

**KEITHLEY**

**Model 7173-50** Two-Pole High Frequency  
Matrix Card (4 × 12)  
Instruction Manual

A GREATER MEASURE OF CONFIDENCE

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Model 7173-50  
Two-Pole High Frequency Matrix Card (4×12)  
Instruction Manual

# Manual Print History

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

Revision A (Document Number 7173-50-901-01) ..... March 1991

# Safety Precautions

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

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

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

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

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

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

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

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

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

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

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

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

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

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


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


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


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

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

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

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

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

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

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

# Model 7173-50 High Frequency Two-Pole 4x12 Matrix Card

**MATRIX CONFIGURATION:** 4 rows by 12 columns.  
**CROSSPOINT CONFIGURATION:** 2-pole Form C with Row Isolator(HI, LO).  
**CHARACTERISTIC IMPEDANCE:** 50Ω nominal.  
**CONNECTOR TYPE:** BNC.  
**MAXIMUM SIGNAL LEVEL:** 30V, 0.5A switched, 10VA.  
**COMMON MODE VOLTAGE:** 42V peak (LO to Chassis).  
**CONTACT LIFE:**  
 Cold Switching:  $5 \times 10^6$  closures.  
 At Maximum Signal Level:  $3 \times 10^5$  closures.  
**PATH RESISTANCE:**  
 HI:  $<2.0\Omega$  initial,  $<4.0\Omega$  at end of contact life.  
 LO:  $<0.10\Omega$  initial,  $<0.15\Omega$  at end of contact life.  
**CONTACT POTENTIAL:**  $<15\mu\text{V}$  per crosspoint (HI to LO).  
**OFFSET CURRENT:**  $<200\text{pA}$  (HI to LO).  
**ISOLATION:**  
 Path:  $>10^{10}\Omega$ ,  $<0.040\text{pF}$ .  
 Differential:  $>10^9\Omega$ , 150pF nominal.  
 Common Mode:  $>10^9\Omega$ , 9400pF nominal.

**RISE TIME (50Ω load and 50Ω source):**  $<2\text{nS}$ .

**AC PERFORMANCE (50Ω load and 50Ω source):**

	1 MHz	10 MHz	100 MHz	200MHz
<b>CROSSTALK:<sup>1</sup></b>	$<-85\text{dB}$	$<-50\text{dB}$	$<-35\text{dB}$	
<b>INSERTION LOSS:</b>	$<0.2\text{dB}$	$<0.4\text{dB}$	$<1.5\text{dB}$	$<3.0\text{dB}$
<b>VSWR (TYPICAL):</b>			1.4	1.7

<sup>1</sup>Closed crosspoint to closed crosspoint

**RELAY DRIVE CURRENT:** 108mA (per crosspoint).

**RELAY SETTling TIME:**  $<6\text{ms}$ .

**ENVIRONMENT:**

Operating:  $0^\circ$  to  $50^\circ\text{C}$ , up to  $35^\circ\text{C}$  at 70% R.H.

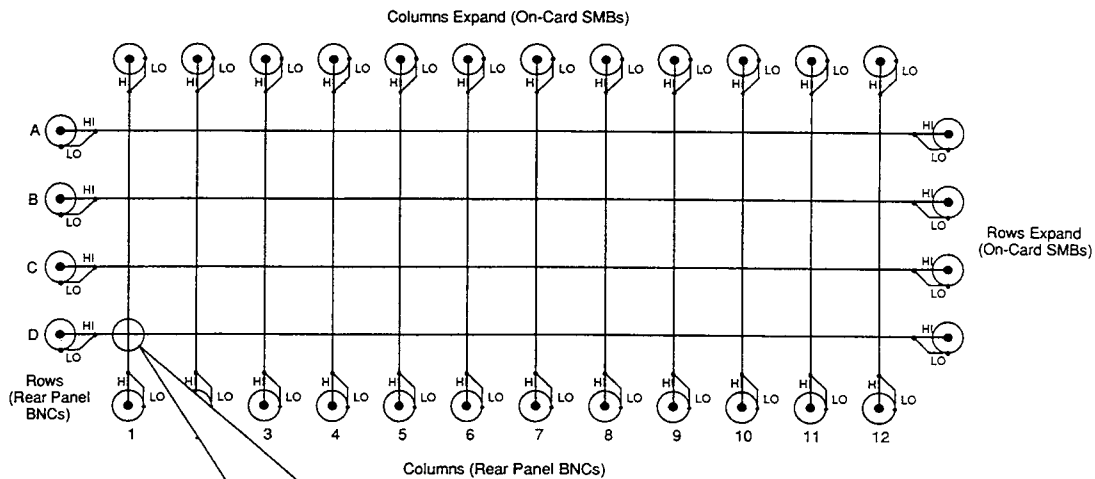
Storage:  $-25^\circ$  to  $65^\circ\text{C}$ .

**ACCESSORY SUPPLIED:** Instruction manual.

Specifications apply for one 7173-50 with all row isolators in automatic mode.

Specifications subject to change without notice.

## Simplified Model 7173-50 Schematic



### Row Isolator Control

Automatic mode: Isolator contact opens when crosspoint (HI and LO contact) is closed.

Manual mode: Isolator contact is controlled independent of crosspoint (HI and LO contact).

# Model 7173-50

## **SECTION 1** **General Information**

Contains information on Model 7173-50 features, specifications, and accessories.

## **SECTION 2** **Installation**

Gives detailed instructions for installing the Model 7173-50 in the mainframe and also covers expansion cable installation

## **SECTION 3** **Operation**

Covers card connections and matrix configurations, and also discusses operating considerations.

## **SECTION 4** **Applications**

Discusses typical application for the Model 7173-50, including a test system for analog or digital devices, and a test system for resistor networks.

## **SECTION 5** **Service Information**

Contains performance verification procedures, troubleshooting information, and principles of operation for the matrix card.

## **SECTION 6** **Replaceable Parts**

Lists replacement parts, and also includes component layout and schematic drawings for the Model 7173-50.



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# SECTION 1

## General Information

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### 1.1 INTRODUCTION

This section contains general information about the Model 7173-50 Two-Pole High Frequency Matrix Card.

Section 1 is arranged in the following manner:

- 1.2 Features
- 1.3 Warranty Information
- 1.4 Manual Addenda
- 1.5 Safety Symbols and Terms
- 1.6 Specifications
- 1.7 Unpacking and Inspection
- 1.8 Repacking for Shipment
- 1.9 Optional Accessories

### 1.2 FEATURES

The Model 7173-50 is a coaxial, two-pole, 4 row  $\times$  12 column matrix card, which is designed for 50 $\Omega$  characteristic impedance operation (as indicated by the -50 designa-

tion in the model number). The Model 7173-50 can also be used in 75 $\Omega$  applications. Typical data for such applications is located in the Appendix.

Key features of the Model 7173-50 matrix card include:

- High bandwidth and isolation for optimum transmission of high-frequency signals.
- Low contact potential and offset current for minimal effects on low-level signals.
- Quick-disconnect BNC connectors to DUT and instrumentation.
- On-card SMB connectors allow easy expansion of matrix columns and rows using additional Model 7173-50 matrix cards and optional Model 7173-50-CSEP SMB to BNC cable sets.

### 1.3 WARRANTY INFORMATION


Warranty information is located on the inside front cover of this instruction manual. Should your Model 7173-50 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 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 **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

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

## 1.6 SPECIFICATIONS

Model 7173-50 specifications may be found at the front of this manual. These specifications are exclusive of the matrix mainframe specifications, which are summarized in the Model 707 Instruction Manual.

## 1.7 UNPACKING AND INSPECTION

### 1.7.1 Inspection for Damage

The Model 7173-50 is packed in a resealable, anti-static bag in order to protect it from damage due to static discharge and from contamination which could degrade card performance. Before removing the card from the bag, note the following precautions on card handling:

1. Always grasp the card by the handle and side edges. Do not touch the board surfaces, components, or edge connectors.

2. When the Model 7173-50 is not installed in the switching mainframe, store the card in the anti-static bag and original packing carton.

After carefully unpacking the card from its shipping carton, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately. Save the original packing carton for storage or possible future shipment.

If you intend to install the Model 7173-50 in the mainframe at this time, refer to the installation instructions in Section 2.

### 1.7.2 Shipment Contents

The following items are included with every Model 7173-50 order:

- Model 7173-50 Two-Pole High Frequency Matrix Card.
- Model 7173-50 Instruction Manual.
- Additional accessories as ordered.

### 1.7.3 Instruction Manual

The Model 7173-50 Instruction Manual is three-hole drilled so that it can be added to the three-ring binder of the Model 707 Switching Matrix Instruction Manual. After removing the plastic wrapping, place the manual in the binder after the mainframe instruction manual. Note that a manual identification tab is included and should precede the matrix card instruction manual.

If an additional instruction manual is required, order the manual package, Keithley part number 7173-50-901-00. The manual package includes an instruction manual and any pertinent addenda.

## 1.8 REPACKING FOR SHIPMENT

Should it become necessary to return the Model 7173-50 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 ACCESSORIES

The following accessories are available to make connections to the Model 7173-50.

### 1.9.1 Accessories for Low-level Signal Applications

The following accessories are recommended for low-level signal applications where low noise is important, and they may not be suitable for high-frequency applications.

**Model 4801:** Low-noise coaxial cable, 48" (1.2m) in length, with male BNC connectors on both ends.

**Model 4802-10:** Low-noise coaxial cable, 10ft. (3m) in length, with a male BNC connector at one end and unterminated at the other end.

**Model 4803:** Low-noise cable kit. Includes 50ft. of low-noise coaxial cable, 10 male BNC connectors, and five female BNC chassis-mount connectors.

**Model 4804:** Male BNC to female triax adapter.

**Model 4851:** BNC shorting plug.

**Model 6147:** Male triax to female BNC adapter.

### 1.9.2 Accessories for High-frequency Applications

The accessories summarized below are recommended for high-frequency applications. These accessories as-

sure proper 50 $\Omega$  matching, and they may not be suitable for low-noise applications.

**Model 7051-2 BNC-to-BNC Cable:** The Model 7051-2 is 50 $\Omega$  BNC to BNC cable (RG-58C) 2ft. (0.6m) in length. The Model 7051-2 is terminated with male BNC connectors on both ends.

**Model 7051-5 BNC-to-BNC Cable:** The Model 7051-5 is 50 $\Omega$  BNC to BNC cable (RG-58C) 5ft. (1.2m) in length. The Model 7051-5 is terminated with male BNC connectors on both ends.

**Model 7754-3 BNC-to-Alligator Cable:** The Model 7754-3 is a 3ft. (0.9m) 50 $\Omega$  cable (RG-58C), terminated with a male BNC connector on one end and two alligator clips on the other end.

**Model 7755 50 $\Omega$  Feed-Through Terminator:** The Model 7755 is a male BNC to female BNC adapter that is internally terminated with a 50 $\Omega$  resistor. VSWR is <1.1, DC to 250MHz.

**Model CS-115:** Male UHF to female BNC adapter.

### 1.9.3 Matrix Expansion Accessories

**Model 7173-50-CSEP:** Set of four SMB to BNC coaxial matrix expansion cables, each 25" in length. One set of cables is required to add more columns, and three sets are necessary to add more rows (matrix expansion requires one or more additional Model 7173-50 cards). Each cable is terminated with a male BNC connector on one end, and a right angle female SMB connector on the other end.

**SMB Resistive Terminator:** Female SMB terminator, internally terminated with a 51 $\Omega$ ,  $\pm 1\%$  resistor (Sealectro Corporation Part Number 61-001-0101).

# SECTION 2

## Installation

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### 2.1 INTRODUCTION

This section contains information on installing the Model 7173-50 in the Model 707 Mainframe.

#### WARNING

The information in this section is intended for use only by qualified service personnel. Matrix card installation must be performed only by qualified technical personnel who are familiar with electronics equipment. User-supplied lethal voltages may be present on exposed matrix card circuit board surfaces and terminals.

Section 2 includes the following information:

- 2.2 **Handling Precautions:** Summarizes precautions that should be taken when handling the matrix card.
- 2.3 **Matrix Card Installation:** Gives step-by-step procedures for installing the Model 7173-50 in the mainframe.
- 2.4 **Matrix Card Removal:** Describes how to remove the card from the mainframe.

- 2.5 **Installing Expansion Cables:** Describes how to install cables to expand a matrix using additional Model 7173-50 cards.

### 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 any possible contamination, always grasp the card by the handle or the card edges. Do not touch board surfaces or components.

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 contamination is suspected, clean the card as discussed in Section 5.

### 2.3 MATRIX CARD INSTALLATION

Before making connections, the Model 7173-50 should be installed within the Model 707 Switching Matrix, as summarized below. Figure 2-1 shows the installation procedure.

