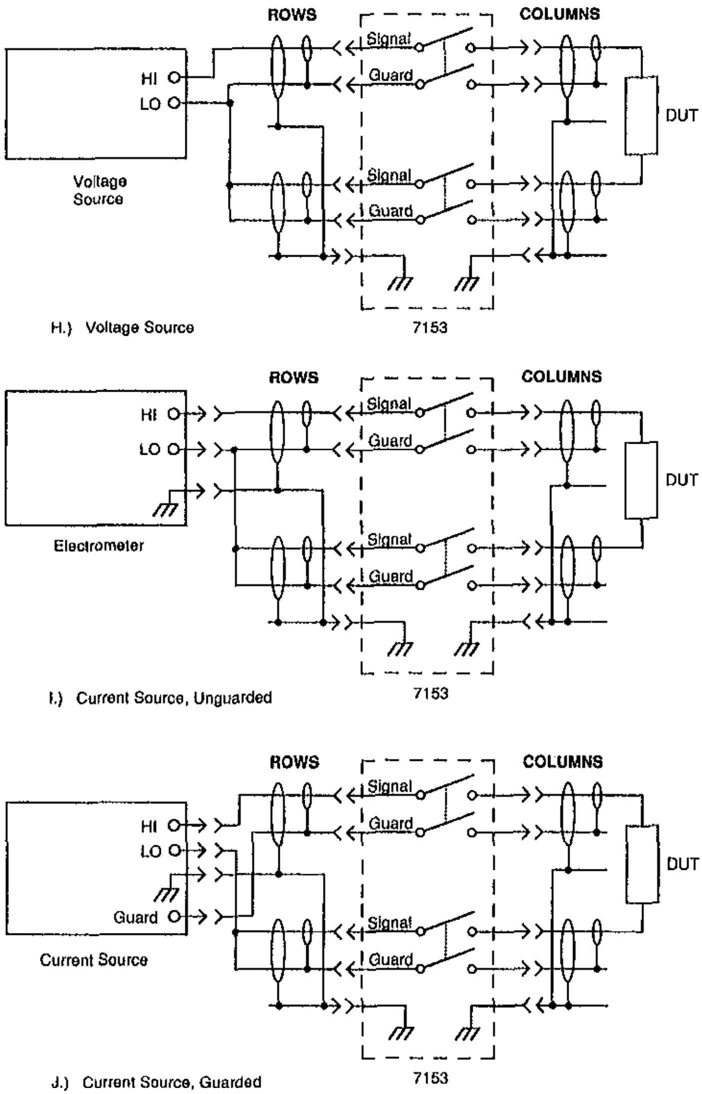


F.) Electrometer, Fast Current

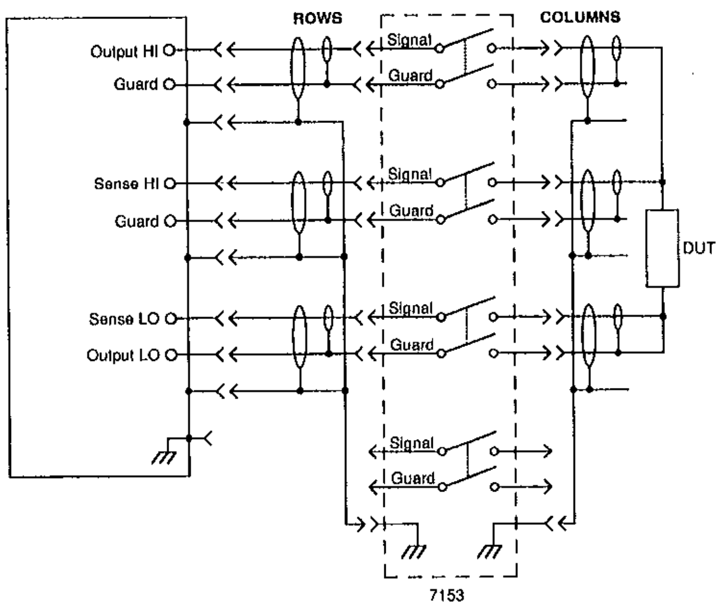


G.) Electrometer, Resistance (Guarded)

General Instrument Connections (Cont.)



General Instrument Connections (Cont.)



K.) Source/Measure Unit

Note : DUT shielding/guarding not shown.

General Instrument Connections (Cont.)

2.6.4 Keithley Instrument Connections

The following paragraphs outline connecting typical Keithley instruments to the Model 7153 High Voltage 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 237 High Voltage Source Measure Unit
- Model 230 Programmable Voltage Source
- Model 220 Programmable Current Source

NOTE

The following figures show instruments connected to matrix rows. Keep in mind that they could just as well be connected to matrix columns. Also, it doesn't matter which rows (or columns) are used since the row/column specifications are uniform.

WARNING

To prevent electric shock that could cause injury or death, do not apply power to cables that are not connected.

Model 617 Electrometer Connections

Connections for the Model 617 Electrometer are shown in Figure 2-9 and are described as follows:

1. Connect the matrix end of the Model 7153-TRX cable assembly to ROW of the Model 7153.
2. Connect the Model 6172 2-slot male to 3-lug female triaxial adapter to the INPUT of the Model 617.
3. Connect Row 1 of the Model 7153-TRX cable assembly to the triax adapter on the INPUT of the Model 617.
4. Connect three 3-lug female to female triax adapters (item 3 in Table 2-1) to the three triax/banana cables (Model 237-BAN-3)..
5. Connect the triax adapter end of a triax/banana cable to Row 2 of the Model 7153-TRX, and connect the banana end of the cable to the

COM terminal of the Model 617. The shorting link between COM and chassis ground should be removed for this application.

6. Set the Model 617 GUARD switch to the OFF position.
7. Connect the triax adapter end of the other two triax/banana cables to Rows 3 and 4 of the Model 7153-TRX cable assembly, and connect the banana ends of the cables to the V-SOURCE HI and LO terminals of the Model 617.

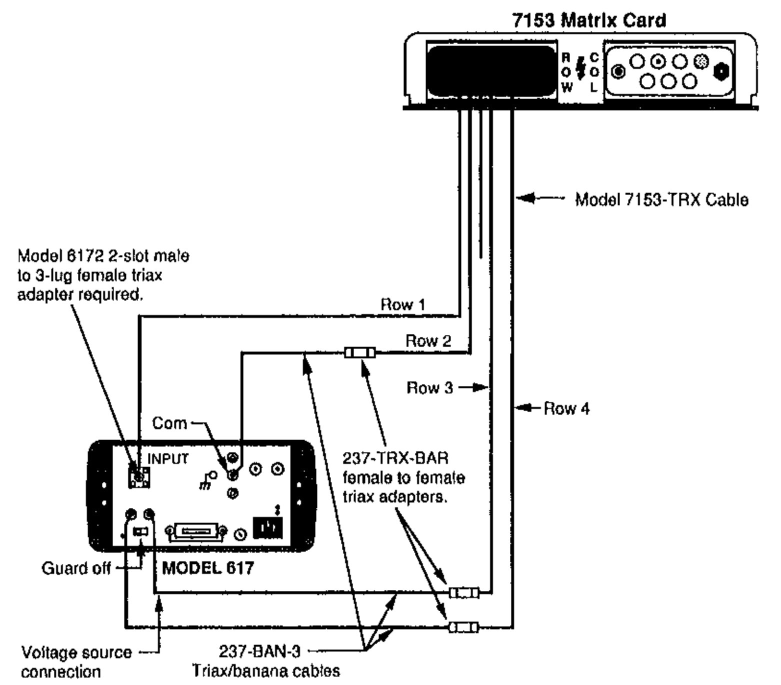


Figure 2-9. Electrometer Connections

Model 237 Source Measure Unit Connections

Connect the Model 237 or other similar Source Measure Unit to the matrix card as shown in Figure 2-10. This configuration for four-terminal measurements is similar to the one shown in Figure 2-8K.

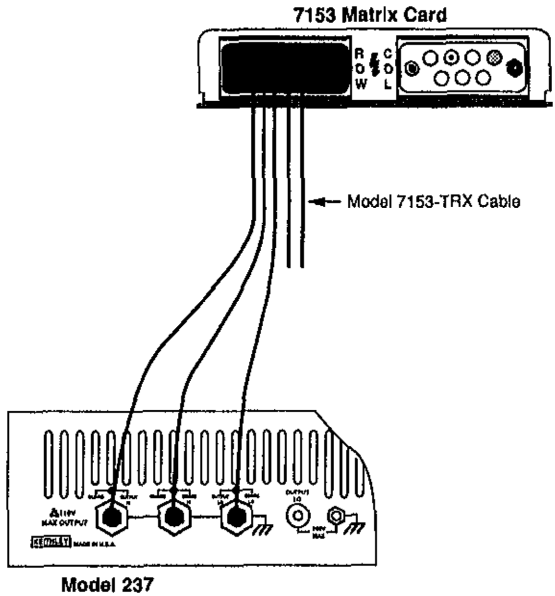


Figure 2-10. Model 237 Source Measure Unit

WARNING
For high voltage testing, DUT should be installed in an interlocked, safety earth grounded test fixture, such as the Keithley Model 8006. To avoid electrical shock, be sure to connect the interlock cable from the Source Measure Unit to the test fixture.

Model 230 Voltage Source Connections

Referring to Figure 2-11, connect the Model 230 OUTPUT and COMMON terminals to the desired rows using two Model 237-BAN-3 cables and two Model 237-TRX-BAR adapters.

For remote sensing applications, the SENSE OUTPUT and SENSE COMMON terminals of the Model 230 can be connected to the two remaining rows using the same cabling method.

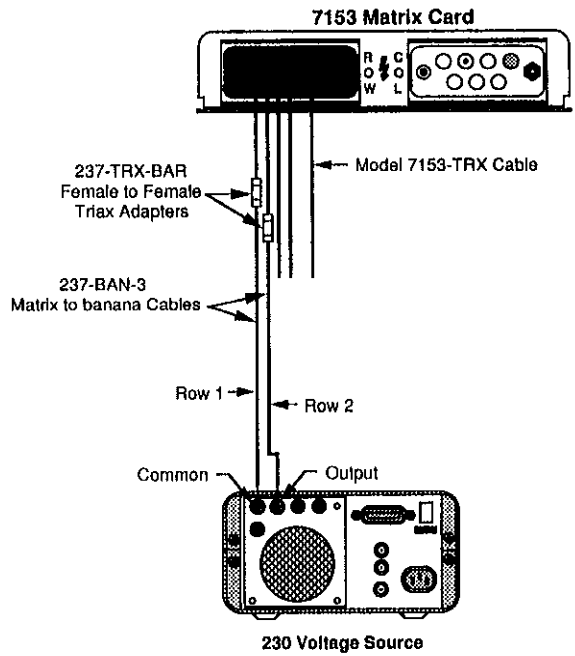


Figure 2-11. Model 230 Voltage Source Connections

Model 220 Current Source Connections

The Model 220 Current Source can be connected to the matrix card as shown in Figure 2-12.

1. Connect the matrix end of the Model 7153-TRX cable assembly to ROW of the Model 7153.
2. Connect the Model 6172 (item 2 in Table 2-1) 2-slot male to 3-lug female triaxial adapter to the Model 220.

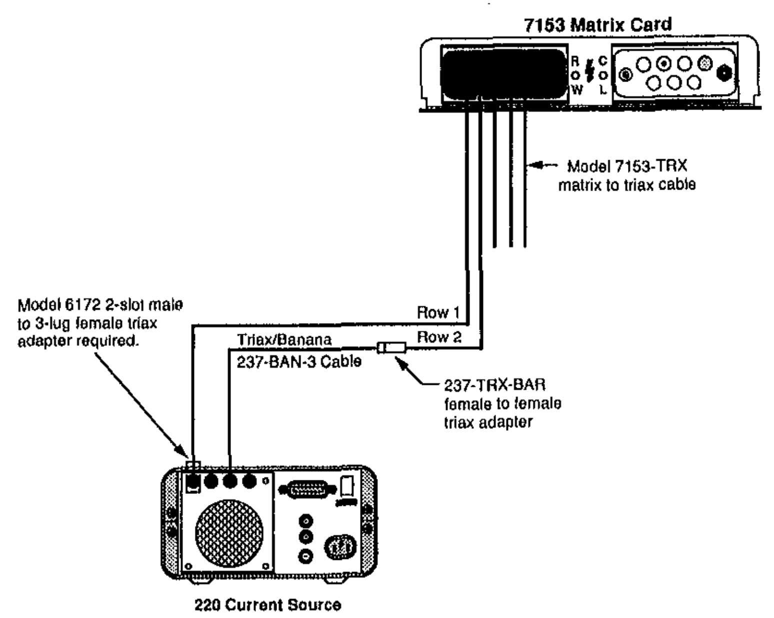


Figure 2-12. Model 220 Current Source Connections

3. Connect Row 1 of the Model 7153-TRX cable assembly to the 6172 triax adapter.
4. Connect a 3-lug female to female triax adapter to the triax/banana cable.
5. Connect the triax adapter end of the triax/banana cable to Row 2 of the Model 7153-TRX, and connect the banana end of the cable to the OUTPUT COMMON jack of the Model 220.

NOTE

The configuration shown allows common to be individually switched (ROW 2). Thus, do not connect ROW1 Guard of the matrix card (which is also common) to a DUT.

2.6.5 Typical Test Fixture Connections

Typically, a test fixture will be connected to desired columns of the Model 7153. Normally, the test fixture will be equipped with 3-lug female triax connectors to facilitate the use of the Model 7153-TRX cable assembly. These typical test fixture connections are shown in Figure 2-13.

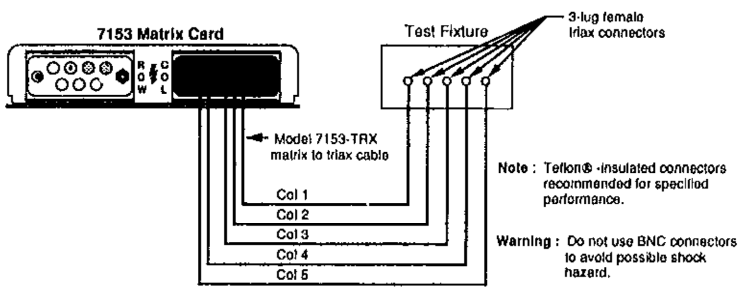


Figure 2-13. Typical Test Fixture Connections

WARNING

Do not use BNC cables and adapters because 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 2-14. SIGNAL is connected to the probe or other device contact points, while GUARD is 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.

WARNING

To provide protection from shock hazards, the test fixture chassis must be properly connected to a safety earth ground. A grounding wire (18 AWG or larger) must be attached securely to the test fixture at a terminal designed for safety grounding (the terminal should be marked with the symbol ⏚). The other end of the grounding wire is then attached to a

known safety earth ground, such as a cold water pipe, or a grounded electrical outlet box.

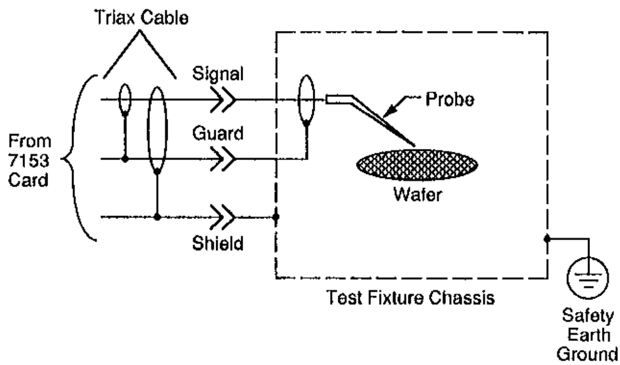


Figure 2-14. Equivalent Circuit of Test Fixture Connections

2.7 MATRIX EXPANSION

A matrix can be expanded by connecting two or more Model 7153 matrix cards together. A single matrix card consists of 20 crosspoints. Thus, each additional matrix card increases the matrix by 20 crosspoints. Connecting the rows or one matrix card to the rows of another matrix card increases the number of matrix columns. Connecting the columns of one matrix card to the columns of another matrix card increases the number of matrix rows.

Matrix Expansion Connections

Model 7153-TRX cables along with the appropriate adapters can be used for matrix expansion. Typical row connections of two matrix cards (which will increase the available matrix columns to 10) are shown in Figure 2-15. The rows of the two matrix cards are connected togehter via four Model 237-TRX-T adapters. The Model 237-TRX is a high voltage 3-slot male triax to dual 3-lug female triax adapter. Standard 3-slot triax cables (such as the Model 7078-TRX) from the instrumentation or DUT test fixture will mate to the male end of the "T" adapters via four Model 237-TRX-BAR adapters.

To connect the rows of more matrix cards, simply use additional Model 237-TRX-T adapters. Each additional matrix card will require four "T" adapters.

Column connections, which increase matrix rows, are made in a similar fashion. The only difference is that the Model 7153-TRX cables are instead connected to the COL connectors on the matrix card.

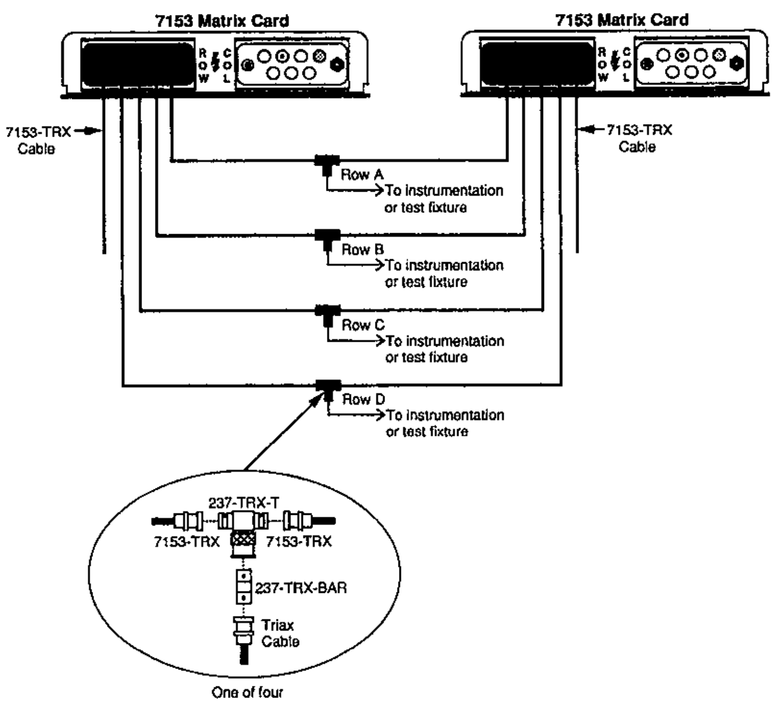


Figure 2-15. Typical Row Connections for Matrix Column Expansion

2.8 MAINFRAME CONTROL OF MATRIX CARD

The information in the following paragraphs does not include operation of the Model 705 or 706 mainframe. That information is provided in the respective mainframe instruction manuals. The following deals primarily with programming information specific to controlling the Model 7153.

Whether from the front panel or over the IEEE-488 bus, matrix control is simply a matter of closing and opening the appropriate matrix crosspoints. Crosspoint assignment numbers for a Model 7153 card are determined by its installed position (card number) in a mainframe. For daisy chain operation, the position of the mainframe in the system is also a determining factor. The following paragraphs explain how to determine crosspoint assignment numbers.

2.8.1 Front Panel Matrix Control

Using the Model 7153 matrix card with an appropriate Keithley mainframe (Model 705 or 706) requires that the matrix mode be selected. To place the mainframe in the matrix mode from the front panel, perform the following steps:

1. Select Program 6 by pressing the PRGM key and then the number 6 key.
2. Press the 0 key and then the ENTER key.

After the ENTER key is pressed, the mainframe is placed in the matrix mode of operation.

With the mainframe in the matrix mode, the display format is as follows:

For the Model 705:

mm n x

where: "mm n" is the crosspoint assignment number.

mm = 2-digit ID number from 01 to 50. This number identifies the mainframe and slot that the card is located in and also indicates the matrix card column number.

n = Matrix card row from 1 to 4.

x denotes the status of the crosspoint. An O indicates that the crosspoint is open, while a C indicates that the crosspoint is closed.

For the Model 706:

mmm n x

where: "mmm n" is the crosspoint assignment number.

mmm = 3-digit ID number from 001 to 250. This number identifies the mainframe and slot that the card is located in and also indicates the matrix card column number.

n = Matrix card row from 1 to 4.

x denotes the status of the crosspoint. An O indicates that the crosspoint is open, while a C indicates that the crosspoint is closed.

In general, controlling the matrix from the front panel consists of displaying the desired matrix crosspoint assignment number and closing (or opening) the crosspoint relay. Table 2-2 and Table 2-3 provide the two-digit (for Model 705) and three-digit (for Model 706) ID numbers that make up the "m" portion of the crosspoint assignment number.

Table 2-2. Two-Digit ID Numbers for Programming Model 705

Model 705	Card Slot Location	Matrix Card Column				
		1	2	3	4	5
Master	Card 1	01	02	03	04	05
	Card 2	06	07	08	09	10
Slave #1	Card 1	11	12	13	14	15
	Card 2	16	17	18	19	20
Slave #2	Card 1	21	22	23	24	25
	Card 2	26	27	28	29	30
Slave #3	Card 1	31	32	33	34	35
	Card 2	36	37	38	39	40
Slave #4	Card 1	41	42	43	44	45
	Card 2	46	47	48	49	50

Table 2-3. Three-digit ID Numbers for Programming Model 706

Model 706	Card Slot Location	Matrix Card Column 1	2	3	4	5
Master	Card 1	001	002	003	004	005
	Card 2	006	007	008	009	010
	Card 3	011	012	013	014	015
	Card 4	016	017	018	019	020
	Card 5	021	022	023	024	025
	Card 6	026	027	028	029	030
	Card 7	031	032	033	034	035
	Card 8	036	037	038	039	040
	Card 9	041	042	043	044	045
	Card 10	046	047	048	049	050
Slave #1	Card 1	051	052	053	054	055
	Card 2	056	057	058	059	060
	Card 3	061	062	063	064	065
	Card 4	066	067	068	069	070
	Card 5	071	072	073	074	075
	Card 6	076	077	078	079	080
	Card 7	081	082	083	084	085
	Card 8	086	087	088	089	090
	Card 9	091	092	093	094	095
	Card 10	096	097	098	099	100
Slave #2	Card 1	101	102	103	104	105
	Card 2	106	107	108	109	110
	Card 3	111	112	113	114	115
	Card 4	116	117	118	119	120
	Card 5	121	122	123	124	125
	Card 6	126	127	128	129	130
	Card 7	131	132	133	134	135
	Card 8	136	137	138	139	140
	Card 9	141	142	143	144	145
	Card 10	146	147	148	149	150

Three-digit ID Numbers for Programming Model 706 (Cont.)

Model 706	Card Slot Location	Matrix Card Column 1	2	3	4	5
Slave #3	Card 1	151	152	153	154	155
	Card 2	156	157	158	159	160
	Card 3	161	162	163	164	165
	Card 4	166	167	168	169	170
	Card 5	171	172	173	174	175
	Card 6	176	177	178	179	180
	Card 7	181	182	183	184	185
	Card 8	186	187	188	189	190
	Card 9	191	192	193	194	195
	Card 10	196	197	198	199	200
Slave #4	Card 1	201	202	203	204	205
	Card 2	206	207	208	209	210
	Card 3	211	212	213	214	215
	Card 4	216	217	218	219	220
	Card 5	221	222	223	224	225
	Card 6	226	227	228	229	230
	Card 7	231	232	233	234	235
	Card 8	236	237	238	239	240
	Card 9	241	242	243	244	245
	Card 10	246	247	248	249	250

Example #1 — In a single card system, program the mainframe (Model 705 or 706) to close Row 3, Column 4 of a matrix card installed in the Card 1 slot of the mainframe.

1. From Table 2-2 or Table 2-3, it can be determined that the required ID number is 04 (for the Model 705) or 004 (for the Model 706).
2. From the given information, the row number is 3. Thus, the crosspoint assignment number is either 04 3 (for the 705) or 004 3 (for the 706).
3. On the mainframe, use the CHANNEL key to display the crosspoint assignment number (04 3 or 004 3).
4. Close the crosspoint relay by pressing the CLOSE key on the mainframe.

Example #2 — In a multi-mainframe system, program the Master mainframe (Model 705) to close Row 2, Column 4 of a matrix card installed in the Card 2 slot of Slave #3 mainframe.

1. From Table 2-2, it can be determined that the required two-digit ID number is 39.
2. From the given information, the row number is 2. Thus, the crosspoint assignment number is 39 2.
3. On the Master mainframe, use the CHANNEL key to display the number 39 2.
4. Close the crosspoint relay by pressing the CLOSE key on the Master mainframe.

Example #3 — In a multi-mainframe system, program the Master mainframe (Model 706) to close Row 2, Column 4 of a matrix card installed in the Card 2 slot of Slave #3 mainframe.

1. From Table 2-3, it can be determined that the required three-digit ID number is 159.
2. From the given information, the row number is 2. Thus, the crosspoint assignment number is 159 2.
3. On the Master mainframe, use the CHANNEL key to display the number 159 2.
4. Close the crosspoint relay by pressing the CLOSE key on the master mainframe.

2.8.2 Matrix Control Over IEEE-488 Bus

NOTE

Operation over the bus is somewhat analogous to front panel operation. Thus, to fully understand the information in this paragraph, make sure that front panel operation, as explained in the preceding paragraph, is understood.

The most often used IEEE-488 device-dependent commands (DDCs) used to operate the Model 7153 are summarized in Table 2-4. For a complete listing and detailed explanation of the commands, see the appropriate mainframe instruction manual.

Table 2-4. Most Often Used DDCs

DDC Model 705	DDC Model 706	Function
A0	A0	Select matrix mode
Bmmn	Bmmmn	Display crosspoint number
Cmmn	Cmmmn	Close crosspoint
Nmmn	Nmmmn	Open crosspoint

Note: mmn and mmmn are crosspoint assignment numbers (see paragraph 2.8.1).

Basically, control over the bus consists of first placing the mainframe in the matrix mode (A0 command) and then closing or opening the desired crosspoint using the C or N command respectively. The B command is used to display the crosspoint and its status (open or closed).

NOTE

The following programming examples use HP 4.0 BASIC. Also, they assume an IEEE address of 17 for the Model 705 and an address of 18 for the Model 706.