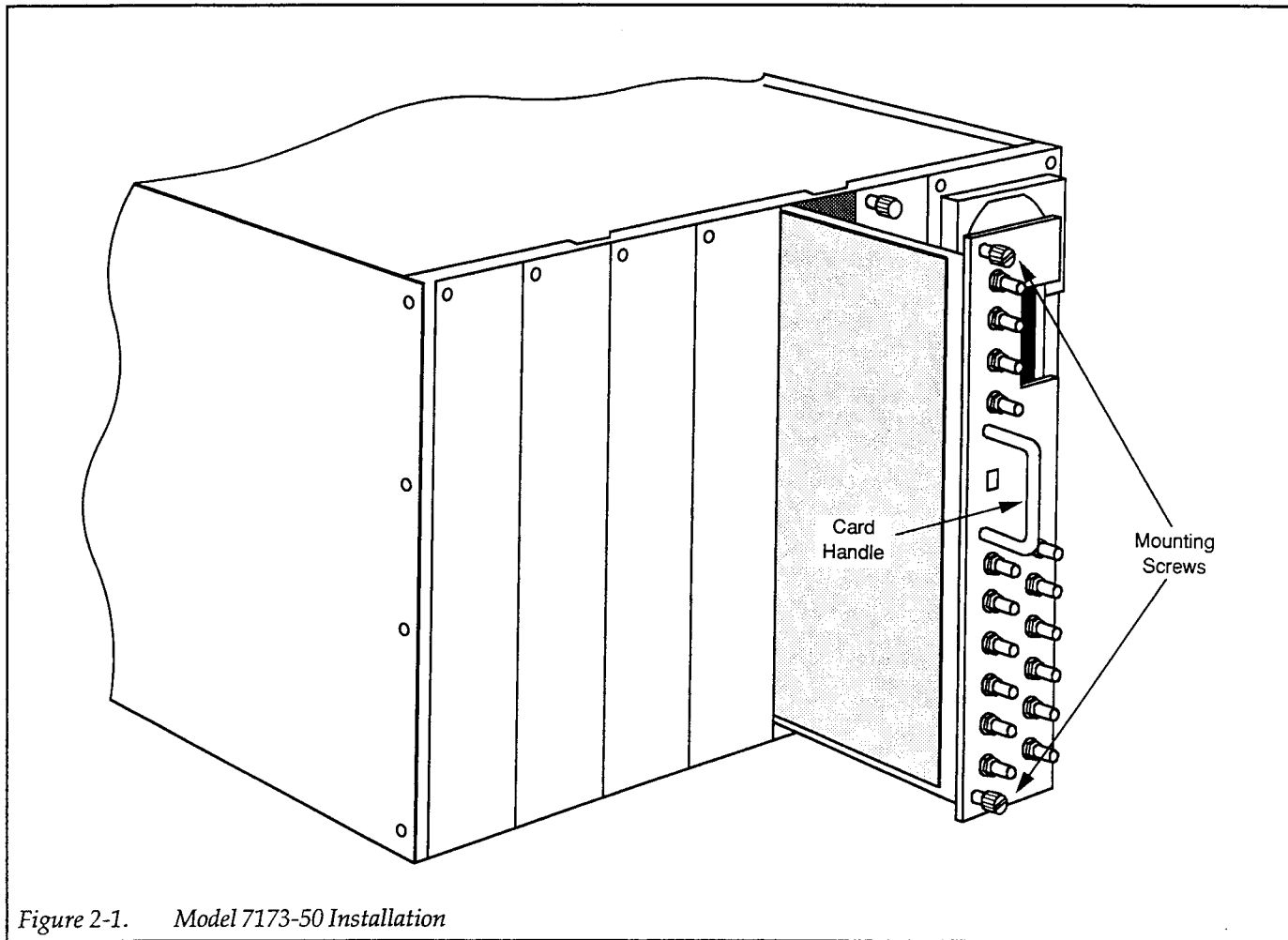


Figure 2-1. Model 7173-50 Installation

**WARNING**

Turn off mainframe power, and disconnect all connecting cables before installing or removing matrix cards.

**CAUTION**

Handle the card only by the handle and top and bottom edges to avoid possible contamination that could degrade card performance.

**NOTE**

If you intend to expand the matrix with additional matrix cards, refer to expansion cable installation instructions in paragraph 2.5 before installing the card in the mainframe.

1. Before installing the card, make sure the access door on top of the Model 707 is fully closed and secured. The access door contains tracks for the card slots and must be in place to properly install the card.
2. With one hand grasping the handle, and the other holding the bottom edge of the card, line up the card with the tracks in the desired slot. Make certain that the component side of the card is facing the fan on the mainframe.
3. Slide the card into the mainframe until it is properly seated in the edge connector at the back of the slot. Once the card is properly seated, secure it to the mainframe by finger tightening the spring-loaded screws.

**WARNING**

The mounting screws must be secured to ensure a proper chassis ground connection between the card and the mainframe. Failure to

properly secure this ground connection may result in personal injury or death due to electric shock.

## 2.4 MATRIX CARD REMOVAL

To remove the matrix card, first turn off the power, and disconnect all connecting cables. Loosen the mounting screws, then pull the card out of the mainframe by the handle. When the back of the card clears the mainframe, support it by grasping the bottom edge near the back of the card.

## 2.5 INSTALLING EXPANSION CABLES

The rows and/or columns of the Model 7173-50 can be expanded using additional Model 7173-50 cards and optional 7173-50-CSEP SMB to BNC cable sets. Expansion is achieved by connecting these cables between the SMB row or column expansion connectors located on the card PC board to the row or column BNC input connectors of an adjacent Model 7173-50 card. Adding expansion cables row-to-row adds columns, and adding expansion ca-

bles column-to-column adds more rows. Refer to paragraph 3.6 in Section 3 for more details on matrix expansion.

Figure 2-2 shows the location of the row and column SMB expansion connectors located on the PC board. Note that one set of expansion cables is necessary to add more columns, while three sets of expansion cables are required to add more rows. To avoid confusion, cables should be marked with user-supplied row and column labels before installation.

To install the expansion cables, loosen the cable clamp on the rear panel of the Model 7173-50 card, then route the SMB connector ends of the cables through the clamp. Connect the SMB connectors to the appropriate row or column SMB jacks located on the PC board. Connect the BNC connectors on the other end of the expansion cables to the corresponding BNC row or column jacks on the second Model 7173-50 card. Push any extra cable length into the cable clamp, then tighten the cable clamp securely. Figure 2-3 shows an example with expansion cables installed.

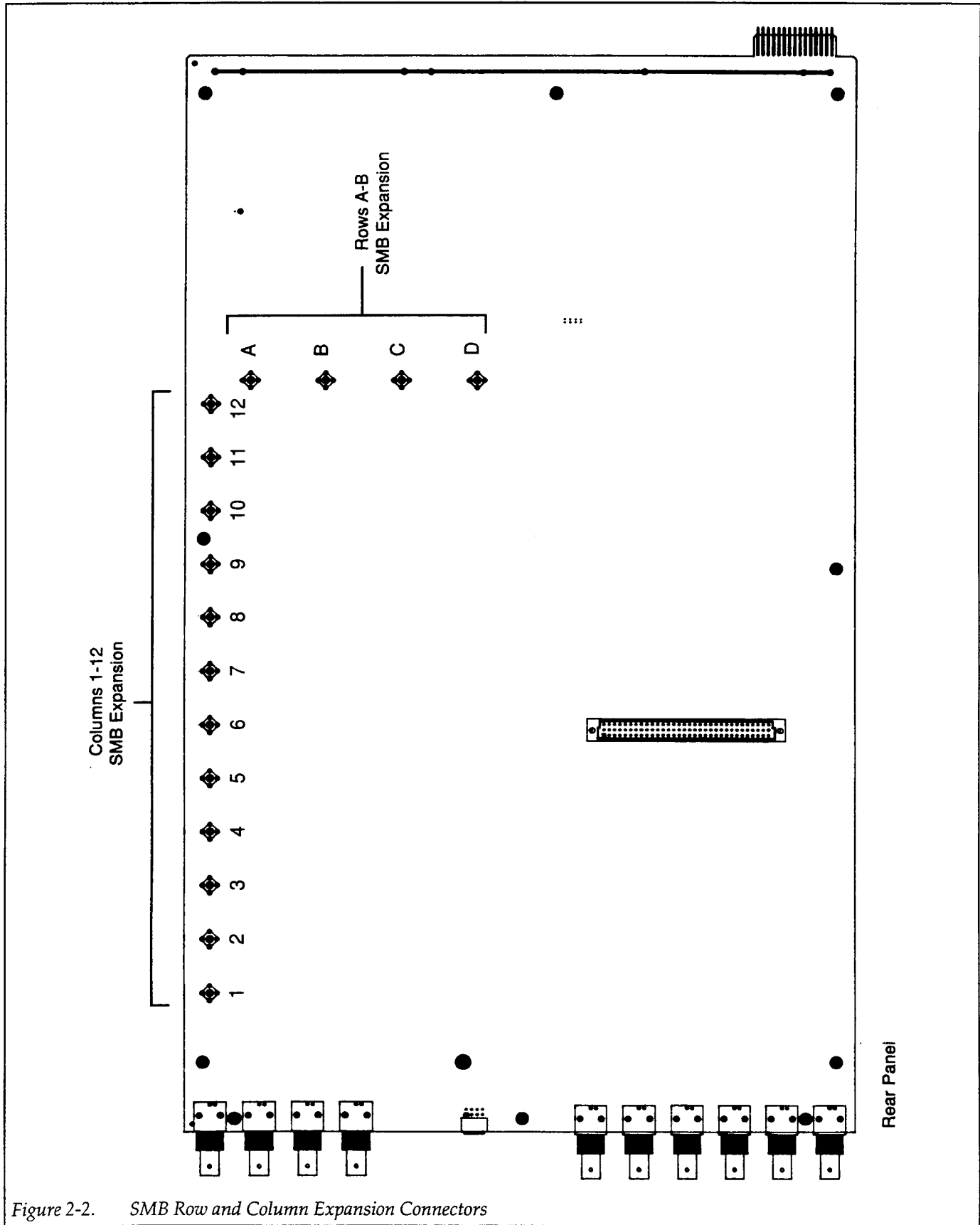
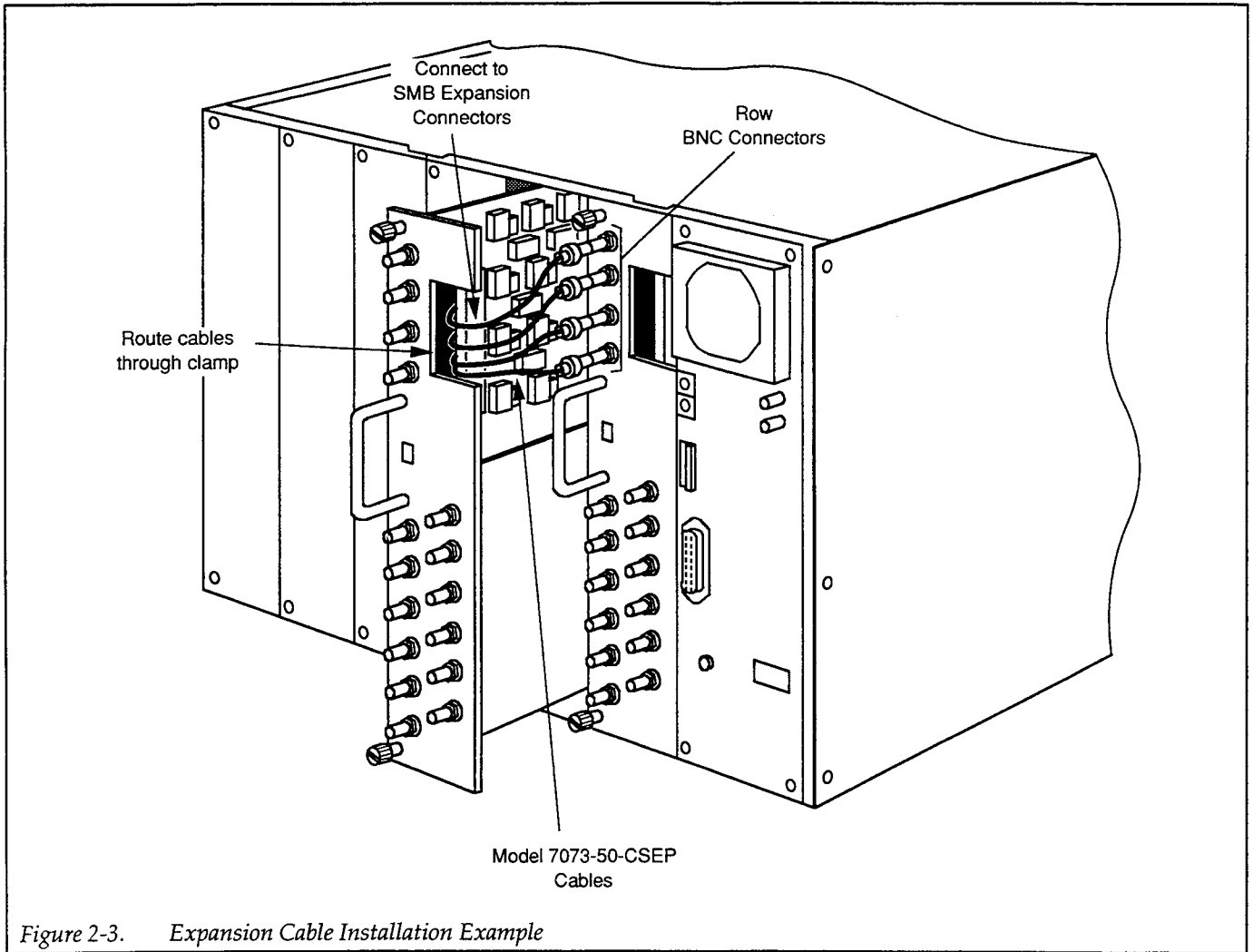


Figure 2-2. SMB Row and Column Expansion Connectors



# SECTION 3

## Operation

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### 3.1 INTRODUCTION

This section contains information on matrix card connections and matrix expansion and is arranged as follows:

- 3.2 **Rear Panel Configuration:** Summarizes the connectors, switches, and expansion cable clamp located on the Model 7173-50 rear panel.
- 3.3 **Basic Matrix Configuration:** Outlines the basic matrix configuration of the card and also discusses switching configurations.
- 3.4 **Connections:** Discusses methods used to connect the Model 7173-50 to DUTs and instrumentation.
- 3.5 **Automatic and Manual Row Isolator Operation:** Explains the automatic and manual row isolator operating modes of the Model 7173-50 including programming these modes with the ROW ISOLATOR CONTROL DIP switches.
- 3.6 **Matrix Expansion:** Discusses the various matrix configurations that are possible by interconnecting

two or more Model 7173-50 cards with optional SMB to BNC cables.