Example #1 — In a multi-mainframe system, program the master mainframe from (Model 705) over the IEEE bus to close Row 1, Column 5 of a matrix card installed in the Card 1 slot of Slave #4 mainframe.

1. From Table 2-2 it can be determined that the required two-digit ID number is 45.
2. From the given information, the row number is 1. Thus, the crosspoint assignment number is 45 1.
3. Enter the following programming statements into the HP computer:

```
REMOTE 717
OUTPUT 717; "A0X"
OUTPUT 717; "B451X"
OUTPUT 717; "C451X"
OUTPUT 717; "N451X"
```

The second statement places the master Model 705 in the matrix mode. The third statement displays crosspoint 45 1 and its current status (open or closed). The fourth statement closes crosspoint 45 1, and the last statement opens crosspoint 45 1.

Example #2 — In a multi-mainframe system, program the master mainframe (Model 706) from over the IEEE bus to close Row 4, Column 1 of a matrix card installed in the Card 8 slot of Slave #4 mainframe.

1. From Table 2-3 it can be determined that the required three-digit ID number is 236.
2. From the given information, the row number is 4. Thus, the crosspoint assignment number is 236 4.
3. Enter the following programming statements into the HP computer:

```
REMOTE 718
OUTPUT 718; "A0X"
OUTPUT 718; "B2364X"
OUTPUT 718; "C2364X"
OUTPUT 718; "N2364X"
```

The second statement places the master Model 706 in the matrix mode. The third statement displays crosspoint 236 4 and its current status (open or closed). The fourth statement closes crosspoint 236 4, and the last statement opens crosspoint 236 4.

2.9 MEASUREMENT CONSIDERATIONS

Many measurements made with the Model 7153 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.

2.9.1 Magnetic Fields

When a conductor cuts through magnetic lines of force, a very small voltage 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 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.

2.9.2 Radio Frequency Interference

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

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

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

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

2.9.3 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 2-16, the resulting ground loop causes current to flow through the instrument LO signal leads and then back through power line ground. This circulating current develops a small but undesirable voltage between the LO terminals of the two instruments. This voltage will be added to the source voltage, affecting the accuracy of the measurement.

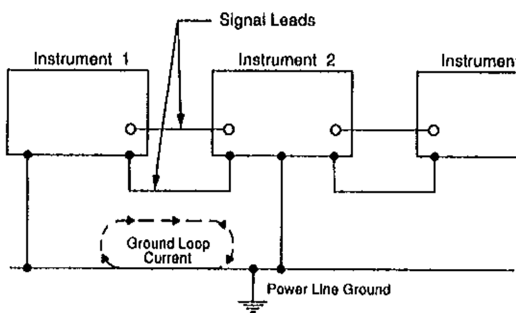


Figure 2-16. Power Line Ground Loops

Figure 2-17 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, only one instrument is connected to power line ground.

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

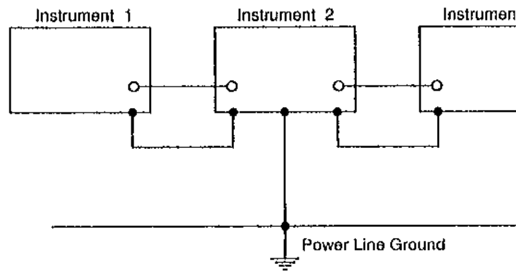


Figure 2-17. Eliminating Ground Loops

2.9.4 Keeping Connectors Clean

As is the case with any high-resistance device, the integrity of coaxial, triaxial and other 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. 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.

2.9.5 Noise Currents Caused by Cable Flexing

Noise currents can be generated by bending or flexing coaxial or triaxial cables. Such currents, which are 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 cable has 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 currents 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.

2.9.6 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 surrounding the HI signal path should be connected to signal LO (or chassis ground for instruments without isolated LO terminals). Since most Model 7153 matrix applications call for separately switching LO, a separate connection from LO to the cable shield at the source or measurement end must be provided, as in the example of Figure 2-18. Here, we are using the GUARD path of the Model 7153 to carry the shield out to the device under test. Needless to say, this arrangement should not be used with guarding, as GUARD and LO should not be connected together.

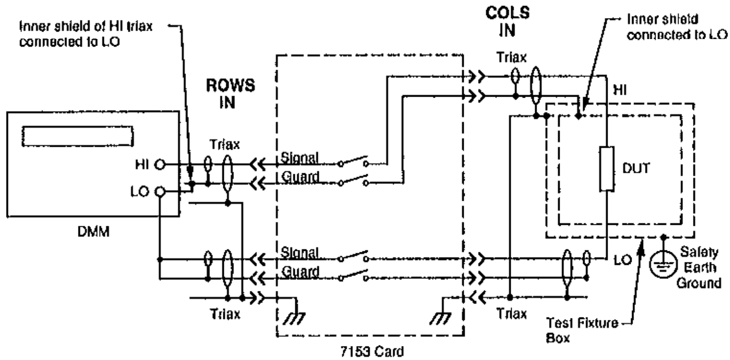


Figure 2-18. Shielding Example

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

If the device under test is to be shielded, the shield should be connected to the LO terminal. If you are using the GUARD connection as shield, care should be taken to insulate the outer ring of the triaxial connector mounted on the test fixture from the test fixture itself. Otherwise, LO will be connected to earth ground, possibly resulting in a ground loop. An alternative is to use two shields, one mounted within (and insulated from) the other. In this case, the GUARD path would be connected to the inner shield, while the outer shield would be earth grounded. This arrangement is shown in Figure 2-19. Incidentally, this configuration is also recommended for guarded applications, with the inner shield as guard, and the outer shield acting as a safety shield.

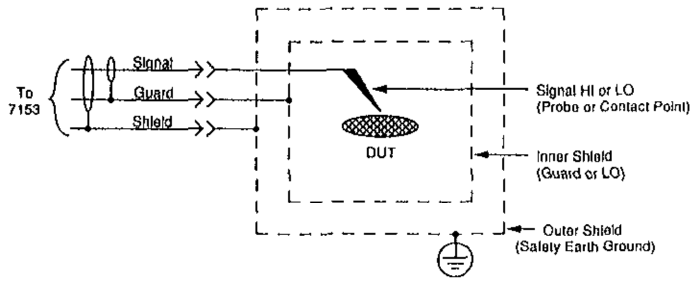


Figure 2-19. Dual Shielded Test Fixture

2.9.7 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. For triaxial cables, the inner shield is used as guard.

Guarding minimizes leakage resistance effects by driving the cable shield with a unity-gain amplifier, as shown in Figure 2-20. 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.

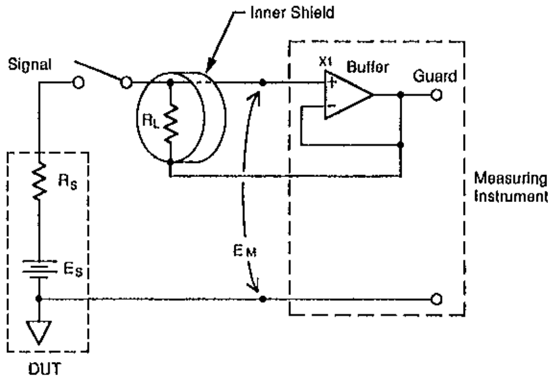


Figure 2-20. Guarded Circuit

In order to use guarding effectively with the Model 7153, the GUARD path of the matrix card should be connected to the guard output of the sourcing or measuring instrument. Figure 2-21 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 2-19 is recommended for safety purposes (guard voltage may be hazardous with some instruments). With most instruments, special adapters or cables may be required to connect guard to the inner shield, and at the same time route signal LO through a separate cable.

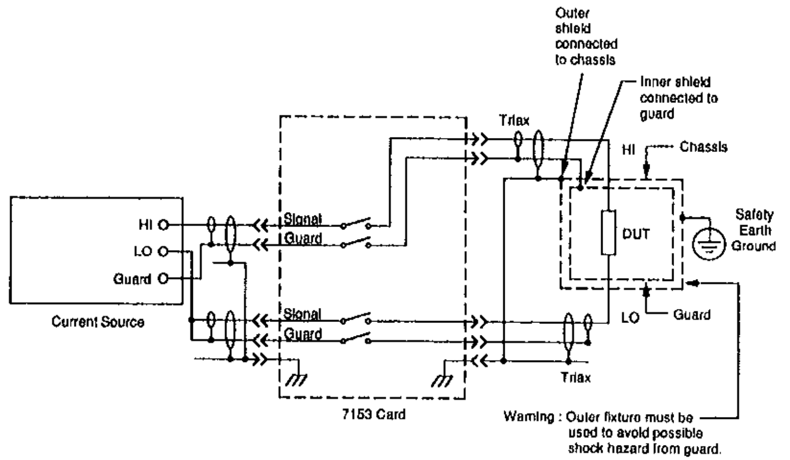


Figure 2-21. Typical Guarded Signal Connections

SECTION 3
Applications

3.1 INTRODUCTION

This section covers typical applications for the Model 7153 High Voltage Low Current Matrix card and is organized as follows:

3.2 Semiconductor Test Matrix: Details a semiconductor test matrix that can be used to perform a variety of different tests on semiconductors such as FETs.

3.3 Resistivity Testing Using Matrix Switching in a SMU Test System: Covers methods to measure the resistivity of semiconductor samples using the van der Pauw method.

WARNING
To provide protection from shock hazards, the test fixture chassis must be properly connected to a safety earth ground. A grounding wire (18 AWG or larger) must be attached securely to the test fixture at a terminal designed for safety grounding (the terminal should be marked with the symbol ⏚). The other end of the grounding wire is then attached to a known safety earth ground, such as a cold water pipe, or a grounded electrical outlet box.

3.2 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.

3.2.1 System Configuration

Figure 3-1 shows a two Source Measure Unit test configuration. In this example, OUTPUT HI and OUTPUT LO of each Source Measure Unit are independently switched, allowing for maximum versatility.

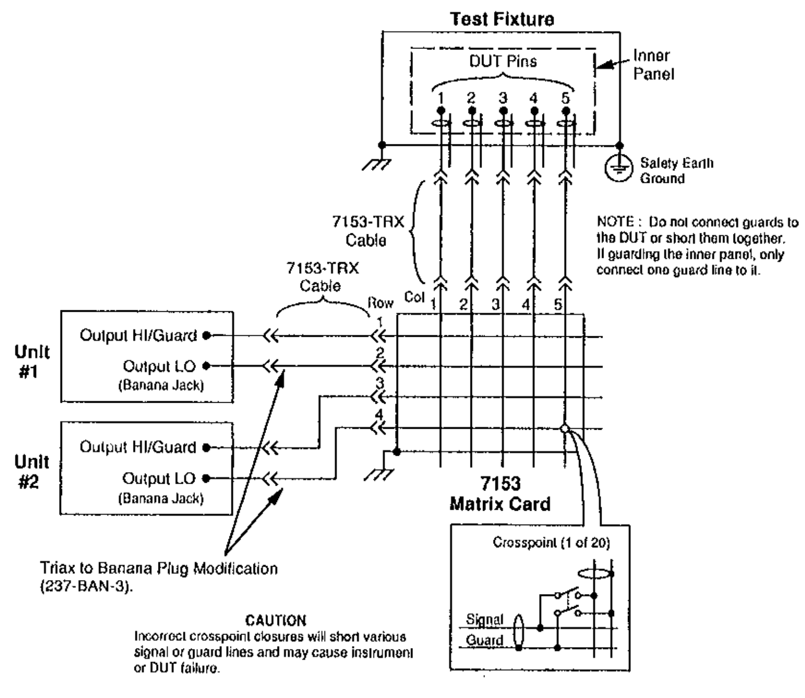


Figure 3-1. Multi Unit Connections to Model 7153

This test configuration has five DUT test pins.

Source Measure Unit and test fixture connections to the matrix card are accomplished using Model 7153-TRX cables. These cable assemblies are terminated with 3-slot triax connectors. On each Source Measure Unit, notice that the banana jack is used to access OUTPUT LO rather than the triax connector. This allows OUTPUT LO to be routed to the signal path of the matrix. On the Source Measure Unit triax connector, OUTPUT LO is located on the inner shell which, through normal triax connections, would put OUTPUT LO on the guard path of the matrix card.

3.2.2 Testing Common-Source Characteristic of FETs

The system shown in Figure 3-1 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 instruments must be connected to the JFET under test, as shown in Figure 3-2. 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.

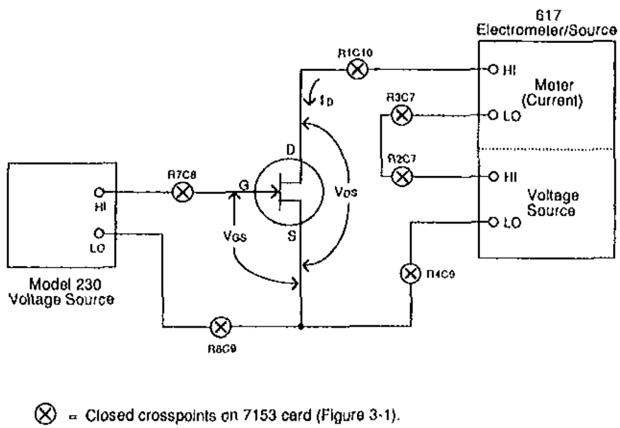


Figure 3-2. System Configuration for Measuring Common-Source Characteristics

3.3 RESISTIVITY TESTING USING MATRIX SWITCHING IN A SMU TEST SYSTEM

One example of where matrix switching is beneficial is when performing resistivity tests on semiconductors. The following paragraphs discuss such resistivity tests using a Source Measure Unit/matrix switching system.