- 3.7 **Typical Connection Schemes:** Provides examples of external connections for single-card, multiple-card, and multiple-mainframe switching systems.
- 3.8 **Operating Considerations:** Covers key characteristics and limitations of the matrix card, and also provides recommendations for optimizing performance.

### 3.2 REAR PANEL CONFIGURATION

Figure 3-1 shows the rear panel of the Model 7173-50. The panel includes 16 BNC connectors for row and column connections, as well as a set of four ROW ISOLATOR CONTROL DIP switches, which are used to control manual/automatic row isolation of each of the four rows.

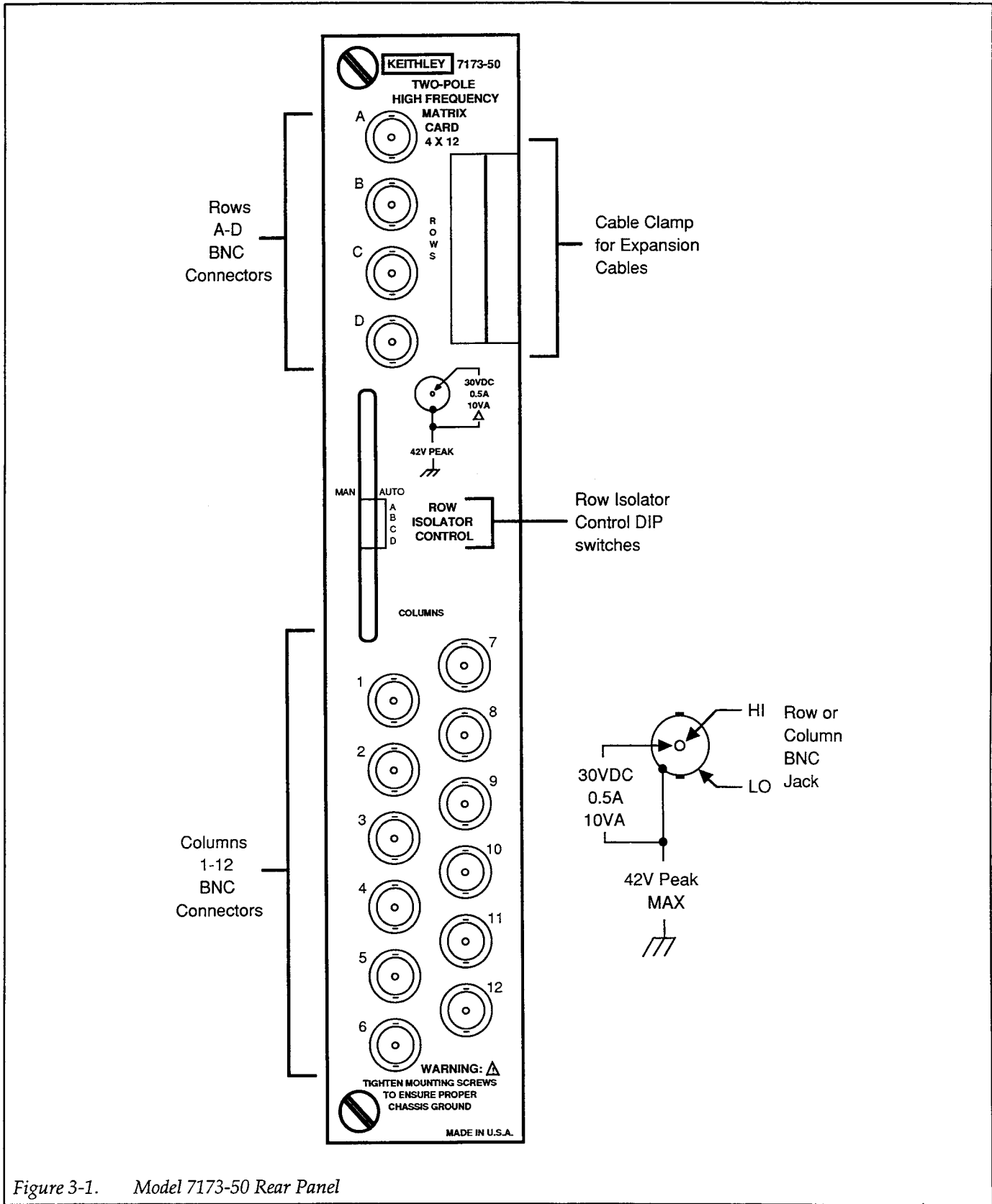


Figure 3-1. Model 7173-50 Rear Panel



### 3.2.1 Row and Column Connectors

The four BNC ROWS connectors are located at the top of the rear panel and are labelled A through D. The twelve BNC COLUMNS connectors are located at the bottom half of the panel and are labelled 1 through 12. The center conductor of each BNC jack is HI, and the shell is LO.

#### WARNING

The maximum recommended voltage between the shell of any BNC jack and chassis ground is 42V peak. Exceeding this value may create a shock hazard.

#### CAUTION

Maximum input to the Model 7173-50 is 30V DC 0.5A, 10VA. Exceeding one of these levels may cause card damage.

### 3.2.2 ROW ISOLATOR CONTROL Switches

The ROW ISOLATOR CONTROL DIP switches are also located on the rear panel of the Model 7173-50 card. These switches are used to program the rows for automatic or manual row isolation. See paragraph 3.5 for complete details on manual/automatic row isolation operation.

### 3.2.3 Cable Clamp

The cable clamp allows for the passage and securing of the matrix expansion cables when used in conjunction with one or more additional Model 7173-50 cards. Matrix expansion is covered in paragraph 3.6. Paragraph 2.5 (Section 2) covers expansion cable installation.

## 3.3 BASIC MATRIX CONFIGURATION

The following paragraphs discuss the basic matrix configuration of the Model 7173-50 and also give examples of switching forms.

### 3.3.1 Simplified Schematic

Figure 3-2 shows a simplified schematic of the Model 7173-50. Note that the card is organized as a 4 × 12 switching matrix (four rows by 12 columns). Each of the 48 crosspoints is made up of a two-pole switch, as shown on the diagram. When a particular crosspoint is closed, connections are made between the corresponding row and column. In the example of Figure 3-2, row D will be connected to column 1 when crosspoint D1 is closed.

The columns of the Model 7173-50 card itself are numbered 1 through 12; however, the actual column numbers used when programming the matrix will depend on the slot in which the matrix card is installed. Table 3-1 summarizes the column number assignments for all six slots in the Model 707 mainframe.

For example, the columns of a matrix card installed in slot 3 of the mainframe are numbered 25 through 36 inclusively. Thus, to close crosspoint B3 on a Model 7173-50 installed in slot 3, you would program the mainframe to close crosspoint B27.

Table 3-1. Matrix Column Number Assignments

7173-50 Card Location	Matrix Column Numbers
Slot 1	1 through 12
Slot 2	13 through 24
Slot 3	25 through 36
Slot 4	37 through 48
Slot 5	49 through 60
Slot 6	61 through 72

### 3.3.2 Single-ended Switching

In the single-ended switching configuration, the source or measure instrument is connected to the DUT through a single pathway, as shown in Figure 3-3. Note that both HI and LO are switched, and that the closure of a single crosspoint will connect an instrument to a DUT. This configuration will yield the highest bandwidth.