3.3.1 System Configuration

Figure 3-3 shows a typical system configuration for performing resistivity tests using a Source Measure Unit. In addition to the Source Measure Unit, which sources the test current and measures the resulting voltage drop across the DUT, the system includes a Model 705 Scanner and a Model 7153 High Voltage Low Current Matrix Card for switching, as well as a Model 8006 test fixture to house the device under test.

With the test configuration shown in Figure 3-3, only one 4-terminal sample can be tested at any given time. However, additional Model 7153 cards can be daisy chained together to expand columns or rows, allowing more than one sample to be tested by a single test procedure.

3.3.2 Test Configuration

Figure 3-4 shows a typical resistivity test configuration for a single leg measurement of one sample. Here, the current source of the Source Measure Unit sources a current between two terminals of the sample, while the voltage meter section of the unit measures the voltage across two of the opposite terminals. Generally, eight such measurements are made, as shown in Figure 3-5.

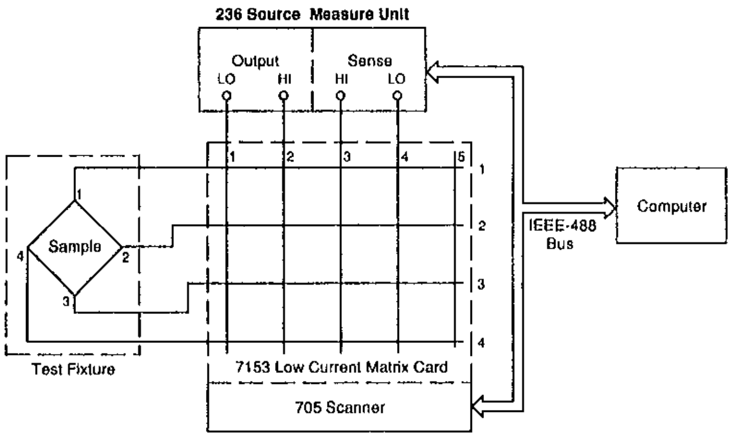


Figure 3-3. System Configuration for Resistivity Tests

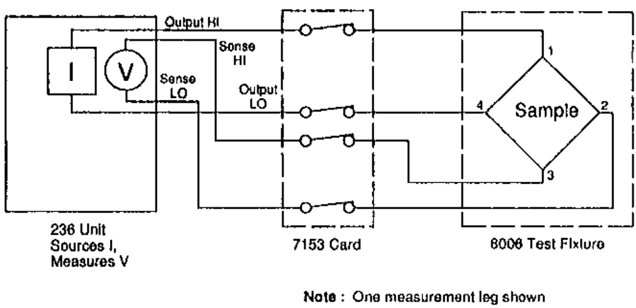


Figure 3-4. Resistivity Test Configuration

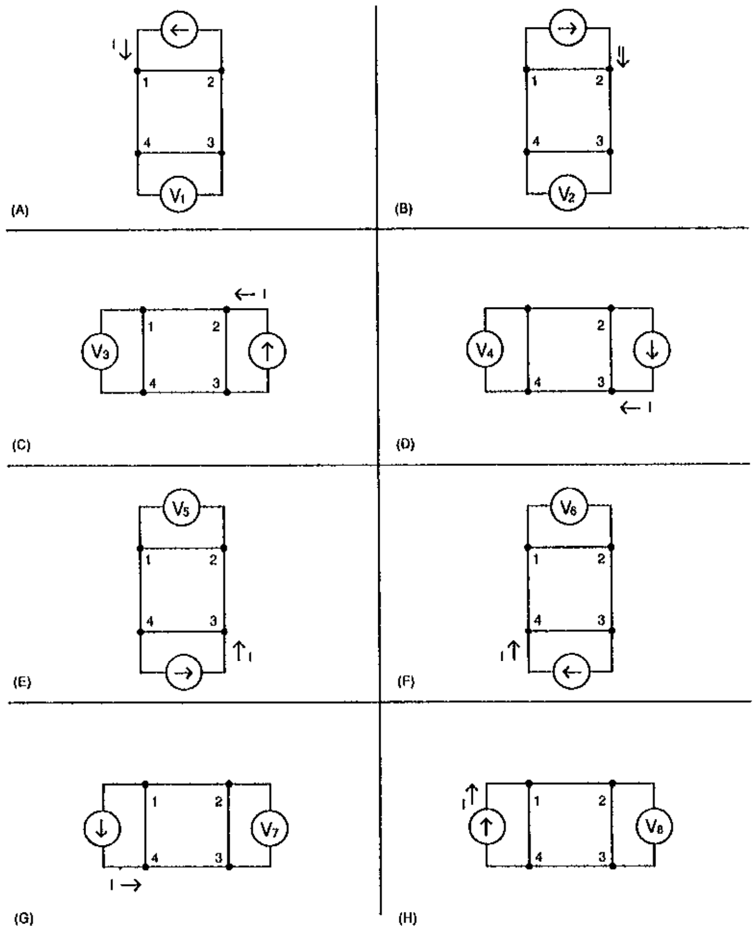


Figure 3-5. Resistivity Measurement Conventions

3.3.3 Resistivity Calculations

Resistivity is calculated from the voltage measurements as follows:

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

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

Where σA and σB 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 236
I is the current sourced by the Model 236 in amperes
f_A and f_B are geometrical factors based on sample symmetry
($f_A = f_B = 1$ for perfect symmetry)

Once σ_A and σ_B are known, the average resistivity, σ_{AVG}, can be computed as follows:

$$\sigma_{AVG} = \frac{\sigma_A + \sigma_B}{2}$$

3.3.4 Test Connections

Figure 3-6 shows the test connections for the resistivity tests. The Model 8006 test fixture should be connected directly to the ROW jacks on the Model 7153 High Voltage Low Current Matrix Card using an optional Model 7153-TRX cable assembly. Connect the Model 236 to the COL jacks of the matrix card, again using a Model 7153-TRX cable assembly. For the OUTPUT HI, SENSE HI, and SENSE LO jacks, you can simply connect the triax cables to the corresponding jacks. For the OUTPUT LO connection, however, it will be necessary to use BNC/banana (Pomona Model 1899) and 3-lug female triax to male BNC (Pomona Model 5299) adapters.

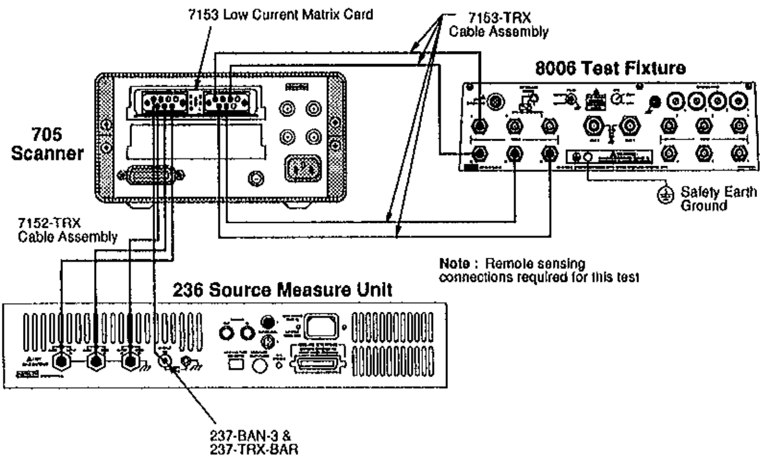


Figure 3-6. Test Connections for Resistivity Tests

3.3.5 Measurement Considerations

The offset current (<1 pA for the Model 7153) comes into play for very low current measurements. The required settling time depends on the impedance levels involved (should be >5RC), and the path isolation can affect the accuracy of high-impedance measurements.

NOTE

In this application, the sense and source leads are connected to separate points on the DUT, which will result in a potential between OUTPUT HI and SENSE HI, and OUTPUT LO and SOURCE LO. Note that the maximum voltage between the OUTPUT and SENSE leads is limited (see specifications). Reduce test current if necessary to keep the voltages below specified limits.

3.3.6 Program: Resistivity Tests Using a Switching Matrix and Source Measure Unit

The following Program demonstrates programming techniques for controlling a switching matrix and Source Measure Unit to perform resistivity tests. The basic procedure for using this program is as follows:

1. With power off, connect the Model 236 Source Measure Unit and the Model 705 Scanner to the IEEE-488 bus of the computer. Also, install the Model 7153 Card in slot 1 of the Model 705 mainframe.
2. Connect the test fixture and the Source Measure Unit to the matrix card using the specified triax cables (see Figure 3-6 and the discussion above for details on test connections).
3. Turn on the Model 236, and allow it to warm up for at least two hours for rated accuracy. Be sure that the primary address of the Source Measure Unit is set to 16. Also, turn on the Model 705, and make sure that its primary address is set to 17.
4. Turn on the computer, then boot up BASIC.
5. Enter lines below into the computer.
6. Connect the sample to be tested to the appropriate socket terminals on the test fixture, and also install the necessary test fixture jumpers. Use the general configuration shown in Figure 3-4 as a guide to test connections. Close the test fixture lid after making connections.
7. RUN the program, and follow the prompts on the screen. You will be prompted to enter the desired sample current value and then the sample thickness, which should be entered in centimeters. When entering the current, keep the approximate DUT resistance values in mind so as not to create an over voltage compliance condition. Also, you must not exceed the maximum voltage between output and sense leads of the Source Measure Unit.
8. Once the parameters are entered, the test will begin. The program will program the Source Measure Unit, and then begin the tests by closing crosspoints. A total of eight measurements will be taken and stored in an array.
9. Once the testing has been completed, the resistivity values will be calculated and displayed.

3.3.7 Program Description

Refer to the Program listing below and the flowchart shown in Figure 3-7 for the following description.

At the start of the program, both the Source Measure Unit and the scanner are returned to default conditions (line 20), and the reading array and command string are dimensioned (line 40). Next, the Model 236, which sources the test current and measures the sample voltage, is programmed as follows (lines 60-120):

- Source I, DC mode
- 10V compliance, autorange measure
- Remote sensing
- Measure only data format with no prefix, DC data output
- Continuous trigger on GET
- Line cycle integration

The Model 705 is then placed in remote (line 140), and the scanner is placed into matrix mode (line 150). Next the operator is prompted to input the desired test current, at which point the Source Measure Unit is programmed with the current value (lines 160 and 170). The operator is then prompted for the sample thickness (line 180), and the program waits for the operator's signal to begin (lines 190 and 200).

Once the operator starts the test, the Model 236 is armed and placed into operate (line 210), and the unit is then triggered (line 220). The program then enters a loop (line 230) to test the sample with a total of eight readings. As part of each loop, the Model 705 command string is read from the DATA statements at the end of the program (line 240), and the unit is then programmed to close the desired crosspoints (line 250). After a two-second delay for settling (line 260), a voltage reading is requested from the Model 236 and placed into an array (line 270). The crosspoints are then opened by reading the next command string (line 280) and then programming the Model 705 accordingly (line 290), and then the program loops back for the next measurement (line 300)

Finally, the program computes both σ_A and σ_B (lines 320 and 330), and then it calculates and displays the average resistivity, σ_{AVG} (line 360). Note that the Model 705 command strings are located in DATA statements at the end of the program (lines 380-530).

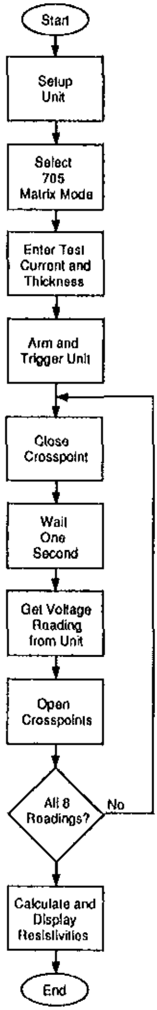


Figure 3-7. Program Flowchart

```
10   REM RESISTIVITY TEST PROGRAM REV 1.3
20   CLEAR 7                        ! Clear Unit and scanner
30   OUTPUT KBD;CHR$(255);CHR$(75); ! Clear screen
40   DIM V(8),Cmd$[25]              ! Dimension reading array,command string
50   REM ****** 236 setup (sources I,measures V) **********************
60   REMOTE 716                     ! Put 236 in remote
70   OUTPUT 716;"F1,0X"             ! Source I, DC mode
80   OUTPUT 716;"L10,0X"            ! 10V compliance, autorange measure
90   OUTPUT 716;"O1X"               ! Remote sense
100  OUTPUT 716;"G4,2,0X"           ! Measure data,no prefix,DC data
110  OUTPUT 716;"T1,0,0,0X"         ! Continuous trigger on GET
120  OUTPUT 716;"S2Z0X"             ! Line cycle integration,suppress off
130  REM ****** 705 scanner setup (switches devices) ******************
140  REMOTE 717                     ! Put 705 in remote
150  OUTPUT 717;"A0X"               ! Select matrix mode
160  INPUT "Enter test current",Itest        ! Input desired test current
170  OUTPUT 716;"B";Itest;",0,1000X"         ! Program 236 test current
180  INPUT "Enter sample thickness (cm)",Ts ! Input sample thickness
190  PRINT "Close lid, press CONT to begin"
200  PAUSE
210  OUTPUT 716;"R1X"               ! Arm 236,
220  TRIGGER 716                    ! Trigger 236
230  FOR I=1 TO 8                   ! Loop for all eight measurements
240  READ Cmd$                      ! Read 705 command string
250  OUTPUT 717;Cmd$                ! Close crosspoints
260  OUTPUT 716;"N1X"               ! Put 236 in operate
270  WAIT 2                         ! Wait two seconds for settling
280  ENTER 716;V(I)                 ! Get voltage reading from 236
290  OUTPUT 716;"N0O0X"             ! Put 236 in standby,local sense
300  READ Cmd$                      ! Read 705 command string
310  OUTPUT 717;Cmd$                ! Open crosspoints
320  NEXT I                         ! Loop back for next reading
330  OUTPUT 716;"N0X"               ! Put 236 in standby
340  Pa=(1.1331*Ts*(V(2)+V(4)-V(1)-V(3)))/Itest ! Compute Pa
350  Pb=(1.1331*Ts*(V(6)+V(8)-V(5)-V(7)))/Itest ! Compute Pb
360  PRINT "Pa=";Pa                 ! Display Pa
370  PRINT "Pb=";Pb                 ! Display Pb
380  PRINT "Device average resistivity=";(Pa+Pb)/2  ! Display resistivity
390  REM DATA STATEMENTS CONTAINING 705 COMMAND STRINGS
400  DATA "C01:2C02:1C03:3C04:4X"
410  DATA "N01:2N02:1N03:3N04:4X"
420  DATA "C02:2C01:1C03:3C04:4X"
430  DATA "N02:2N01:1N03:3N04:4X"
440  DATA "C02:2C01:3C04:4C04:1X"
450  DATA "N02:2N01:3N04:4N04:1X"
460  DATA "C02:3C01:2C03:4C04:1X"
470  DATA "N02:3N01:2N03:4N04:1X"
480  DATA "C02:3C01:4C03:1C04:2X"
490  DATA "N02:3N01:4N03:1N04:2X"
500  DATA "C02:4C01:3C03:1C04:2X"
510  DATA "N02:4N01:3N03:1N04:2X"
520  DATA "C02:4C01:1C03:2C04:3X"
530  DATA "N02:4N01:1N03:2N04:3X"
540  DATA "C02:1C01:4C03:2C04:3X"
550  DATA "N02:1N01:4N03:2N04:3X"
560  END
```

3.4 SMU REMOTE SENSING

The Model 7153 matrix card can also be used by a single Source Measure Unit for remote sensing. For remote sensing, the Source Measure Unit could be connected to the matrix card as shown in Figure 3-8. OUTPUT HI/GUARD, SENSE HI/GUARD, SENSE LO and OUTPUT LO are connected to separate rows for maximum switching flexibility and optimum low current performance. Making the SENSE LO connection also connects OUTPUT LO to the matrix card through the triax connector. However, since it is connected to the inner shield, it is of no consequence as long as it is not used at the test fixture. In this test configuration, OUTPUT LO is accessed at the Source Measure Unit banana jack so that it can be independently switched.

The test configuration in Figure 3-8 "uses" four matrix rows. Remote sensing can be accomplished using three matrix rows by using OUTPUT LO at the triax connector. In this configuration, SENSE LO and OUTPUT LO use the same row. The disadvantage to this is the loss of some switching flexibility. Another option is to make OUTPUT LO a system common that is not routed (not switched) through the card. All commons are simply connected directly to the OUTPUT LO banana jack.

For high current applications where leakage current is not a consideration, the guard paths of the matrix card can be used for 4-wire sensing as shown in Figure 3-9. With this configuration only two matrix crosspoints are required to accomplish 4-wire connections to the DUT.

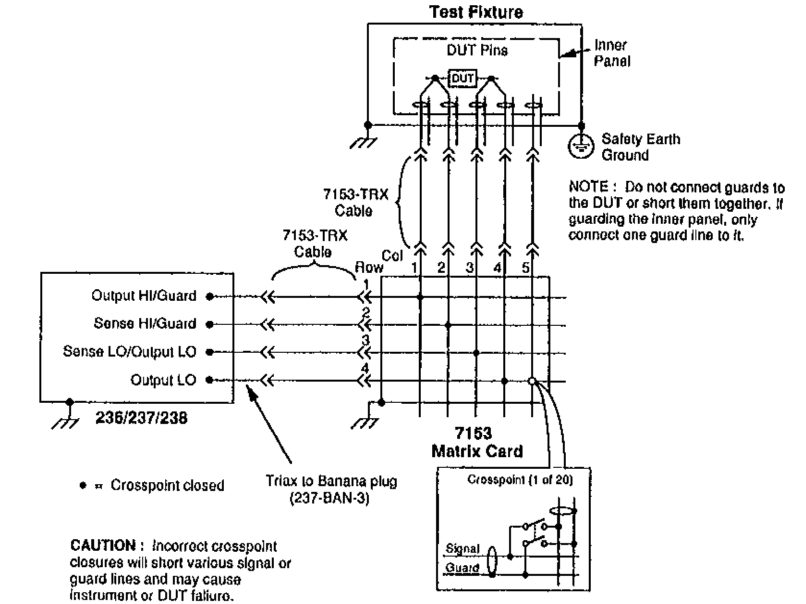


Figure 3-8. Remote Sense and Guard Connections to Model 7153

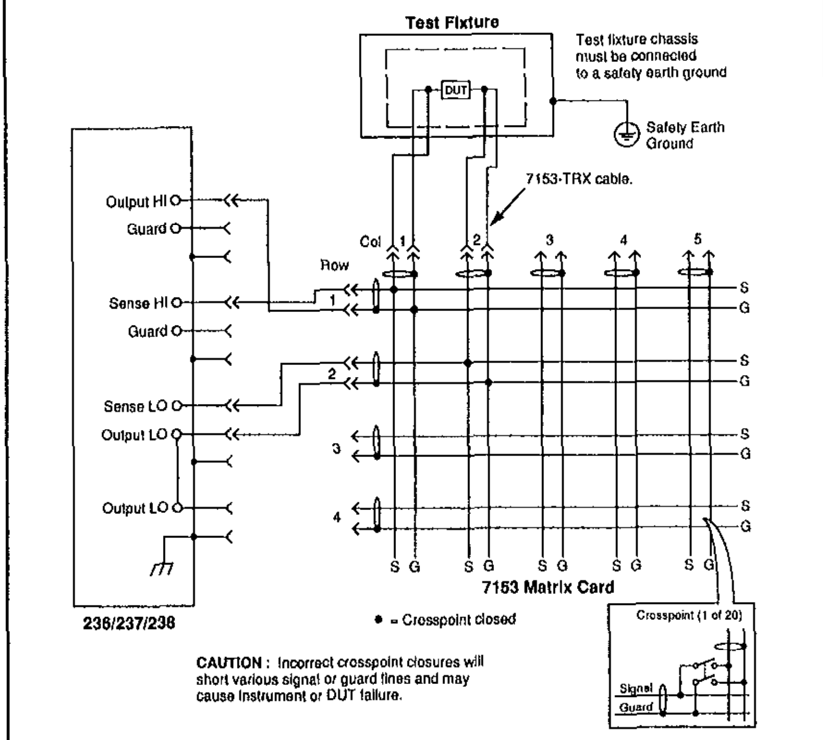


Figure 3-9. Remote Sensing with Guard

REFERENCES

ASTM, F76-84. "Standard Method for Measuring Hall Mobility and Hall Coefficient in Extrinsic Semiconductor Single Crystals". Annual Bk. ASTM Stds., 1986: 10.05 155.

Coyle, G. et al, Switching Handbook. Keithley Instruments Inc., Cleveland, Ohio (1987).

Van der Pauw, L. J. "A Method of Measuring Specific Resistivity and Hall Effects of Discs of Arbitrary Shape". Philips Rec. Repts., 1958: 13 1.

SECTION 4
Service Information

4.1 INTRODUCTION

This section contains information necessary to service the Model 7153 High Voltage 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 Performance Verification: Covers the procedures necessary to determine if the card is operating properly.

4.2 HANDLING AND CLEANING PRECAUTIONS

Because of the high-impedance circuits on the Model 7153, 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. 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. Should it become necessary to use solder on the circuit board, remove the flux from the work areas when the repair has been completed. Use Freon® TMS or TE or the equivalent along with clean cotton swabs or a clean, soft brush to remove the flux. Take care not to spread the flux

to other areas of the circuit board. Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.

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

4.3 PERFORMANCE VERIFICATION

WARNING
The following test procedures should only be performed by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury.

The following paragraphs discuss performance verification procedures for the Model 7153, including offset (leakage) current, contact potential, path isolation, input isolation (differential and common mode), and path resistance.

All test procedures are to be performed with the Model 7153 installed in a Model 705 or 706 scanner mainframe. Also, the matrix card being checked must NOT be connected to any other card.

4.3.1 Environmental Conditions

All verification measurements except for isolation and offset current should be made at an ambient temperature between 0°C and 35°C and at a relative humidity of less than 70%. Path isolation, input isolation and offset current verification must be performed at an ambient temperature of 23°C and at a relative humidity of less than 60%. If the matrix card has been subjected to temperature or humidity extremes, allow the card to environmentally stabilize for at least one hour before performing any tests.

4.3.2 Recommended Test Equipment

Table 4-1 summarizes the equipment necessary to make the performance verification tests, along with the application for each item.

Table 4-1. Recommended Test Equipment

Manu-facturer	Model or Part No.	Description	Applications
Keithley	617	Electrometer	Offset current and isolation
Keithley	181	Nanovoltmeter	Contact potential
Keithley	196	DMM	Path resistance
Keithley	705 or 706	Scanner mainframe	All tests
Keithley	7153-TRX	Matrix to Triax Cable	Offset current and path isolation
Keithley	6011	Triax to alligator clip cable	Common mode input isolation
Keithley	6012	Triax to UHF adapter	Differential input isolation
Keithley	6172	2-slot to 3-lug triax adapter	Offset current, path isolation and common mode input isolation
AMP	201144-1	Guard terminal extender	Common mode input isolation and contact potential
—	—	Signal terminal extender (#26 AWG copper wire)	Contact potential
Keithley	1481	Low thermal input cable	Contact potential
Keithley	237-BAN-3	Triax to Banana Cable	Path Isolation

Recommended Test Equipment (Cont.)

Manufac-turer	Model or Part No.	Description	Applications
AMP	45638-2	Coax crimping tool	Cable preparation
Pomona	5278	Female to Female triax adapter	Path Isolation
—	Special Con-nections	See Table 4-2	—

4.3.3 Special Connection Requirements

Many of the procedures in this section require special cables and connectors. The following provides the information needed to construct this equipment. The parts used to prepare this equipment are listed in Table 4-2.

Signal to Guard Shorting Plug

One low thermal shorting plug is required to check path resistance and contact potential. The shorting plug (see Figure 4-1) is built by modifying a miniature coaxial connector pin. The short is accomplished by jamming a small length of #24 AWG copper wire between the center conductor (signal) and the outer casing (guard). The wire is then soldered to the connector pin.

Table 4-2. Special Connection Parts

Description	Model or Part No.*	Application
Signal to Guard Short		
Miniature coax connector	Amp 201144-1	Contact potential and path resistance
Coax to Banana Cable		
Miniature coax connector	Amp 201144-1	Differential input isolation
Coax Cable	Belden®9239	
Banana plugs (2 required)	BG-10-2	
Ferrule	CS-747-3	
Signal Terminal Extender		
Miniature coax connector	Amp 201144-1	Contact potential
Coax Cable	Belden®9239	
Ferrule	CS-747-3	

*Keithley numbers except for the two Belden® entries.

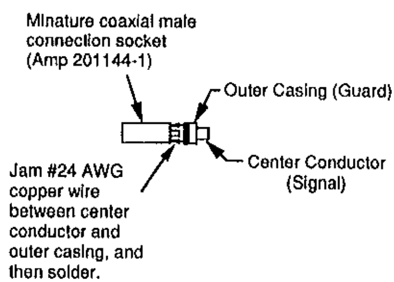


Figure 4-1. Signal-to-Guard Short Preparation

Coax to Banana Cable

One coax/banana cable is required to check path resistance and differential input isolation. The coax/banana cable is shown in Figure 4-2. A miniature coaxial female connector pin is connected to a suitable length of coaxial cable using the AMP-45638-2 crimping tool. Banana plugs are then connected to the other end of the cable as shown in the drawing. The cable should be kept as short as possible.

WARNING
High voltage will be present on the guard terminal when checking input isolation. To avoid electrical shock that could result in injury or death, make sure that the twisted braid (guard) of the cable is adequately insulated.

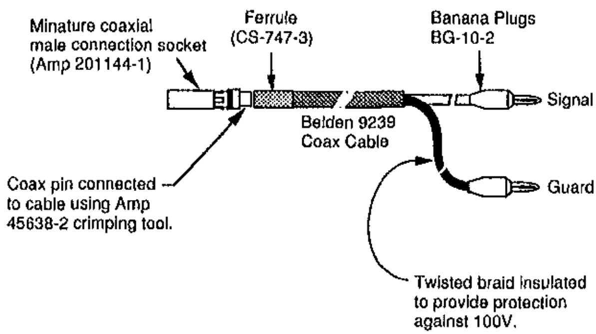


Figure 4-2. Coax to Banana Cable Preparation

Signal Terminal Extender

In order to check contact potential, a signal terminal extender is required. Figure 4-3 shows how a signal extender can be built. A suitable length of coaxial cable is connected to a female coaxial connector pin. A portion of the outer shield and inner insulator of the cable is then removed to expose a section of the center conductor (signal terminal). Make sure the outer shield (guard) does not short out to the center conductor (signal).