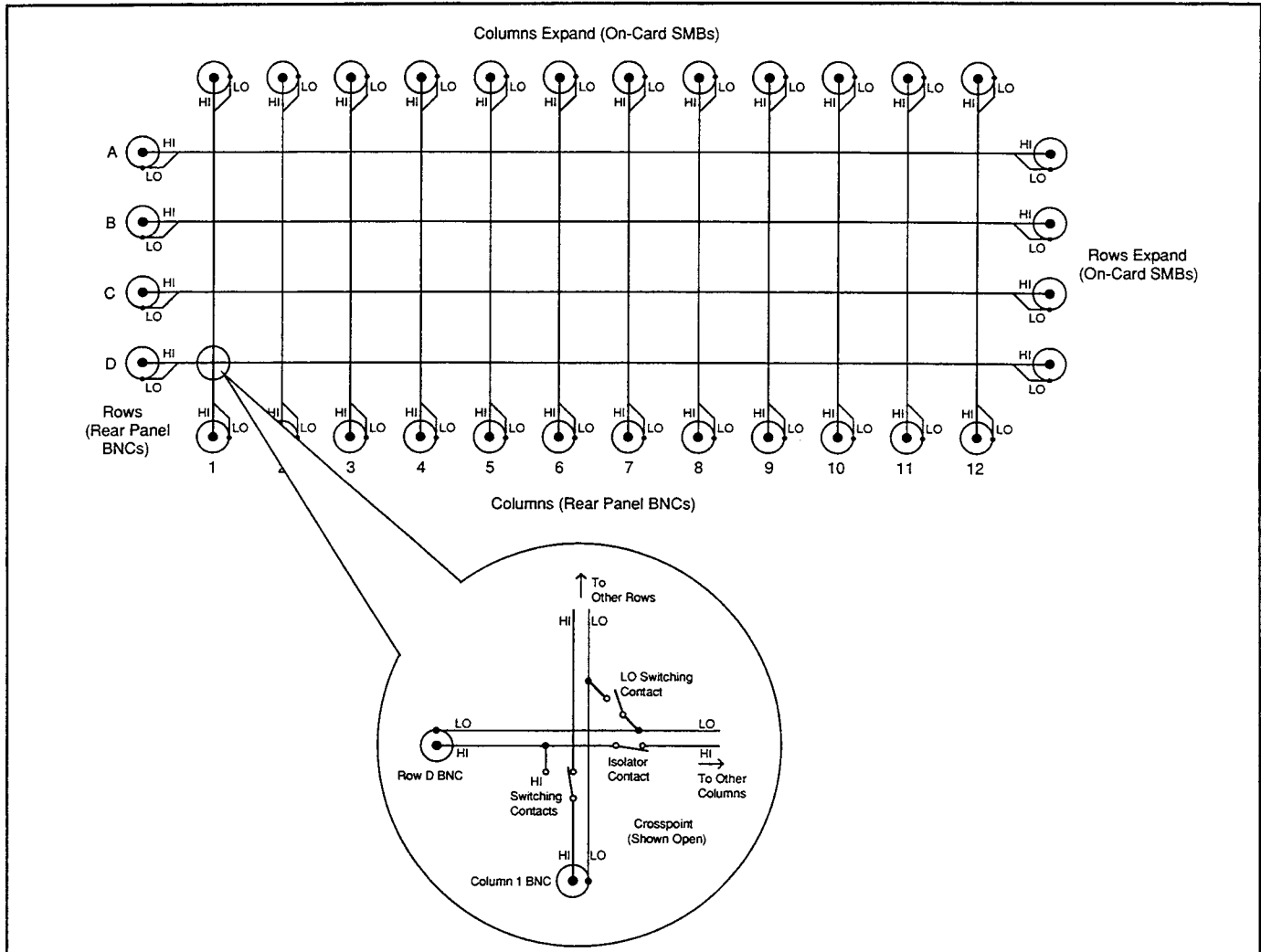


Figure 3-2. Simplified Model 7173-50 Schematic

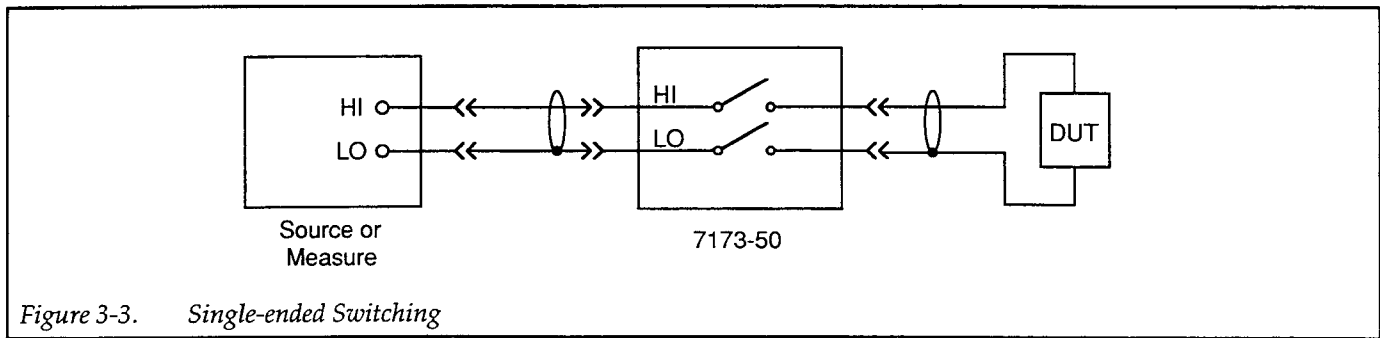


Figure 3-3. Single-ended Switching

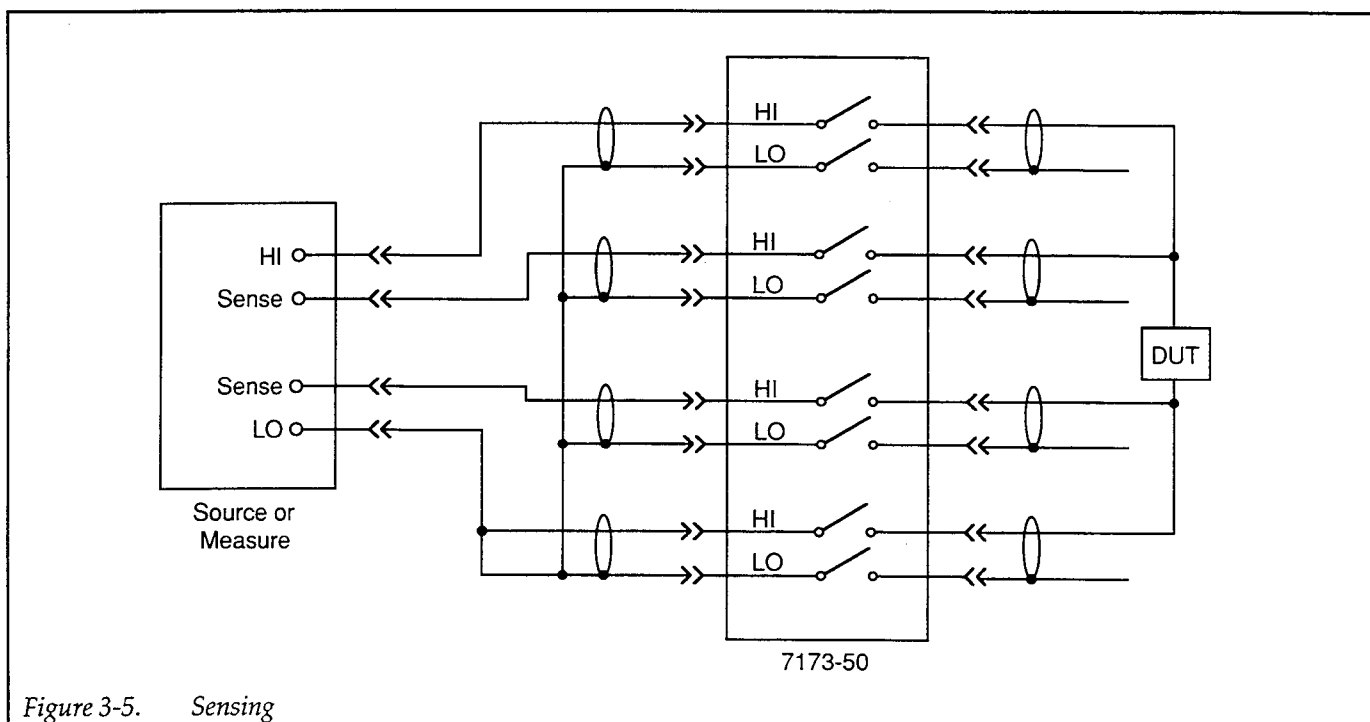
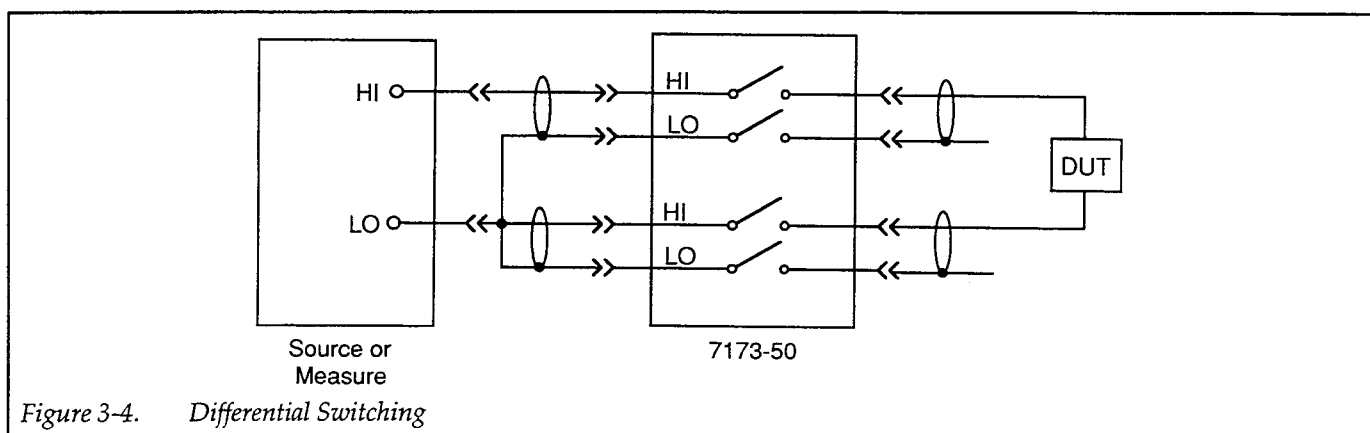
### 3.3.3 Differential Switching

The differential or floating switching configuration is shown in Figure 3-4. The advantage of using this configuration is that the terminals of the source or measure instrument are not confined to the same matrix crosspoint. Each terminal of the instrument can be connected to any of the 48 matrix crosspoints. In the illustration, matrix card LO is also used as a shield.

### 3.3.4 Sensing

Figure 3-5 shows how the matrix card can be configured to use instruments that have sensing capability. The main advantage of using sensing is the cancellation of effects of matrix card path resistance and the resistance of external cabling. Whenever path resistance is a consideration, sensing should be used.

In the illustration, matrix card LO terminals are again used as shields.



## 3.4 CONNECTIONS

### WARNING

To avoid injury or death, make sure all power is off and stored energy in external circuitry is discharged before making connections to the matrix card. Do not exceed 42V peak between the outer shell of any BNC connector and chassis ground.

### CAUTION

Maximum card input is 30V, 0.5A, 10VA. Exceeding one of these values may result in damage to the matrix card.

External connections to the Model 7173-50 matrix card should be made after the card is installed in the Model 707 mainframe. Rows and columns of the matrix card are terminated with 2-lug female BNC connectors. Matrix card connections to instrumentation and test circuits terminated with similar type BNC connectors can be made using BNC to BNC cables such as those described in paragraph 1.9.

### NOTE

For low-noise, DC or low-frequency applications, use only low-noise cables such as the Model 4801. For high-frequency applications, use only 50 $\Omega$  cables such as the Model 7051. Using connecting cables that do not have a nominal 50 $\Omega$  characteristic impedance may seriously degrade the high-frequency performance of the matrix card.

For connections to those instruments without BNC connectors, special cables or adapters (such as banana, triax, or UHF) are available (using non-BNC connectors may affect high-frequency performance, however). For DUTs, it may be desirable to terminate them with BNC connectors so that BNC cables can be used to connect them to the matrix card.

The matrix can also be expanded by installing optional BNC to SMB cables. Matrix expansion is discussed in paragraph 3.6.

## 3.5 MANUAL/AUTOMATIC ROW ISOLATOR OPERATION

Each of the four rows can be set up for automatic or manual row isolator operation. In automatic isolator mode, a row isolator relay contact associated with a specific crosspoint will automatically open when that crosspoint is closed. In the manual isolator mode, however, isolator relay operation is not automatic, and the isolator relays can be manually controlled with mainframe programming commands.

### 3.5.1 Setting the Row Isolator Mode

To set the row isolator mode for a specific row, simply set the associated ROW ISOLATOR CONTROL switch to the desired position (see Figure 3-1 for switch locations). Set switches to AUTO for automatic mode, or set switches to MAN for manual mode.

### NOTE

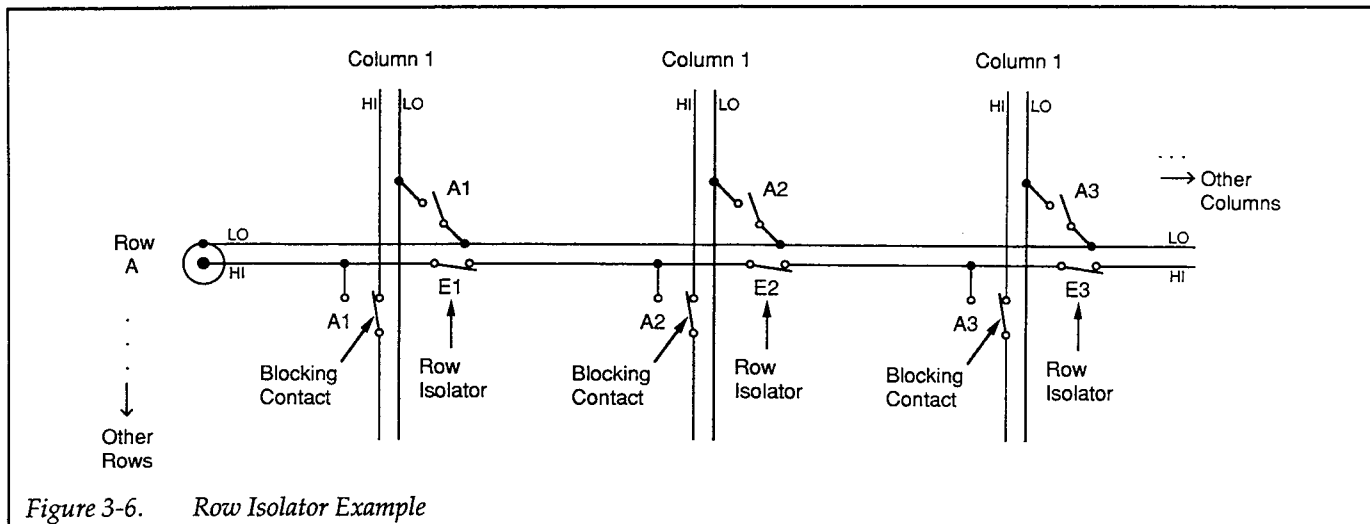
Isolator mode data is part of card identification information that is read by the mainframe only upon power-up. For that reason, you must momentarily power down the mainframe after changing ROW ISOLATOR CONTROL switch positions before the new switch positions are recognized.

### 3.5.2 Automatic Row Isolator Mode

The automatic isolator mode should be used in cases where maximum bandwidth characteristics of the card are maintained. Note, however, that the rows cannot be used bidirectionally in the automatic mode (see paragraph 3.5.4).

As shown in the partial schematic of Figure 3-6, each crosspoint has two relay contacts which connect the rows and column, plus an additional isolator relay contact, which is in series with the HI pathway of the row in question.

For example, if crosspoint A1 is closed, both relay contacts labelled A1 will close, while the E1 contact will automatically open (in the automatic row isolator mode), disconnecting the HI pathway of the crosspoint from the remainder of the row to the right. This row isolation is necessary to maintain a nominal 50 $\Omega$  characteristic impedance through the pathway, optimizing card bandwidth.



When a row is in automatic mode, an isolator can still be manually controlled. However, this feature can only be used when the crosspoint is open because the isolator will automatically open when the crosspoint is closed. One use for this feature would be to reduce crosstalk from a signal not being switched. In this case, you could open the isolation closest to the input jack (for example, E1 for crosspoint A1).

### 3.5.3 Manual Row Isolator Mode

In the manual row isolator mode, the isolator contacts associated with specific crosspoints (see Figure 3-6) do not automatically open when those crosspoints are closed. Instead, you can manually open or close specific isolator contacts by programming the mainframe to open or close specific contacts. This feature is useful in applications where two or more columns are to be connected to a specific row, or in cases where bidirectional signal routing is required. In Figure 3-6, for example, you could route a signal connected to row A to columns 1, 2, and 3 simultaneously. In the automatic isolator mode, simultaneous routing is not possible because the isolator relay associated with a given crosspoint will open the pathway to all columns to the right of the closed crosspoint.

**NOTE**

Using the manual row isolator mode may reduce the bandwidth and increase the rise time of the matrix card.

The isolator relays are addressed as normal crosspoints, with the designations summarized in Table 3-2. For example, to open or close the isolator relay associated with crosspoint A3, you would program the mainframe to close or open "crosspoint" E3.

**NOTE**

Since the isolator relay contacts are normally closed contacts, the logic convention used when controlling isolator relays is inverted. Thus, you must program the mainframe to open an isolator relay to actually close the designated isolator relay contact and program the mainframe to close an isolator relay to open that isolator relay contact. For example, to actually open isolator E3 contacts, program the mainframe to close E3.

**Table 3-2. Isolator Designations**

Crosspoints	Associated Isolator Designations
A1-A12	E1-E12
B1-B12	F1-F12
C1-C12	G1-G12
D1-D12	H1-H12

NOTE: Column assignments assume card is in slot 1. See Table 3-1 for column assignments.

### 3.5.4 Requesting ROW ISOLATOR CONTROL Switch Information

Information concerning the status of the four ROW ISOLATOR CONTROL switches is contained in the card ID information, which can be obtained by using the Model 707, U5 command. (See Section 4 of the Model 707 Instruction Manual.) Table 3-3 summarizes card ID information and the corresponding switch positions.

**Table 3-3. Card ID Indicating ROW ISOLATOR CONTROL Switch Positions**

Card ID	ROW ISOLATOR CONTROL Switch Positions			
	A	B	C	D
7173*0	M	M	M	M
7173*1	A	M	M	M
7173*2	M	A	M	M
7173*3	A	A	M	M
7173*4	M	M	A	M
7173*5	A	M	A	M
7173*6	M	A	A	M
7173*7	A	A	A	M
7173*8	M	M	M	A
7173*9	A	M	M	A
7173*A	M	A	M	A
7173*B	A	A	M	A
7173*C	M	M	A	A
7173*D	A	M	A	A
7173*E	M	A	A	A
7173*F	A	A	A	A

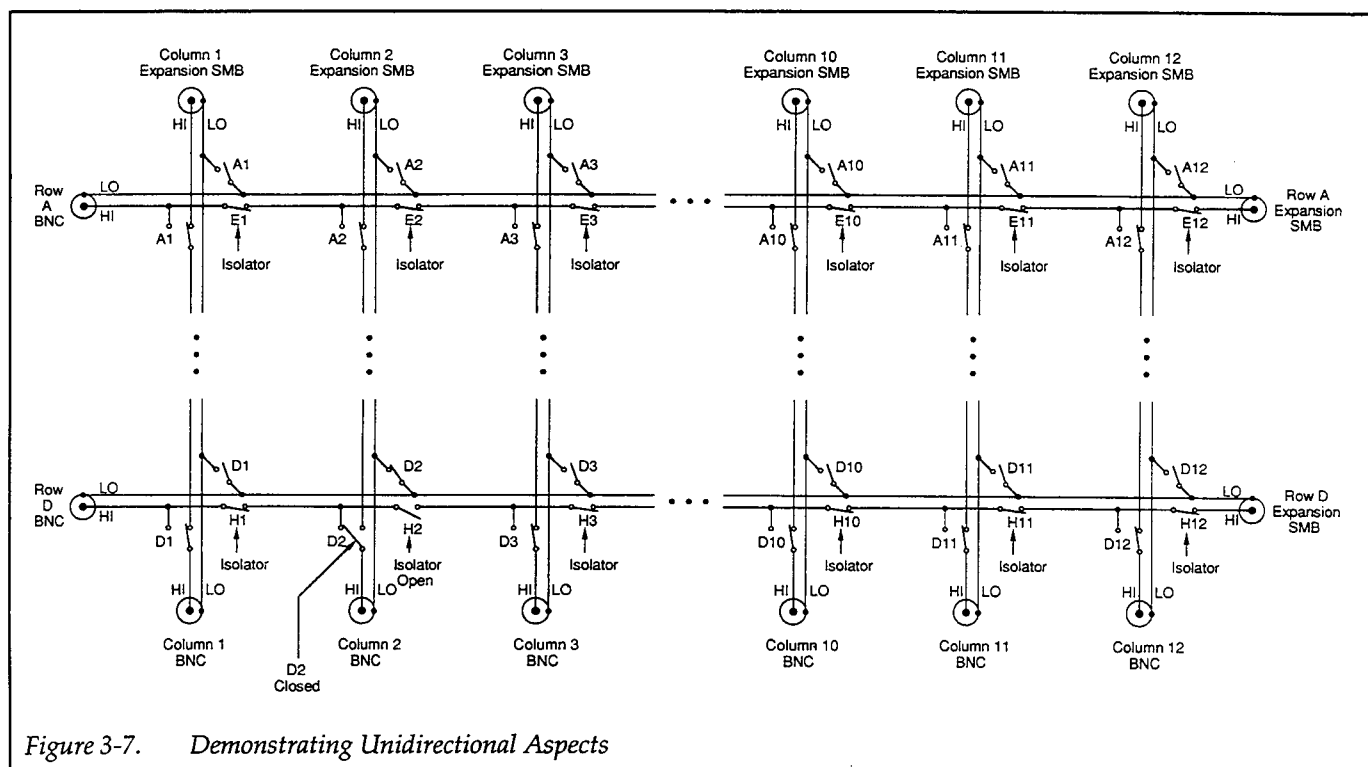
NOTE: A = Automatic; M = Manual  
Card ID information can be read using Model 707 U5 command

### 3.5.5 Unidirectional and Bidirectional Matrix Aspects

The Model 7173-50 is not a fully bidirectional matrix, a factor which has important implications in applications requiring multiple crosspoint closure, or when expanding the matrix using additional cards. Because of the blocking action of each HI crosspoint relay contact, the columns are always unidirectional. Similarly, a row is always unidirectional when that row is in the automatic row isolator mode because an isolator associated with a closed crosspoint always opens. Any given row can be bidirectional if that row is set for the manual row isolator mode.

Figure 3-7 demonstrates the unidirectional aspects of the matrix card. Assume, for example, that the card is in the automatic row isolator mode and that crosspoint relay D2 is closed. With this crosspoint closed, the blocking action of the D2 HI relay contact isolates the crosspoint from the rest of the column, including (and this is important) rows on any expansion cards connected to the card through the SMB column expansion connectors on this particular card.

In a similar manner, the open isolator contact (H2) disconnects the row to the right of column 2 from the row D BNC input, including any columns located on expansion cards connected through the SMB row expansion connectors. Unlike the situation with the columns, however, the rows can be made to be bidirectional by selecting the manual isolator mode for the row(s) in question and making sure that all row isolator relays are closed by appropriately programming the mainframe.



### 3.6 MATRIX EXPANSION

The following paragraphs discuss installing cables to expand the matrix and various matrix expansion schemes.

#### 3.6.1 Installing Expansion Cables

The rows and/or columns of the Model 7173-50 can be expanded using additional Model 7173-50 cards and optional Model 7173-50-CSEP SMB to BNC cable sets. Expansion is achieved by connecting these cables between the SMB row or column expansion connectors located on the card PC board to the row or column BNC input connectors of an adjacent Model 7173-50 card. Adding expansion cables row-to-row adds columns, and adding expansion cables column-to-column adds more rows.

Refer to paragraph 2.5 in Section 2 for details on installing expansion cables.

#### 3.6.2 Narrow Matrix Expansion

The rows of two to six Model 7173-50 cards installed in one mainframe can be connected together to add more columns and expand a narrow matrix up to  $4 \times 72$  in one mainframe. Note that each additional matrix card will add 12 columns to the matrix. Figure 3-8 shows an example of a three-card matrix expansion, which yields a  $4 \times 36$  narrow matrix.

Connections between the cards are made using the optional Model 7173-50-CSEP SMB to BNC cables, as outlined in paragraph 2.5. The SMB row expansion jacks of the card in slot 1 are connected to the BNC row input jacks of the card in slot 2; in the same manner, the SMB row expansion jacks of the card in slot 2 are connected to the BNC row input jacks of the card in slot 3.

In the automatic row isolator mode, this matrix configuration is not bidirectional. In the manual isolator mode, however, all rows are bidirectional when row isolator relays remaining in their normally closed positions.





### 3.6.4 Partial Matrix Implementation

A fully implemented matrix provides a relay at each possible crosspoint. For example, a fully implemented  $8 \times 24$  matrix using four Model 7173-50 cards would contain 192 crosspoints. A partially implemented matrix can be obtained by removing one Model 7173-50 from the mainframe, as shown in Figure 3-10. The partial matrix still has an  $8 \times 24$  configuration, but it now contains only 144 crosspoints instead of the 192 crosspoints of the full  $8 \times 24$  matrix.

An obvious advantage of using a partially implemented matrix is that fewer matrix cards are required. Another reason for using this implementation is to keep some devices from being accidentally connected to certain other devices.

Because Model 7173-50 columns are not bidirectional, Measure #1 can be connected to DUT #1 or DUT #2, but Measure #1 cannot be connected to Source #1 or Source #2. Similarly, DUT #1 cannot be connected to DUT #2 with the card in the automatic row isolator mode. To do so, the card must be in the manual row isolator mode, in

which case the rows are bidirectional. Column 2 can be connected to column 13 by programming the mainframe to close A2 and A13. If, however, maximum bandwidth is to be maintained, isolator contacts E1 and E13 can be programmed open to eliminate the unterminated stub.

### 3.6.5 Mainframe Matrix Expansion

Matrices using up to 30 Model 7173-50 cards are possible by daisy-chaining five Model 707 mainframes together. Using 30 Model 7173-50 cards would provide 1440 crosspoints.

In general, connecting columns of a card in one mainframe to the columns of a card in another mainframe increases the number of rows in the matrix. Similarly, connecting the rows of a card in one mainframe to the rows of a card in another mainframe increases the number of columns in the matrix. Refer to the Model 707 Instruction Manual for detailed information on daisy-chaining mainframes.

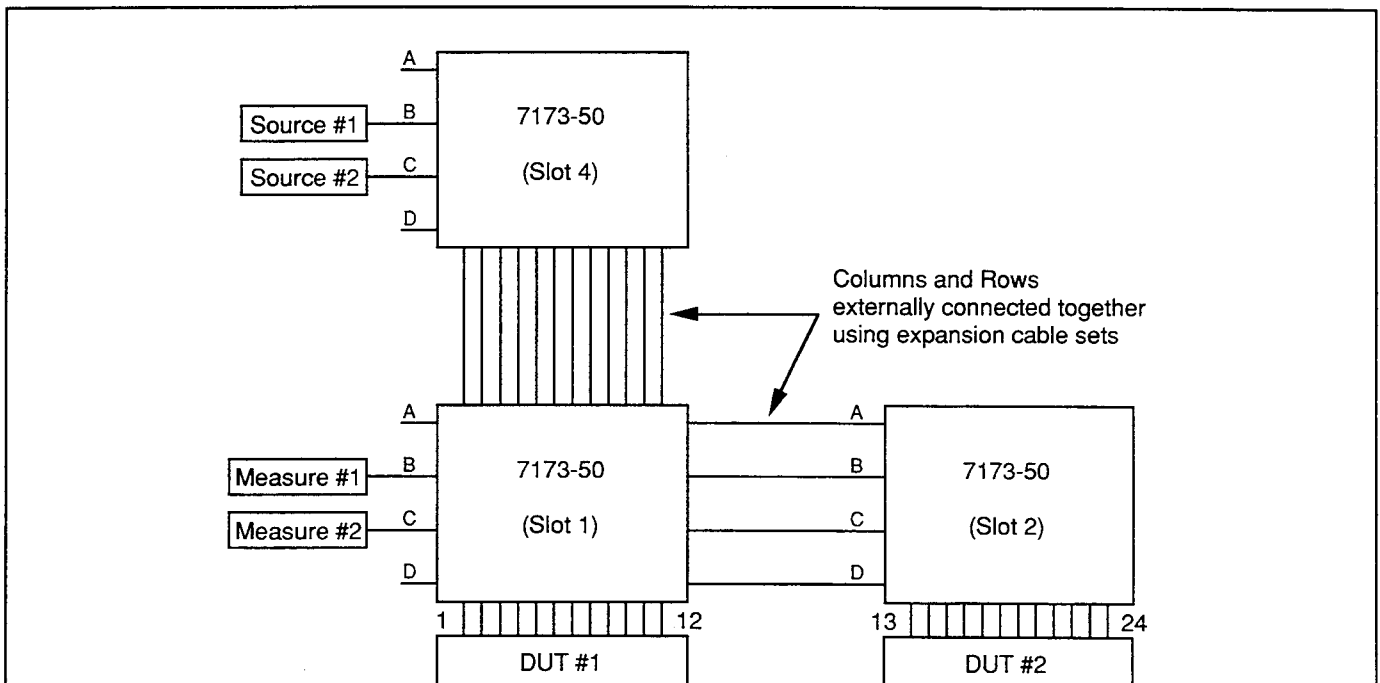


Figure 3-10. Partial Matrix Example ( $8 \times 24$ )

### 3.7 TYPICAL CONNECTION SCHEMES

The information in this paragraph provides typical connection schemes for single-card, multiple-card, and multiple-mainframe configurations.

#### 3.7.1 Single-card Systems

Figure 3-11 shows an example of how a single-card system might be connected for high-bandwidth applications. In this configuration, the instruments are connected to the rows, and the DUTs are connected to the columns. For maximum bandwidth, the card should be in the automatic row isolator mode. In automatic mode, however, only one crosspoint per row and column can be connected, which means that only one DUT terminal can

be connected to a particular instrument terminal at any given time.

A more versatile single-card system is shown in Figure 3-12. Here, instruments are connected to both rows and columns, with the DUTs connected to the remaining columns. With this configuration, the card should be placed in the manual row isolator mode. With the card in the manual isolator mode, many crosspoints per row can be closed simultaneously, but only one crosspoint per column can be used. This configuration would allow many DUT terminals to be connected to any instrument terminal simultaneously. Bandwidth can be optimized by carefully programming row isolator relays so that only essential isolator contacts remain closed.