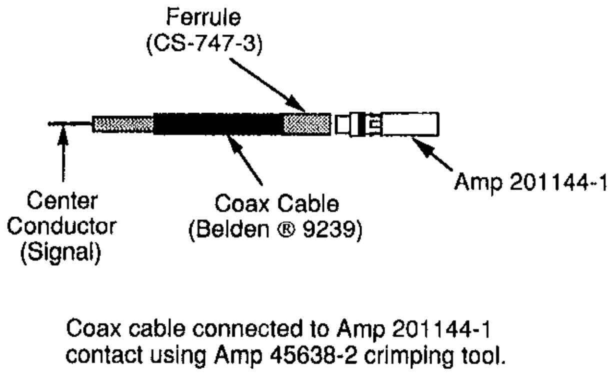


Figure 4-3. Signal Terminal Extender

4.3.4 Offset Current Verification

Recommended Equipment

- Keithley 617 Electrometer
- Keithley 7153-TRX Matrix to Triax Cable
- Keithley 6172 2-slot to 3-lug triax adapter

Test Connections

Figure 4-4 shows the test connections for offset current verification. The Model 7153 row being tested is to be connected to the Model 617 Electrometer input as shown. Note that the electrometer ground strap is to be removed, and the electrometer should be operated in the unguarded mode.

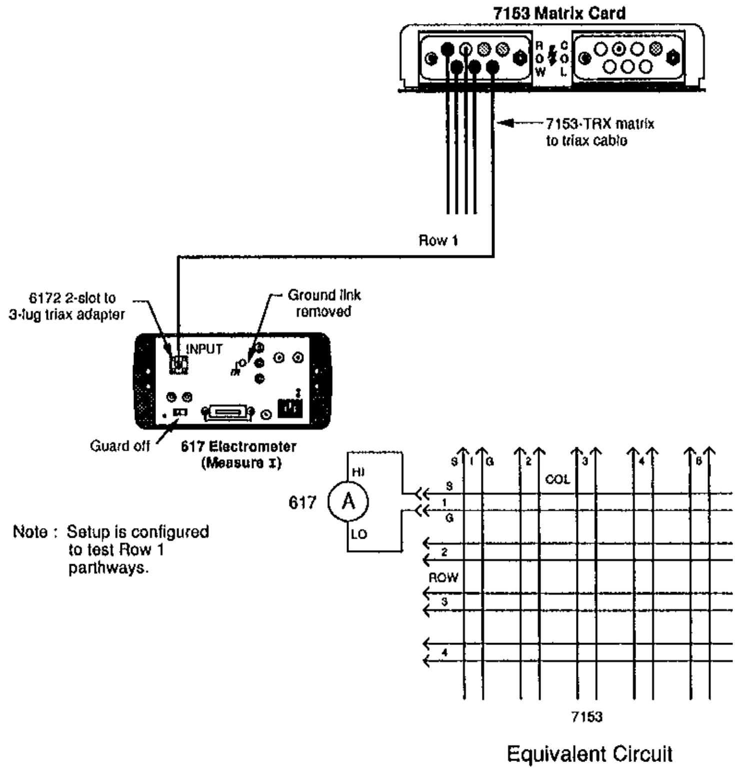


Figure 4-4. Offset Current Testing

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. 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.

3. Connect the Model 617 to row 1 of the Model 7153, as shown in Figure 4-4.
4. Close crosspoint R1C1 (row 1, column 1) by using the Model 705 or 706 front panel controls.
5. Disable zero check on the Model 617, and allow the reading to settle.
6. Verify that the offset current reading is <1pA.
7. Enable zero check on the Model 617, and open crosspoint R1C1.
8. Repeat steps 4 through 7 for crosspoints R1C2 through R1C5. Only one crosspoint at a time should be closed.
9. Disconnect the cable from row 1, and connect it instead to row 2.
10. Repeat steps 4 through 7 for crosspoints R2C1 through R2C5. Only one crosspoint at a time should be closed.
11. On the Model 617, enable zero check.
12. Repeat steps 3 through 8 for rows 3 and 4. The electrometer should be connected to the row being tested, and only one crosspoint must be closed at a time.

4.3.5 Contact Potential Verification

Recommended Equipment

- Keithley 181 Nanovoltmeter
- Keithley Model 1481 Low Thermal Input Cable
- Signal to guard short (custom built; see Figure 4-1)
- Signal Terminal Extender (custom built; see Figure 4-3)
- Guard Terminal Extender (AMP-201144-1)

Test Connections

Figure 4-5 shows the test connections for contact potential verification.

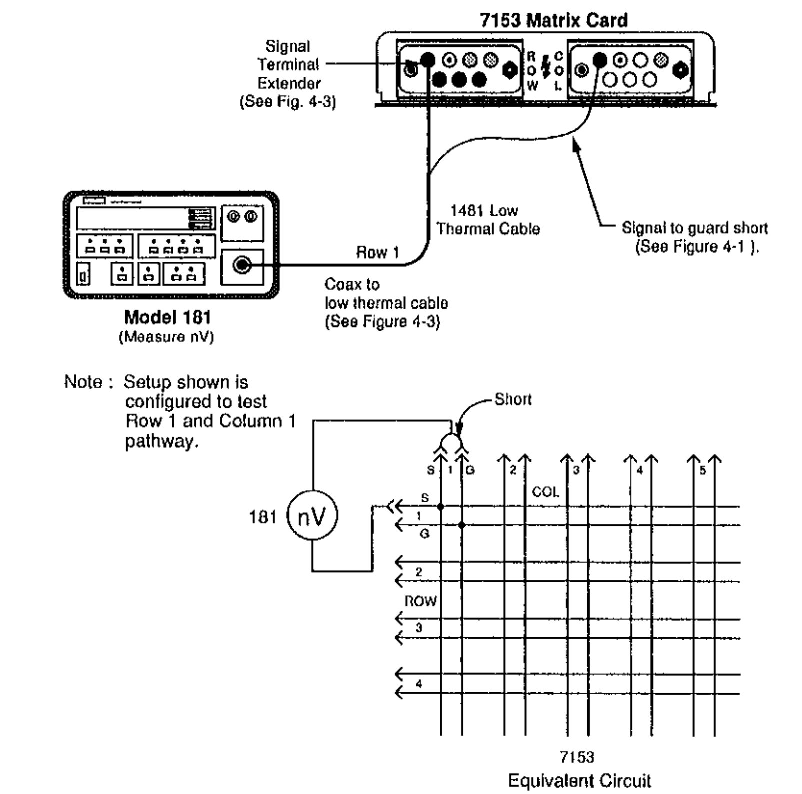


Figure 4-5. Contact Potential Testing

Procedure

1. Turn on Model 181 power and allow to warm up for one hour.
2. Connect the Model 1481 cable to the Model 181.
3. Connect the jumper to column 1 at the COL receptacle and install the Signal Terminal Extender in row 1 of the ROW receptacle.
4. After the prescribed warm up period, set the Model 181 to the 2mV range, short the alligator clips of the cable together, and press ZERO to null out internal offset. Leave ZERO enabled for the entire procedure.
5. Referring to Figure 4-5, connect the Model 181 to row 1 signal and column 1 jumper of the matrix card.
6. Program the mainframe to close crosspoint R1C1 (row 1, column 1).

7. Verify that the reading on the Model 181 is <20μV.
8. From the mainframe, open crosspoint R1C1 and move the jumper to column 2.
9. Repeat steps 6 through 8 to check the rest of the signal pathways (crosspoints R1C2 through R1C5) of the row. Only one crosspoint at a time should be closed.
10. Remove the Signal Terminal Extender from row 1 and install the Guard Terminal Extender.
11. Repeat step 6 through 9 to check the guard pathways of row 1.
12. Repeat steps 5 through 11 for rows 2 through 4. The nanovoltmeter should be connected to the row being tested and the jumper should be connected to the column being tested.

4.3.6 Path Isolation Verification

These tests check the leakage resistance (isolation) between adjacent matrix paths. Should the card fail any of the tests, clean it using the procedures outlined in paragraph 4.2.

Recommended Equipment

- Keithley 617 Electrometer
- Keithley 7153-TRX Matrix to Triax Cable
- Keithley 6172 2-slot to 3-lug triax adapter
- Pomona 5278 female to female triax adapter
- Triax to banana cable (custom built; see paragraph 2.6.3)

Test Connections

Figure 4-6 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 triax/banana cable, the construction of which is explained in paragraph 2.6.3. Note that both the inner shield and the center conductor are to be connected to the banana plug.

COM and the 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.

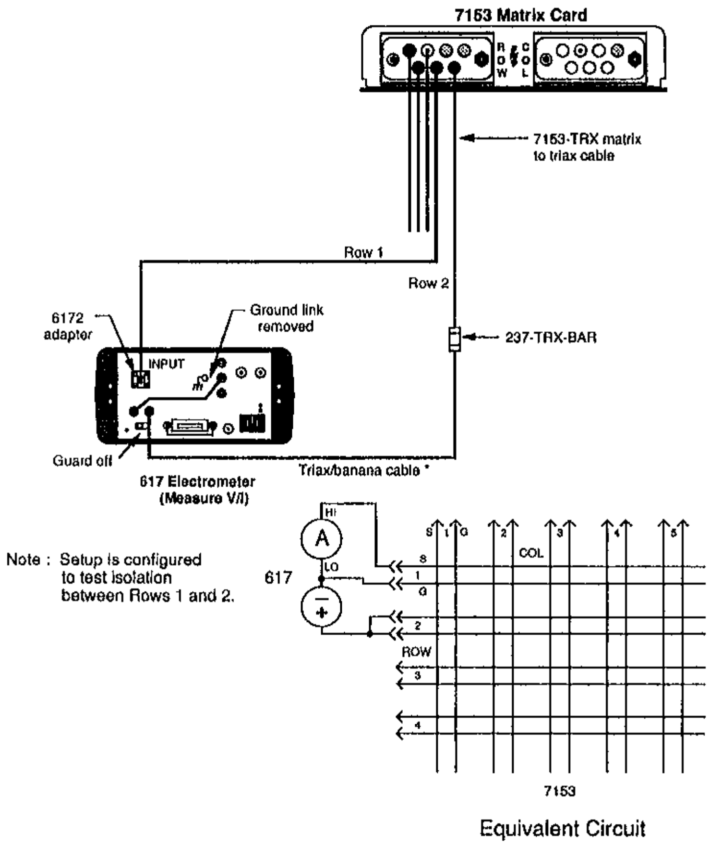


Figure 4-6. Path Isolation Testing

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.

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. After the prescribed warm up period, select the Model 617 amps function, and enable zero check. Select the 20pA range, and zero correct the instrument.
3. Connect the Model 617 to rows 1 and 2 of the matrix card, as shown in Figure 4-6.
4. Program the Model 617 voltage source for a value of +100V, but do not turn on the voltage source output.
5. Close crosspoints R1C1 (row 1, column 1) and R2C2 (row 2, column 2) from the mainframe.
6. With the Model 617 in amps, enable suppress after the reading has settled.
7. Turn on the Model 617 voltage source output, and enable the V/I ohms function on the electrometer.
8. After the reading has settled, verify that the resistance is >10TΩ ($10^{13}\Omega$).
9. Turn off the voltage source, and enable zero check. Disable suppress, and select the amps function on the electrometer.
10. From the front panel of the mainframe, press the RESET button to open all crosspoints.
11. Using Table 4-3 as a guide, repeat steps 5 through 10 for the crosspoint pairs listed starting with Test No. 2. Note that Model 617 is connected to rows 2 and 3 for tests 5 through 8, and connected to rows 3 and 4 for tests 9 through 12. Before moving the test connections, make sure the voltage source is off.

Table 4-3. Path Isolation Testing

Test No.	617 Connection Electrometer Input	617 Connection V-Source Output	Crosspoint Pairs Closed	
1	Row 1	Row 2	R1C1	R2C2
2			R1C2	R2C3
3			R1C3	R2C4
4			R1C4	R2C5
5	Row 2	Row 3	R2C1	R3C2
6			R2C2	R3C3
7			R2C3	R3C4
8			R2C4	R3C5
9	Row 3	Row 4	R3C1	R4C2
10			R3C2	R4C3
11			R3C3	R4C4
12			R3C4	R4C5

4.3.7 Differential Isolation Verification

These tests check the leakage resistance (isolation) between signal and guard of matrix pathways. Should the card fail any of the tests, clean it using the procedures outlined in paragraph 4.2.

Recommended Equipment

- Keithley 617 Electrometer
- Keithley 6012 Triax to UHF adapter
- Pomona 5278 female to female triax adapter
- Coax to banana cable (custom built; see Figure 4-2)

Test Connections

Figure 4-7 shows the test connections for the path isolation tests. The cable is connected to the row being tested. One banana plug (signal) of the cable is to be connected to the Model 617 Electrometer input through a Model 6012 triax to UHF adapter. The plug mates to the center conductor of the UHF connector. The other banana plug (guard) connects to the electrometer voltage source.