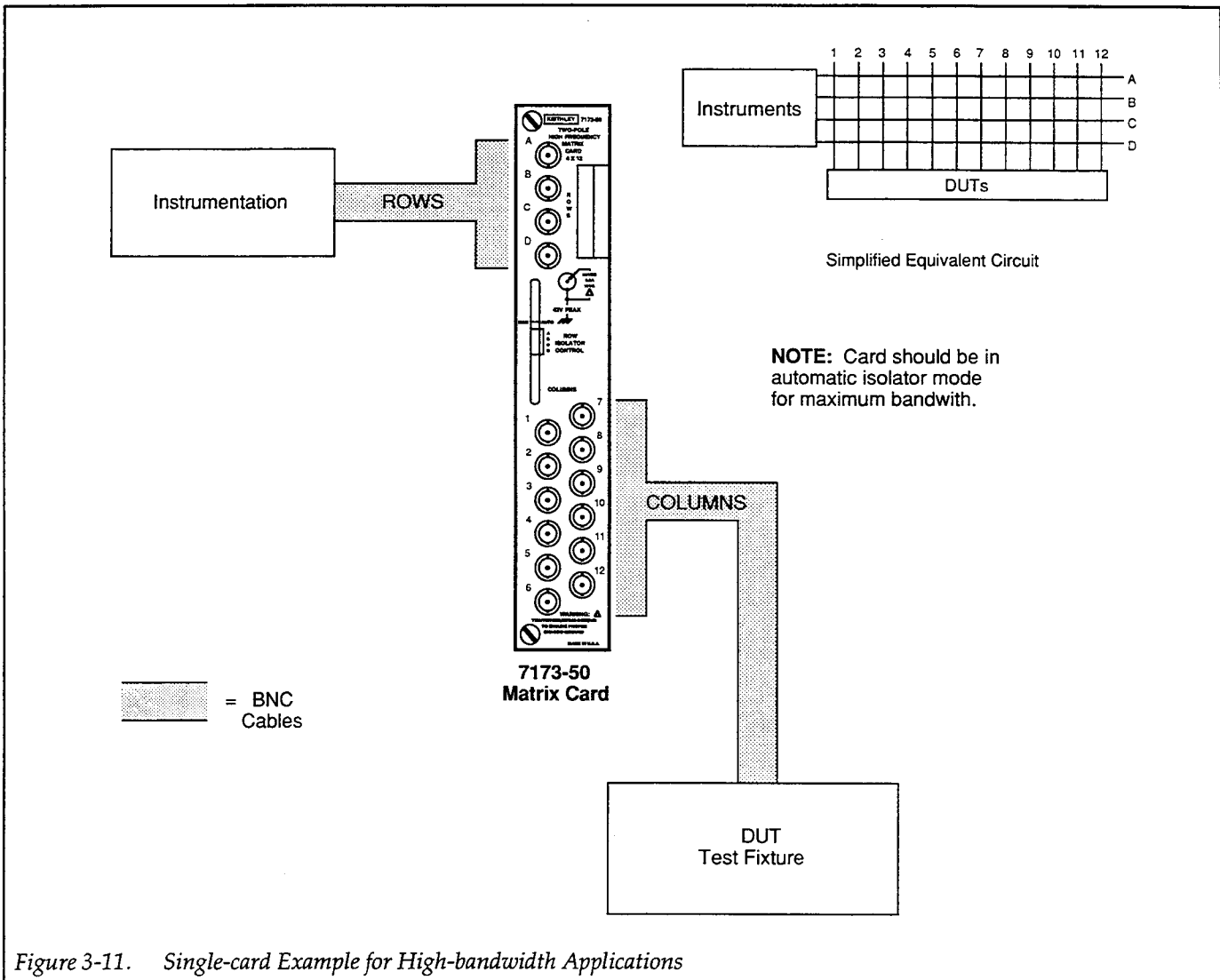


Figure 3-11. Single-card Example for High-bandwidth Applications

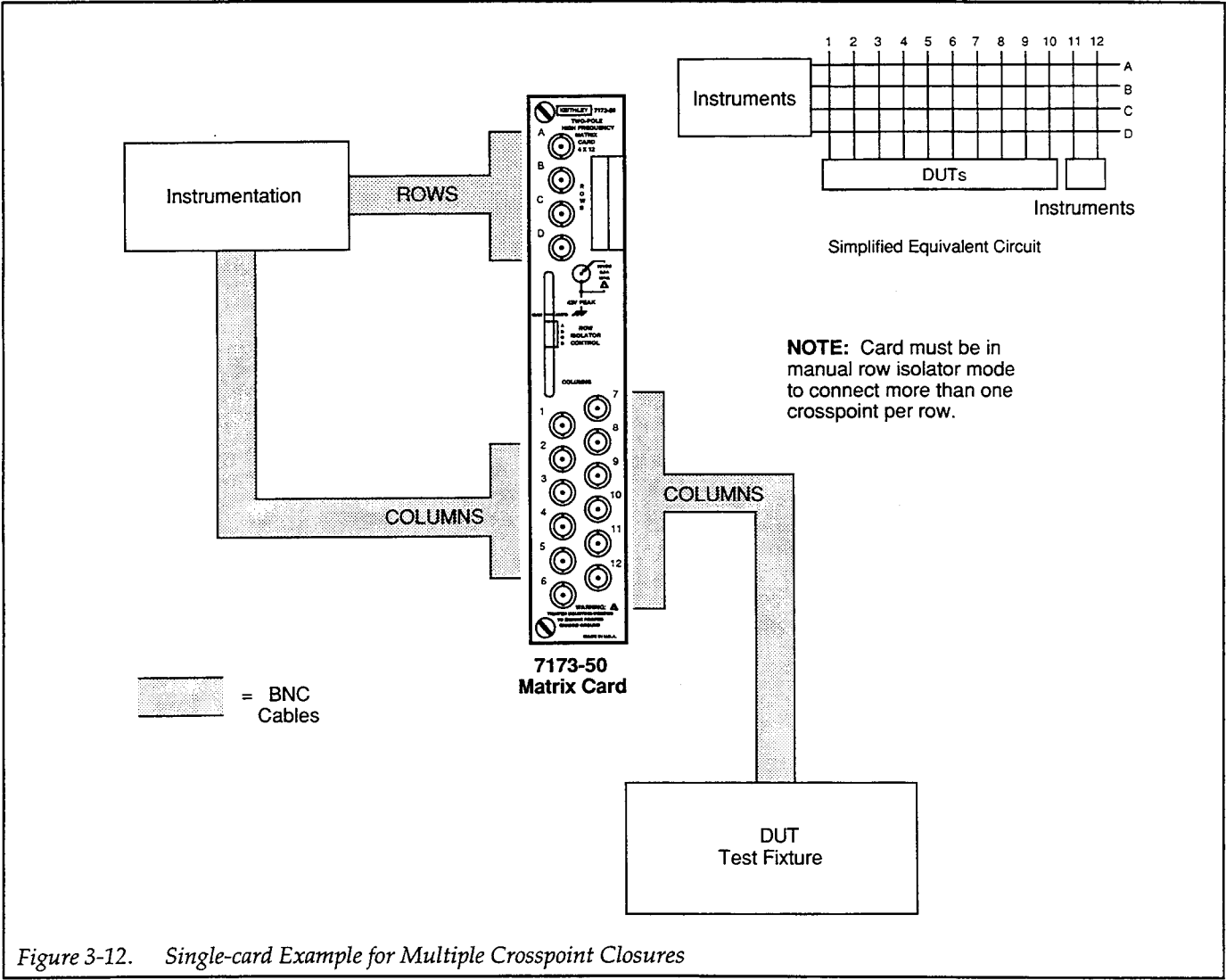


Figure 3-12. Single-card Example for Multiple Crosspoint Closures

### 3.7.2 Multiple-card System

Figure 3-13 shows an example of how a multiple-card system might be connected. In this example, instruments are connected to the rows of the matrix card in slot 1, while the columns are connected to the DUTs. The card rows are connected together using SMB to BNC expansion cable sets.

For maximum bandwidth, all cards should be placed in the automatic row isolator mode. Doing so, however, would limit you to connecting only one DUT terminal to a particular instrument terminal at any given time. For multiple-terminal connections, the cards must be in the manual isolator mode. In that case, you could connect any number of DUT terminals to a particular instrument terminal simultaneously.

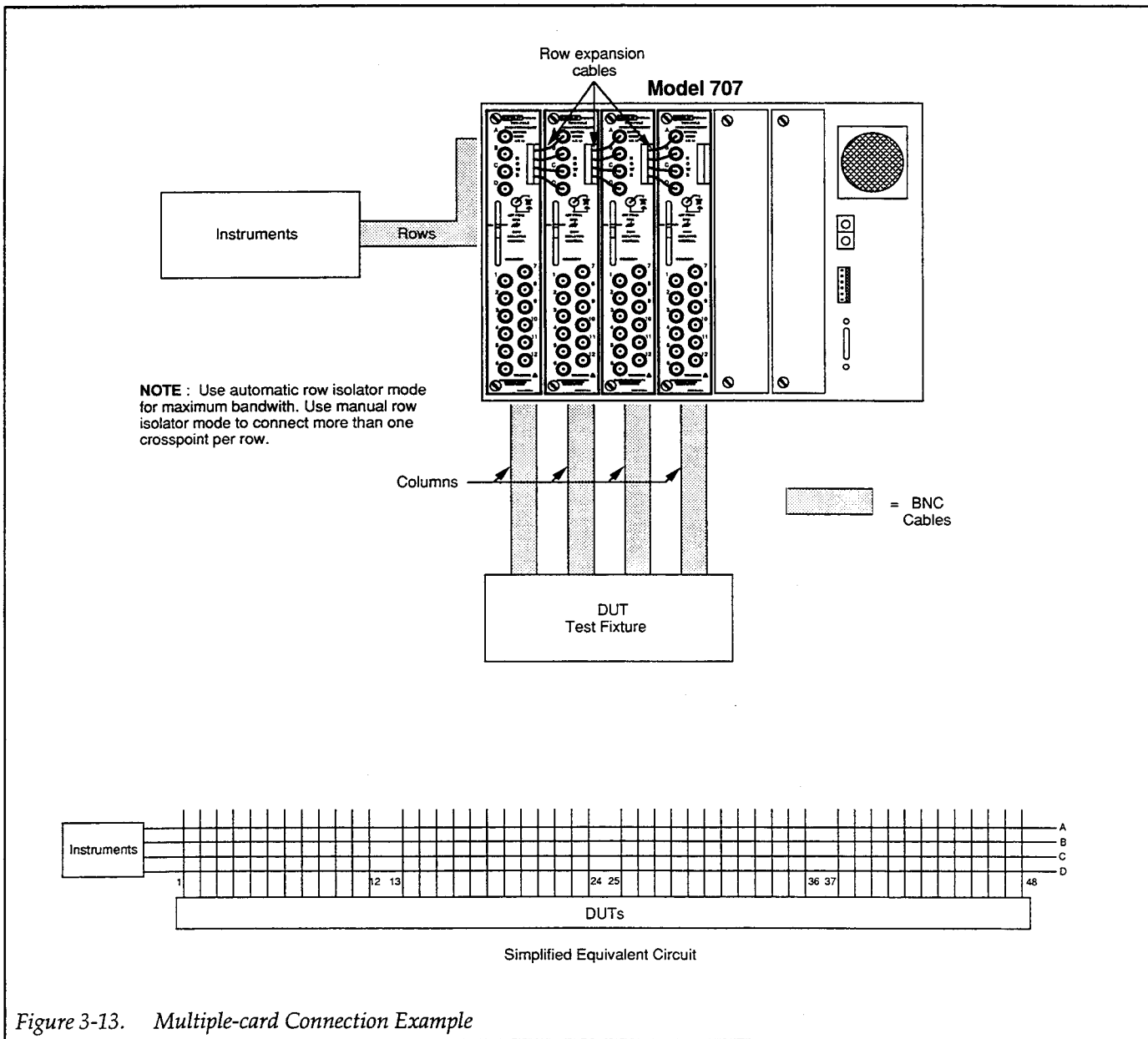


Figure 3-13. Multiple-card Connection Example

### 3.7.3 Multiple-mainframe System

Figure 3-14 shows a typical example of how a multiple-mainframe system might be connected. In this system, both instrumentation and DUTs are connected to the columns. Since two or more crosspoints on a row must be closed at the same time, all cards must be in the manual row isolator mode to allow proper connections with this configuration.

Row connections between cards of a single mainframe are made using the optional SMB to BNC cables. Row expansion connections from one mainframe to another will require four longer SMB to BNC cables.

## 3.8 OPERATING CONSIDERATIONS

This paragraph explains electrical characteristics and limitations of the Model 7173-50 matrix card. Also included are some recommendations on how to maximize card performance.

### 3.8.1 Path Resistance

A matrix path is defined as the route a signal follows from row to column (or column to row) through a single crosspoint. The resistance of each Model 7173-50 matrix path is specified to be  $<2\Omega$ . In systems where path resistance is critical, use instruments with sensing capabilities, or connect source leads through different pathways (4-wire Kelvin connections). If sensing is not possible, keep external cabling as short as possible, and minimize the number of connections to keep path resistance to a minimum.

### 3.8.2 Contact Potential

Each crosspoint relay generates  $<15\mu\text{V}$  of thermal EMF voltage which must be considered in systems where low signal levels are switched. When using differential switching, thermal EMFs caused by the matrix card can be minimized by using two adjacent paths to carry signals. Two adjacent relays (such as A1 and B2) will be at virtually the same temperature, resulting in nearly the

same EMF voltage level, and the signal through the two contacts will be opposite in direction, causing the thermal EMFs of the two crosspoints to cancel.

Thermal EMFs caused by external circuitry can be minimized by using conductors made of the same material such as clean, crimped copper-to-copper connections. As always, use only high-quality cables and conductors. The effects of any residual thermal EMFs can be eliminated by measuring them and subtracting their values from measurements.

### 3.8.3 Offset Current

The Model 7173-50 can generate an offset current of  $<200\text{pA}$  that must be considered in a system where low signal levels are involved. A common source of excessive offset current is the "battery effect" caused by contamination of connectors or cables.

### 3.8.4 Keeping Connectors Clean

As is the case with any high-resistance device, the insulation resistance of BNC and SMB connectors can be degraded 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.

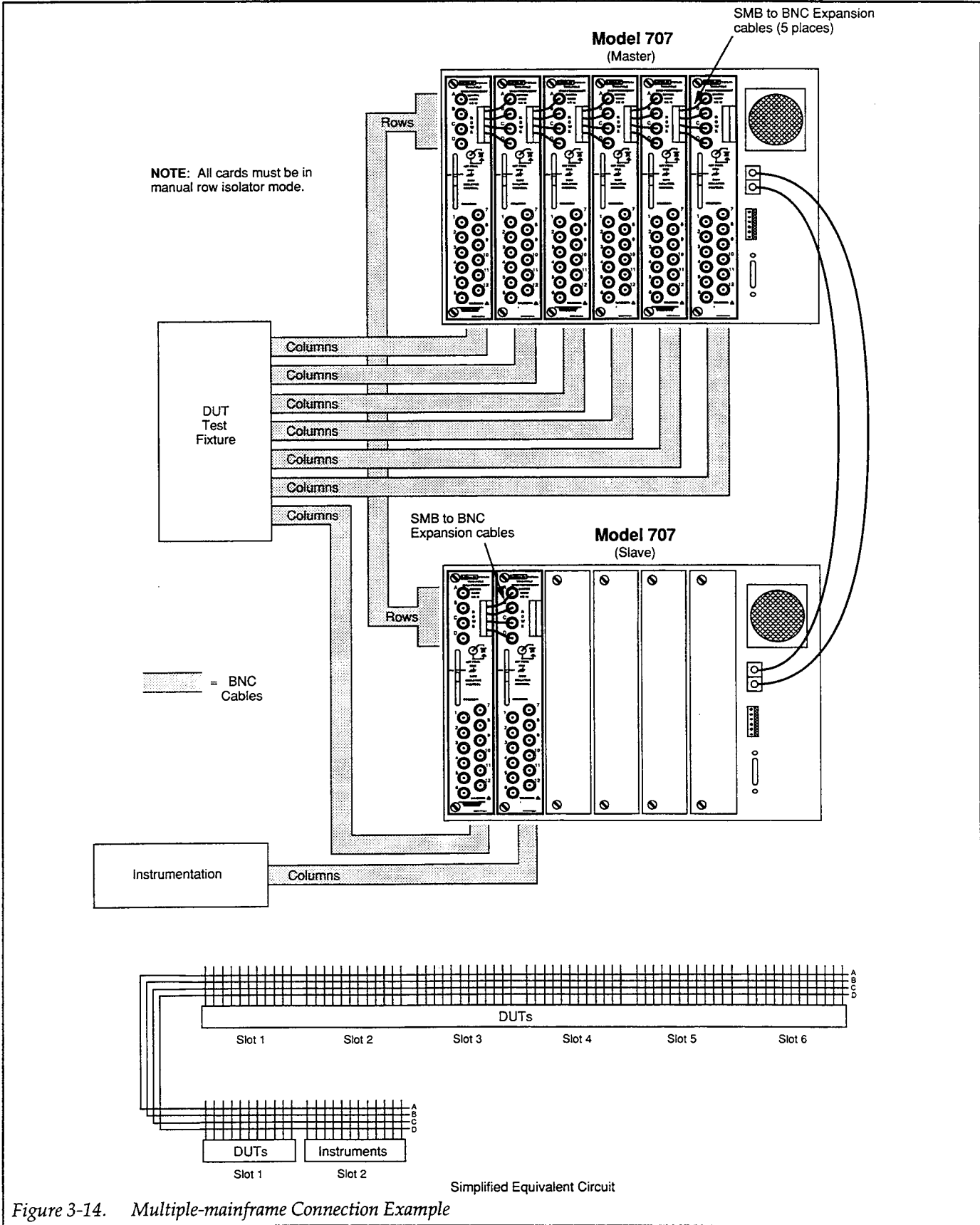


Figure 3-14. Multiple-mainframe Connection Example

### 3.8.5 Cable Noise Currents

Noise currents, which can be detrimental to low-level signals, can be generated by bending or flexing coaxial 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, such as the Model 4801, should be used to minimize these effects in low-level measurement situations. Such cable has a special graphite coating under the shield to provide lubrication and to provide a conduction path to equalize charges. Note, however, that such cables do not necessarily have a nominal 50Ω characteristic impedance and may yield inadequate performance in high-frequency applications.

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.

### 3.8.6 Isolation

Path isolation is the impedance between any two HI conductors using LO terminals as guard. Model 7173-50 matrix card path isolation is specified at  $>10^{10}\Omega$ . Each additional Model 7173-50 card connected through expansion cables further decreases isolation. For example, two cards connected together through expansion cables have better isolation than three cards connected together in a similar manner.

Differential isolation is the impedance between the HI and LO terminals of the column or row input connectors, while common-mode isolation is the impedance between HI and LO connected together and chassis ground.

Model 7173-50 differential and common-mode isolation factors are specified at  $>10^9\Omega$ , but, again, these isolation values will be reduced when more cards are connected together through expansion cables.

Isolation can be maximized by using the minimum number of cards possible in a system (maximum isolation will, of course, be maintained by using only one card). Also, external cables and connectors should have excellent insulation characteristics to maintain the highest isolation throughout the entire system.

### 3.8.7 Insertion Loss and Bandwidth

In a system that maintains a nominal 50Ω characteristic impedance throughout (including sources, loads, and connecting cables), sinusoidal signals up to 200MHz ( $-3\text{dB}$  point) and digital (square wave) signals with rise times as short as 2nsec, can be effectively routed through the card with minimal attenuation or phase shift. Note that these figures apply only when the card is in the automatic row isolator mode; in the manual row isolator mode, bandwidth may be reduced, and rise times may increase considerably if isolator relays on the same row as the closed crosspoint remain closed.

In non-50Ω systems, these figures will degrade somewhat depending on the system impedance. For sinusoidal signals in a non-50Ω system, the  $-3\text{dB}$  point can be calculated as follows:

$$f_{3\text{dB}} = \frac{1}{2\pi RC}$$

where: R = Series source resistance  
C = Differential capacitance of the matrix card and cables.

Typical data for 75Ω systems is located in the Appendix.

# SECTION 4

# Applications

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## 4.1 INTRODUCTION

This section summarizes three typical applications for the Model 7173-50 Two-Pole High Frequency Matrix Card and is arranged as follows:

- 4.2 **Analog and Digital Device Testing:** Describes how two Model 7173-50 cards can be configured to perform a variety of tests on various DUTs.
- 4.3 **Resistor Network Testing:** Discusses typical resistor network tests such as basic resistance measurements, voltage divider checks, and capacitance and inductance measurements.
- 4.4 **LCZ Meter Testing:** Summarizes using an LCZ meter to test inductance, resistance, and impedance of DUTs at various frequencies.

## 4.2 ANALOG AND DIGITAL DEVICE TESTING

This application demonstrates how a variety of equipment connected to a matrix card can be used to perform multiple tests on analog and digital DUTs.

### 4.2.1 Test Setup

An example of a parametric test system is shown in Figure 4-1. Note that the system includes two Model 7173-50 cards with columns connected by expansion cables. Also note that both HI and LO are switched through each crosspoint, and that the DUTs in the system have both input and output terminals. For high-volume testing, a test fixture that uses quick-disconnect sockets will speed up the testing process. Also, BNC connectors could be mounted on the test fixture so that BNC to BNC cables (Keithley Model 7051) can be used to connect the DUTs to the matrix card.

Most test instruments in the system use BNC jacks, simplifying connections to the matrix card using BNC to BNC cables. For instruments that use other types of connectors (such as the Model 263 and Model 196), adapters are available to convert to BNC connections. The necessary adapters for this application are shown in Figure 4-1.



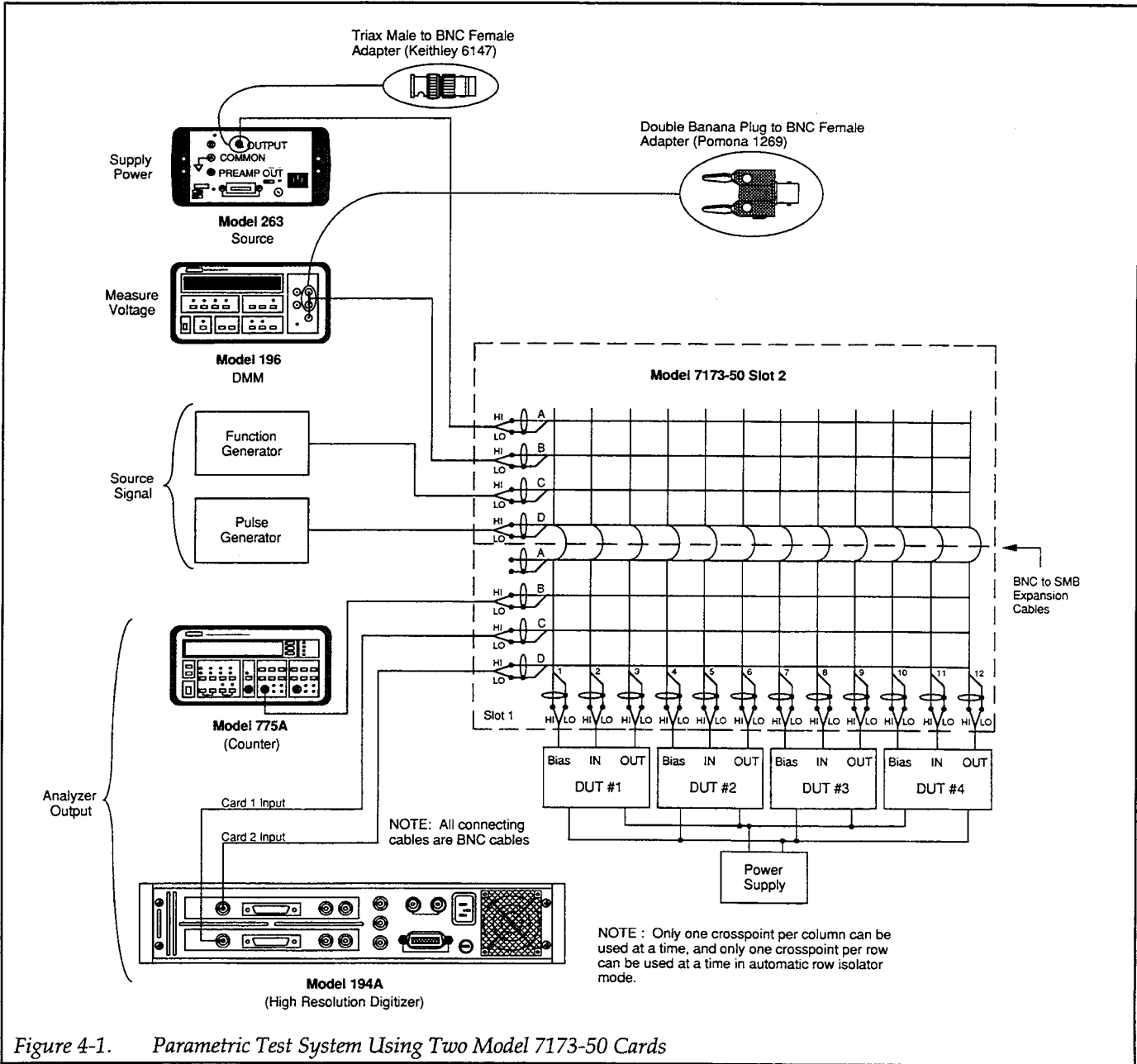


Figure 4-1. Parametric Test System Using Two Model 7173-50 Cards

## 4.2.2 Test Configurations

Because of the versatility of a matrix, any instrument can be connected to any port of any DUT simply by closing the appropriate crosspoint. Keep in mind, however, that only one crosspoint per column can be used at one time. In addition, only one crosspoint per row can be used at a time in the automatic row isolator mode. Keeping these constraints in mind, the instruments and crosspoints are most likely to be used as follows:

**Precision Source** — The Keithley Model 263 is used to source voltage or current, as needed, to the DUT. When testing DUT #1, crosspoint A1, slot 2 will be closed to supply a bias signal to that device. When testing DUTs #2, 3, and 4, crosspoints A4, A7, and A10 (slot 2) will be closed. Only one DUT should be connected at a time so as not to exceed the power output capability of the Model 263 (in the automatic row isolator mode, only one DUT at a time can be connected to the Model 263).