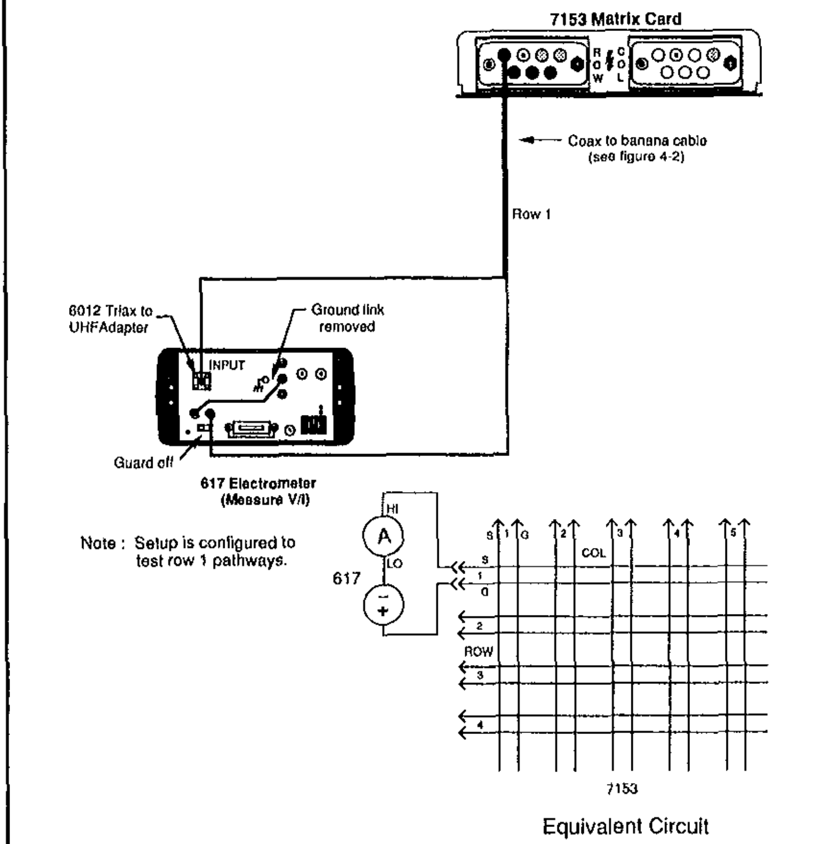


Figure 4-7. Differential Input Isolation Testing

COM and the 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.

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. After the prescribed warm up period, select the Model 617 amps function, and enable zero check. Select the 2nA range, and zero correct the instrument.
3. Connect the Model 617 to row 1 of the matrix card, as shown in Figure 4-7.
4. Program the Model 617 voltage source for a value of +100V, but do not turn on the voltage source output.
5. Close crosspoint R1C1 (row 1, column 1) from the mainframe.
6. With the Model 617 in amps, enable suppress after the reading has settled.
7. Turn on the Model 617 voltage source output, and enable the V/I ohms function on the electrometer.
8. After the reading has settled, verify that the resistance is >10TΩ ($10^{13}\Omega$).
9. Turn off the voltage source, and enable zero check. Disable suppress, and select the amps function on the electrometer.
10. From the front panel of the mainframe, press the RESET button to open the crosspoint.
11. Connect the Model 617 to row 2 of the matrix card and repeat steps 5 through 10 for crosspoint R2C2.

12. Connect the Model 617 to row 3 of the matrix card and repeat steps 5 through 10 for crosspoint R3C3.
13. Connect the Model 617 to row 4 of the matrix card and repeat steps 5 through 10 for crosspoint R4C4.
14. With the electrometer still connected to row 4, repeat steps 5 through 10 for crosspoint R4C5.

4.3.8 Common Mode Isolation Verification

These tests check the leakage resistance (isolation) between signal/guard and chassis ground of matrix pathways. Should the card fail any of the tests, clean it using the procedures outlined in paragraph 4.2.

Recommended Equipment

- Keithley 617 Electrometer
- Keithley 6011 Triax to alligator clip cable
- Signal to guard short (custom built; see Figure 4-1)

Test Connections

Figure 4-8 shows the test connections for these tests. The Model 6011 cable is connected to the electrometer input as shown. The alligator clip on the black test lead of the cable is connected to the screw housing of the receptacle (chassis ground). The signal to guard short is installed in the row to be tested. The alligator clip on the red test lead is then connected to the short (signal/guard).

The Model 617 guard must be turned off for current measurements.

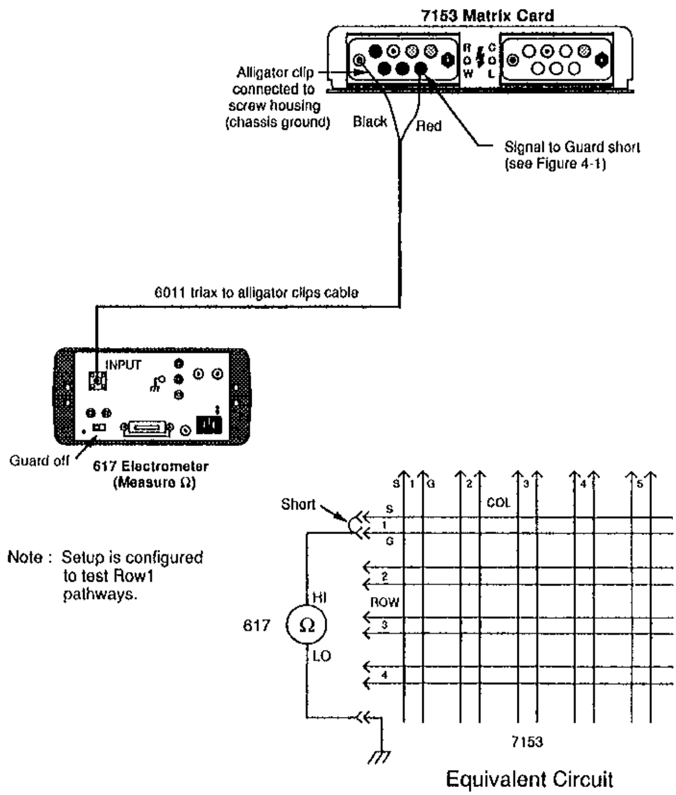


Figure 4-8. Common Mode Input Isolation Testing

Procedure

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. After the prescribed warm up period, select the Model 617 ohms function, enable zero check, and select the 10GΩ range.
3. Connect the Model 617 to row 1 and chassis ground of the matrix card, as shown in Figure 4-8.
4. Close crosspoint R1C1 (row 1, column 1) from the mainframe.
5. On the Model 617, release zero check. After the reading has settled, verify that the resistance is >1GΩ (10^9Ω).
6. On the Model 617, enable zero check.
7. From the front panel of the mainframe, press the RESET button to open the crosspoint.
8. Connect the short and red test lead from the Model 617 to row 2 of the matrix card and repeat steps 4 through 7 for crosspoint R2C2.
9. Connect the short and red test lead from the Model 617 to row 3 and repeat steps 4 through 7 for crosspoint R3C3.
10. Connect the short and red test lead from the electrometer to row 4 and repeat steps 4 through 7 for crosspoint R4C4.
11. With the electrometer still connected to row 4, repeat steps 4 through 7 for crosspoint R4C5.

4.3.9 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.

Recommended Equipment

- Keithley 196 DMM
- Banana to clip-on test lead
- Coax to banana cable (custom built; see Figure 4-2)
- Signal to guard short (custom built; see Figure 4-1)

Connections

Figure 4-9 shows the connections for the path resistance tests. A specially prepared shorting plug is used to connect signal to guard, and is installed at the column being tested. The Model 196 low terminal is connected to the shorted column using the banana/clip-on test lead. This test lead clips onto the installed shorting plug. The high terminal of the DMM connects to the row being tested using the specially constructed coax/banana cable.

Procedure

1. Turn on the Model 196 DMM and allow it to warm up for at least one hour before beginning the test.
2. Using Figure 4-9 as a guide, connect the cable (signal) and test lead to the DMM, but do not make connections to the matrix card.
3. Temporarily clip the test lead to the inner conductor of the coax connector pin of the cable. This will short the DMM input.
4. Select the ohms function, 300Ω range, and 5-1/2 digit resolution on the Model 196.
5. After the reading settles, enable zero on the Model 196 DMM. Leave zero enabled for the following tests.
6. Connect the cable and test lead to the matrix card as shown in Figure 4-9.
7. From the mainframe, close crosspoint R1C1 (row 1, column 1) and allow the reading to settle. Verify that the resistance reading is < 2Ω.
8. On the mainframe, press the RESET button to open the crosspoint.
9. Repeat steps 7 and 8 for columns 2, 3 and 4. In each case the short and test lead must be connected to the column under test, and the crosspoint must be closed.
10. Repeat steps 7 through 9 for rows 2, 3 and 4. In each case, the electrometer is connected to the row under test. 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 < 2Ω.
11. Disconnect the coax/banana cable from the matrix card and the DMM. Also, disconnect the clip-on test lead from the matrix card.
12. On the Model 196, disable zero.
13. Connect the guard banana plug of the cable to the HI terminal of the DMM. Do not make any connections to the matrix card.
14. Temporarily clip the test lead on to the outer shell of the coax connector pin of the cable. This will short the DMM input.
15. After the reading settles, enable zero on the Model 196. Leave zero enabled for the remaining tests.

16. Install the signal to guard shorting plug at column 1.
17. Connect the cable and test lead to the matrix card as shown in Figure 4-9. Note however, that guard (not signal as shown in the drawing) is to be connected to DMM HI.
18. Repeat steps 7 through 10 to test guard pathway resistance.

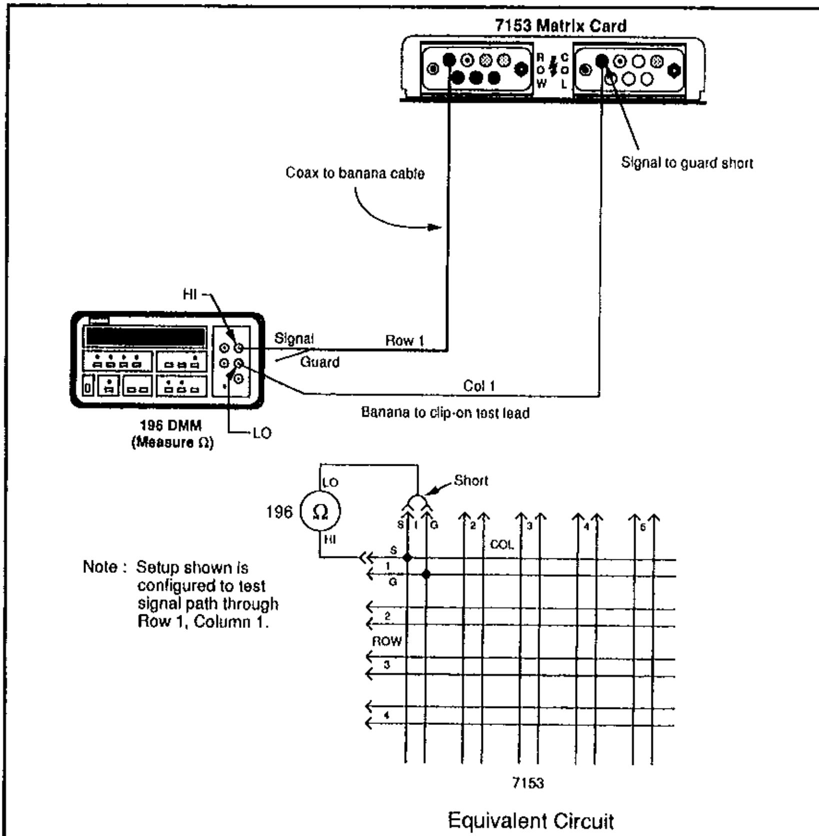


Figure 4-9. Path Resistance Testing

SECTION 5
Replaceable Parts

5.1 INTRODUCTION

This section contains a list of replaceable electrical and mechanical parts for the Model 7153, as well as a component layout drawing and schematic diagram of the card.

5.2 PARTS LIST

Electrical parts are listed in order of the circuit designation. A miscellaneous parts list table is located at the end of this section.

5.3 ORDERING INFORMATION

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

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

5.4 FACTORY SERVICE

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

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

5.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

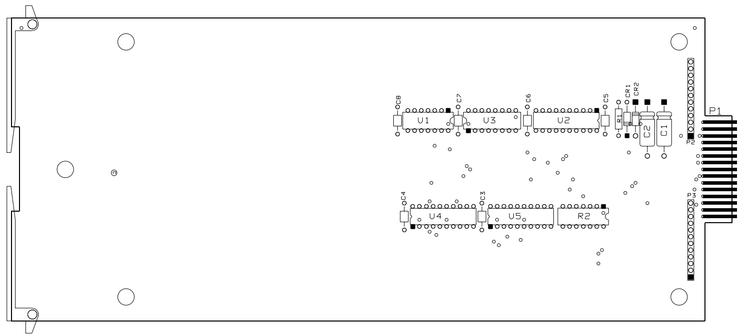
A component layout of the driver board is contained in drawing number 7153-160, while drawing number 7153-166 contains a schematic diagram. A component layout of the delay board is contained in drawing number 7153-100, while drawing number 7153-106 contains a schematic diagram.

DRIVER BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
	HANDLE	FA-119
C1	CAP,22UF,-20+100%,25V,ALUM ELEC	C-437-22
C2	CAP,10UF,-20+100%,25V,ALUM ELEC	C-437-10
C3...8	CAP,.1UF,20%,50V,CERAMIC	C-365-.1
CR1	DIODE,SILICON,IN4148 (DO-35)	RF-28
CR2	DIODE,SILICON,IN4006 (D0-41)	RF-38
P2,P3	CONN, STRIP, 12 PIN	CS-584-1
R1	RES, 40.2K, 1%, 1/8W, METAL FILM	R-88-40.2K
R2	RES, NET, 4.7K, 2%, 1.5W	TF-19-4.7K
U1	IC,DUAL D-TYPE FLIP FLOP,74HC74	IC-337
U2	IC, BUF/LINE DRIVER & RECEIVER, MC	IC-520
U3	IC,8 STAGE SHIFT/STORE REGISTER,4094	IC-251
U4,5	IC,BUF/LINE DRIVER & RECEIVER,74HC240	IC-617

NO. 7153-160

LTR.	ECO NO.	REVISION	ENG.	DATE
A	900925	RELEASED	MS	9/26/90

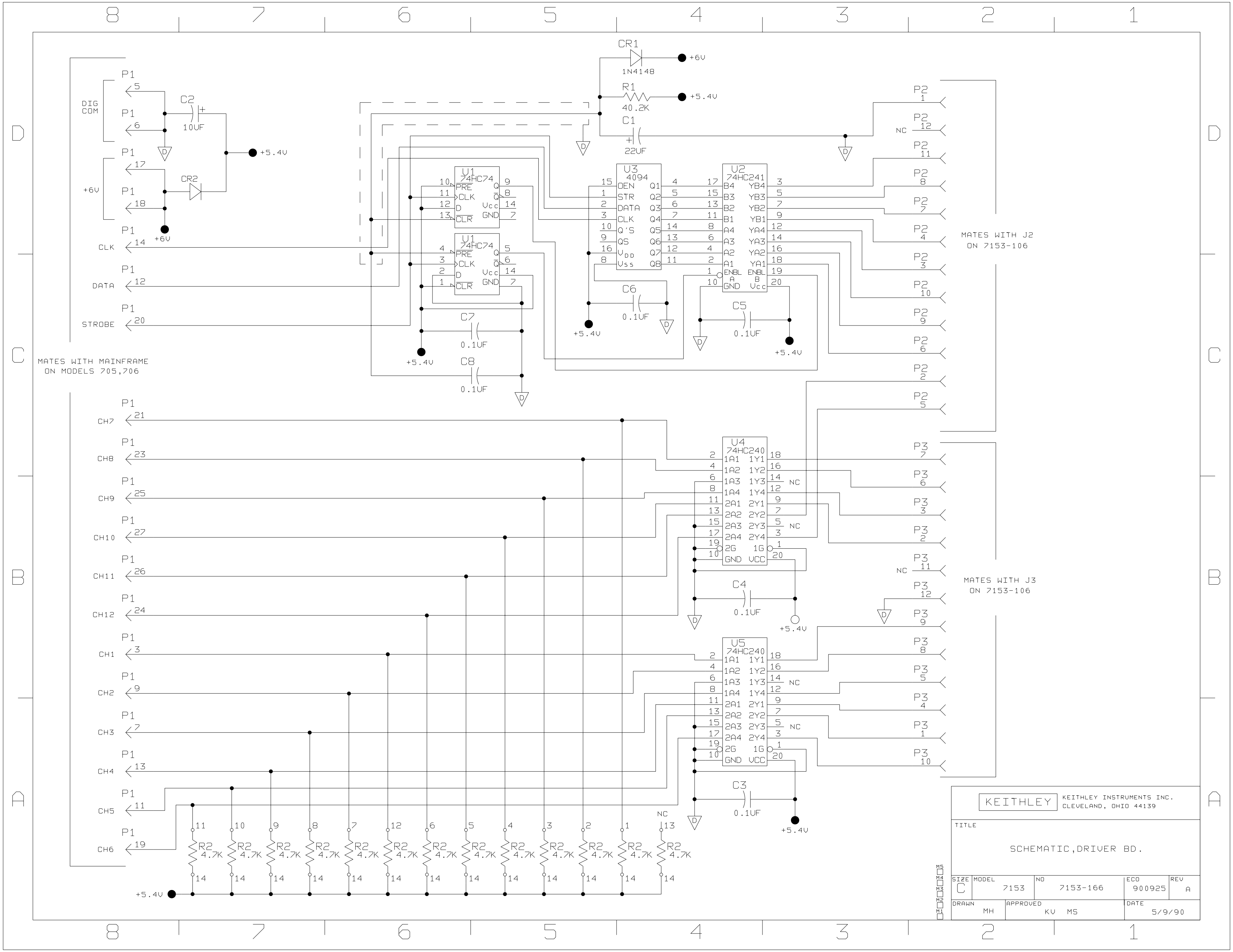


NOTE: FOR MORE COMPONENT INFORMATION REFER TO 7153 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
7153		

USED ON

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 8/29/90	SCALE 1:1	TITLE COMPONENT LAYOUT, DRIVER BOARD
KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±1°	DRN. MAH	ENG. APPR. KV MS	
	XXX=±.005 FRAC.=±1/64	MATERIAL SEE ABOVE		C NO. 7153-160
	SURFACE MAX. 63	FINISH SEE ABOVE		

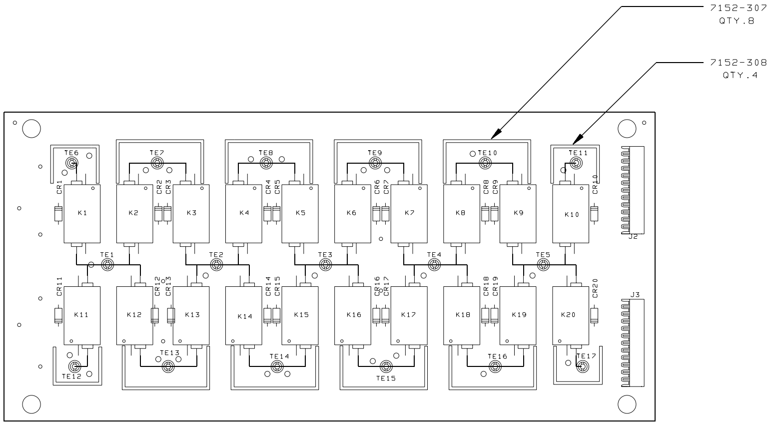

CR1
1N4148
+6V
R1
40.2K
+5.4V
C1
22UF
C2
10UF
DIG COM
+6V
CR2
P1
CLK
DATA
STROBE
U1 74HC74
U3 4094
U2 74HC241
C5 0.1UF
C6 0.1UF
C7 0.1UF
C8 0.1UF
MATES WITH MAINFRAME ON MODELS 705,706
MATES WITH J2 ON 7153-106
MATES WITH J3 ON 7153-106
P2
P3
NC
CH7
CH8
CH9
CH10
CH11
CH12
CH1
CH2
CH3
CH4
CH5
CH6
U4 74HC240
U5 74HC240
C4 0.1UF
C3 0.1UF
R2 4.7K
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC,DRIVER BD.
SIZE C
MODEL 7153
NO 7153-166
ECO 900925
REV A
DRAWN MH
APPROVED KV MS
DATE 5/9/90

RELAY BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
	TERMINAL, COAX SHIELD	TE-114
	TEFLON TERMINAL	TE-111
	18 AWG VINYL BLACK	SC-71-0
	CONTACT, PIN	CS-747-1
	CONTACT, SPRING	CS-747-4
	CONTACT, PIN	CS-747-2
	RELAY SHIELD (LARGE)	7152-307
	RELAY SHIELD (SMALL)	7152-308
	#12PVC(12),#10PVC(3) CABLE	SC-111
	CHASSIS PIN	CS-747-1
CR1..20	DIODE,SILICON,IN4148 (DO-35)	RF-28
	FOR CS-747-2	
	CONTACT, FERRULE	CS-747-3
	FOR SC-111	
	PRE CUT RT-876 SHRINK TUBING, BLACK	TX-17-1/8X3/8
J2,3	CONN, STRIP, 12 PIN	CS-583-1
K1..20	RELAY, REED	RL-143

NO. 7153-100

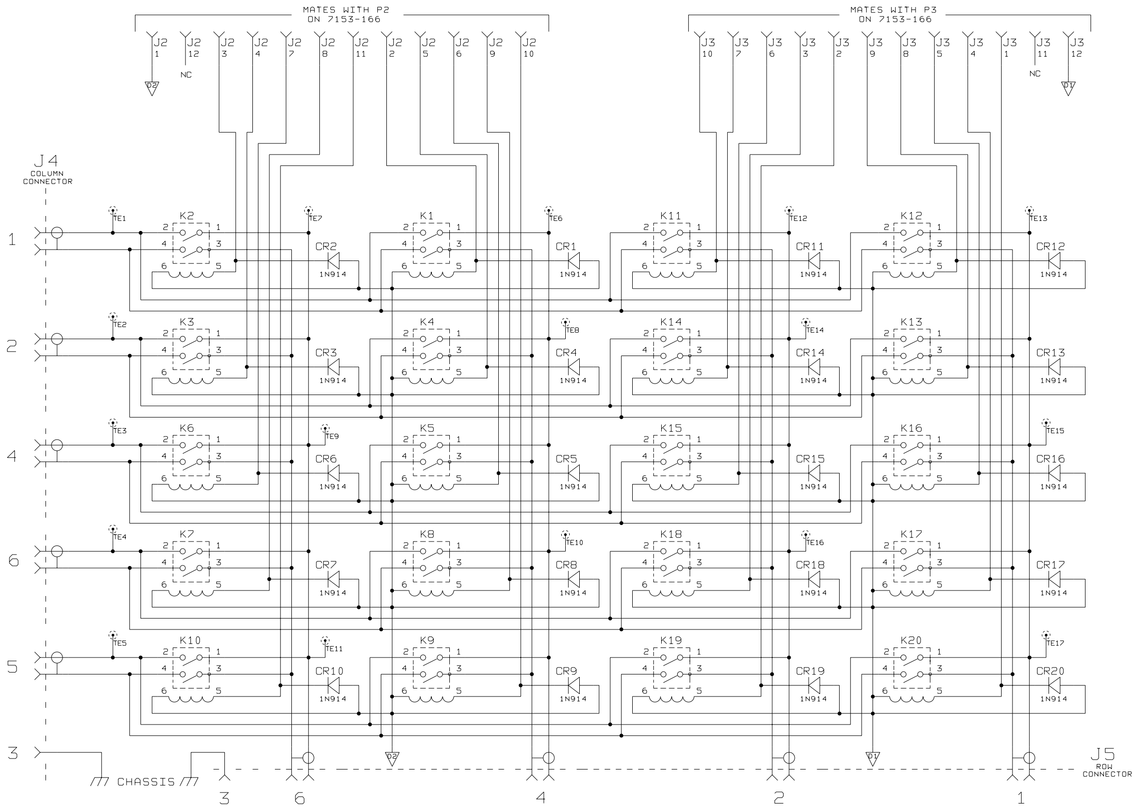
LTR.	ECO NO.	REVISION	ENG.	DATE
A	900925	RELEASED	MS	9/26/90
B	14376	CHG'D ARTWORK FROM REV A TO B.	AS	2/25/91



NOTE: FOR MORE COMPONENT INFORMATION SEE 7153 PRODUCT STRUCTURE.

7153		
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 8/29/90	SCALE 1:1	TITLE COMPONENT LAYOUT, RELAY BOARD
KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±1°	DRN. MAH	ENG. APPR. KV/MS	
	XXX=±.005 FRAC.=±1/64	MATERIAL		C NO. 7153-100
	SURFACE MAX. 63	FINISH		



CONNECTOR CHART		REAR PANEL CONTACT	ACC. CABLE NUMBER
J5	ROW 1	1	1
	ROW 2	2	2
	ROW 3	4	3
	ROW 4	6	4
	CHASSIS	3	G
J4	COLUMN 1	1	1
	COLUMN 2	2	2
	COLUMN 3	4	3
	COLUMN 4	6	4
	COLUMN 5	5	5
	CHASSIS	3	G

KEITHLEY

KEITHLEY INSTRUMENTS INC.
CLEVELAND,OHIO 44139

TITLE: SCHEMATIC,RELAY BOARD

SIZE	MODEL	NO	ECO	REV
D	7153	7153-106	14376	B

DRAWN	APPROVED	DATE
MH	KV/MS	2/22/91

MISCELLANEOUS, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
	PANEL, REAR	7153-301
	FASTENER, BLIND THREADED PEM	FA-171-5
	CABLE TIE	CC-38-2
	FIXED JACKSCREW MALE	CS-660
	4-40X1/4 PHILLIPS PAN HD SEMS SCREW	4-40X1/4PPHSEM
	FIXED JACKSCREW FEMALE	CS-661
	CONNECTOR, HOUSING	CS-745-1
	CONNECTOR, GUARD	CS-745-2
	LUG	LU-27
	SHRINK TUBING, BLACK	TX-17-1/2X1-1/4

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.
Test Instrumentation Group
28775 Aurora Road
Cleveland, Ohio 44139

Printed in the U.S.A.