**Measure Voltage** — In this test system, the Model 196 DMM serves as a versatile measurement tool that can measure the DC component at any port of any DUT. The DMM is connected to a given port of a DUT simply by closing the appropriate crosspoint on row B, slot 2 (crosspoints B1 through B12). Only one crosspoint should be closed at any one time in the manual row isolator mode to avoid shorting DUT ports. The DMM cannot measure source voltages in this configuration because of the blocking action of crosspoint relays.

**Source Signal** — A function generator and a pulse generator will provide a wide range of AC signals required to test DUTs. Although the function generator will provide the standard analog test signals (sine, square, triangle, and ramp) that can also be used to perform some digital circuit testing, the higher speed pulse generator can be used to test both analog and digital circuits at higher speeds. A signal generator can be connected to the IN port of any DUT simply by closing the appropriate crosspoint. For example, to connect the function generator to the IN port of DUT #3, C8, slot 2 would be closed.

**Analyze Output** — The Keithley Model 775A Programmable Counter/Timer and Keithley Model 194A High Resolution Digitizer are used to analyze the output of the

DUTs. These instruments are connected to the desired DUT output ports by closing the desired crosspoints. For example, closing B9, slot 1 will connect the Model 775A Counter to the output of DUT #3.

### NOTES:

1. The Model 7173-50 has a specified offset current of <200pA, but the offset current is typically much lower than this figure. Unless the actual offset current is known, the 200pA value should be used to calculate the minimum current that can be accurately sourced. For example, the lowest Model 263 current that should be sourced for a 1% error figure is 20nA.
2. The system shown in Figure 4-1 uses single-ended switching for all crosspoints, meaning that both HI and LO for each instrument and DUT are switched through a single crosspoint. In some cases, differential switching, with HI and LO routed through separate crosspoints, may be better because of added switching versatility. The system discussed in paragraph 4.3 uses differential switching.

## 4.3 RESISTOR NETWORK TESTING

The resistor network testing application discussed in this paragraph demonstrates a differential (or floating) matrix that can be used to perform a variety of tests on resistor networks. Typical tests include resistance measurements, capacitance or inductance measurements, and AC and DC voltage measurements.

### 4.3.1 Resistor Test System Configuration

The test system for this application is shown in Figure 4-2. Note that two Model 7173-50 cards are configured to form a 4 × 24 matrix. The usual SMB to BNC expansion cables are used to connect the card rows together, yielding a total of 24 columns.

#### NOTE

All rows of both Model 7173-50 cards must be operated in the manual row isolator mode to allow the use of more than one crosspoint per row at a time.



The system in Figure 4-2 uses a Keithley Model 230 to source DC voltages and a general-purpose function generator to source AC voltages. The Model 196 DMM is used to measure both AC (up to 100kHz) and DC parameters.

A consideration in these checks is the effects of Model 196 input impedance on voltage measurements. The input impedance is shunted across the resistor being measured. The resultant divider resistance is the parallel combination of the resistor under test and the input impedance of the Model 196. As long as the input impedance is much larger than the resistor being measured, the error introduced into the measurement will be minimal.

The resistor network is tested by applying a voltage across the entire network and measuring the voltage across each element in the divider. Both DC and AC tests can be carried out in essentially the same manner.

#### 4.3.4 CV Measurements

In applications where capacitance vs. voltage DUT characteristics are a factor, the Keithley Model 590 CV Analyzer can be used as a CV meter to measure the capacitance with changes in voltage across each resistor element or across the combined elements of the network. The Model 590 can measure capacitance at 100kHz or 1MHz depending on the module(s) installed and has an internal 20V DC source to bias the DUT.

### 4.4 LCZ METER TESTING

The Model 7173-50 can be used in conjunction with an LCZ meter to perform inductance, capacitance, and im-

pedance tests on a variety of capacitors, inductors, and semiconductor devices. The following paragraphs discuss a basic system configuration for LCZ meter testing along with basic test information.

#### 4.4.1 LCZ Test System Configuration

Figure 4-3 shows the basic test configuration using a Model 7173-50 matrix card and a Keithley Model 3321 LCZ Meter. The matrix card, of course, provides the switching functions to the three DUTs in the test system, allowing multiple DUTs to be tested without manually changing connections to each DUT. Additional matrix cards could be added to test more DUTs automatically. Since 4-wire connections are required for the LCZ meter, each additional card would add three DUTs to the system.

The Model 3321 LCZ Meter shown in the system has the following capabilities:

- 0.1% basic accuracy and 4-1/2 digit resolution.
- Selectable test frequencies of 120Hz, 1kHz, 10kHz, and 100kHz.
- 2V internal bias supply and externally applied bias up to 35V allows a DC bias to be applied to the DUT.
- 50mV RMS and 1V RMS test signal levels.
- IEEE-488 interface, allowing test automation.

In addition to the common L, C, and Z parameters, the Model 3321 also measures ESR (equivalent series resistance), G (conductance), Q (quality factor), D (dissipation factor), and the phase angle of the impedance.

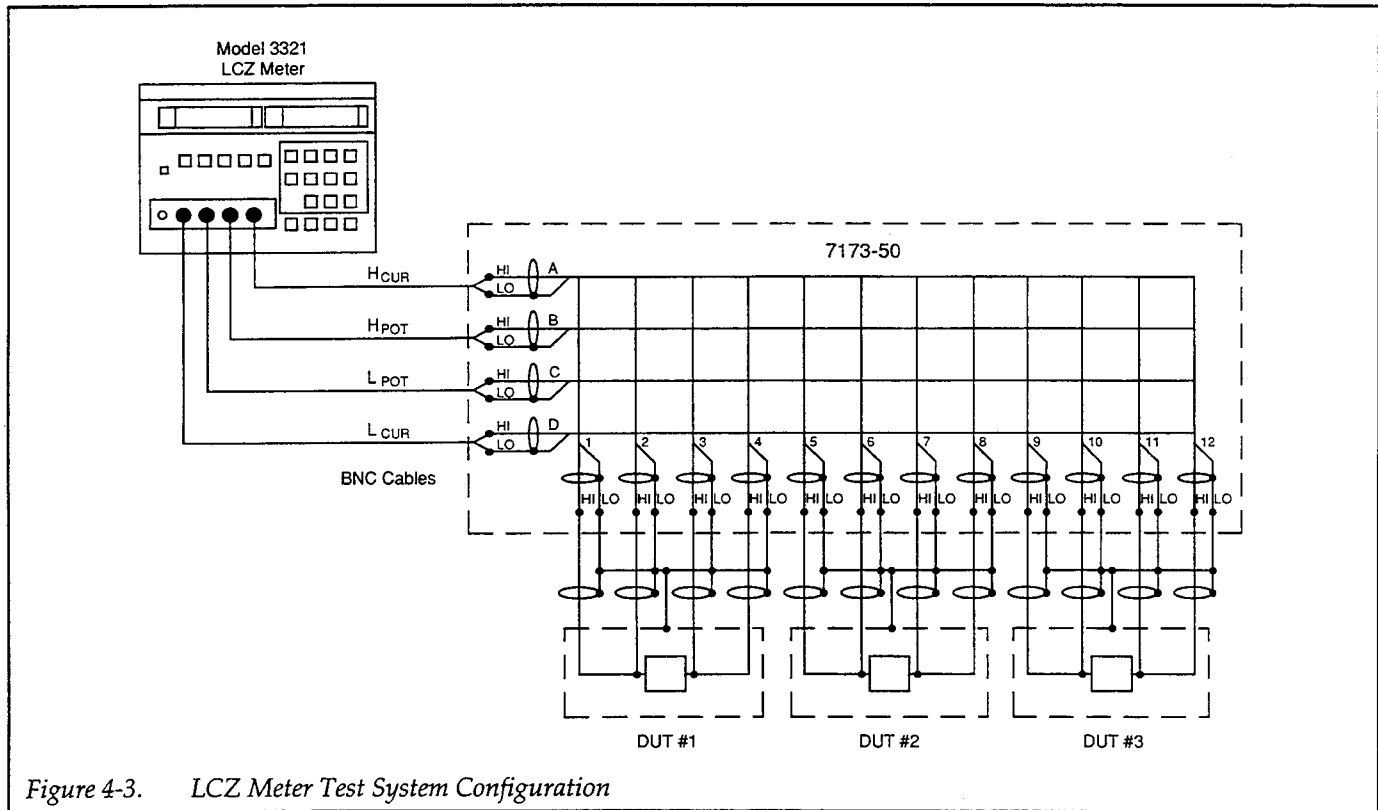


Figure 4-3. LCZ Meter Test System Configuration

#### 4.4.2 LCZ Test Switching

Table 4-1. Crosspoint Closed for LCZ Testing

All LCZ measurements are made using 4-wire connections. As a result, four crosspoints must be closed to test each DUT. Table 4-1 summarizes which crosspoint in Figure 4-3 must be closed to test each DUT. All unused crosspoints must, of course, be open.

DUT	Crosspoints Closed
#1	A1, B2, C3, D4
#2	A5, B6, C7, D8
#3	A9, B10, C11, D12

# SECTION 5

## Service Information

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### 5.1 INTRODUCTION

This section contains information necessary to service the Model 7173-50 Matrix Card and is arranged as follows:

- 5.2 **Handling and Cleaning Precautions:** Discusses handling precautions and methods to clean the card should it become contaminated.
- 5.3 **Performance Verification:** Covers the procedures necessary to determine if the card is operating properly.
- 5.4 **Principles of Operation:** Briefly discusses circuit operation.
- 5.5 **Special Handling of Static-sensitive Devices:** Reviews precautions necessary when handling static-sensitive devices.
- 5.6 **Troubleshooting:** Presents some troubleshooting tips for the Model 7173-50.

#### WARNING

The procedures in this section are intended only for qualified service personnel.

### 5.2 HANDLING AND CLEANING PRECAUTIONS

Because of the high-impedance circuits on the Model 7173-50, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be taken when servicing the card.

1. Handle the card only by the edges and handle. Do not touch 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, use a flux that is rosin RMA based. 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.

### 5.3 PERFORMANCE VERIFICATION

The following paragraphs discuss performance verification procedures for the Model 7173-50, including contact resistance, contact potential, path isolation, differential isolation, common-mode isolation, and offset current.

The verification procedures in this section are somewhat lengthy because of the large number of row and column combinations that are checked. As an alternative to extensive testing, you may want to check only those pathways to be used, or only those suspected of substandard performance.

#### CAUTION

Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the handle and top and bottom edges. To not touch connector insulators, board surfaces, or components.

#### NOTES:

1. The performance verification procedures must be performed with all SMB to BNC expansion cables disconnected from the Model 7173-50 card being tested.

2. Failure of any performance verification test may indicate the matrix card is contaminated. See paragraph 5.2 for procedures to clean the card.

#### 5.3.1 Environmental Conditions

All verification measurements should be made at an ambient temperature between 18°C and 28°C and at a relative humidity of less than 70%. (The card can be tested between 0°C and 35°C, but test instruments should be operated between 18°C and 28°C for rated accuracy.) 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.

#### 5.3.2 Recommended Test Equipment

Table 5-1 summarizes the equipment necessary to make the performance verification tests, along with the application for each item.

#### NOTE

Do not use the Model 7070 Universal Adapter Card as an extender card when performing the verification procedures. The Model 7173-50 must be installed directly in the main-frame.

Table 5-1. Recommended Verification Equipment

Description	Model	Specifications	Application
Sensitive Digital Voltmeter	Keithley 182	3mV; 0.0076%	Contact potential
DMM	Keithley 196	300Ω; 0.01%	Path resistance
Electrometer/Source	Keithley 617	10pA, 100pA; 1.6% 30V source; 0.2%	Offset current, isolation
Low thermal cable with alligator clips*	Keithley 1506	—	Contact potential
Triax to alligator clips cable**	Keithley 6011	—	Isolation
Triax to triax cable	Keithley 7024-3	—	Offset current, differential isolation
BNC to alligator clips cable	Keithley 7754-3	—	Contact potential, common-mode isolation
Low-noise coax cable (BNC to BNC)	Keithley 4801	—	Path isolation
Double binding posts to male BNC adapters (2)	Pomona 1296	—	Contact resistance, path isolation
Double binding posts to female BNC adapter	Pomona 1269	—	Path isolation
Female BNC to female BNC adapter	Pomona 3283	—	Contact potential
Female triax to male BNC adapter	Keithley 4804	—	Offset current, isolation

\*Supplied with Model 182 when so ordered.

\*\*Supplied with Model 617.

### 5.3.3 Path Resistance Tests

Perform the following steps to verify that each set of crosspoint contacts are closing properly and that the path resistance is within specification. Tests for HI and LO pathways are done separately (the basic procedures for HI and LO pathways are the same; only the connections are different). Figure 5-1 shows connections for path resistance testing.

1. Turn off Model 707 power if the mainframe is presently turned on.
2. Install the Model 7173-50 in slot 1 of the Model 707.
3. Set all ROW ISOLATOR CONTROL switches on the matrix card to the AUTO mode.
4. Turn on the Model 196 DMM, and set the instrument to the 300Ω resistance range. Connect four test leads to the OHMS and OHMS sense terminals of the DMM. Allow a one-hour warm-up period for rated Model 196 accuracy.
5. Temporarily short the four test lead ends together, then enable zero on the Model 196 DMM after allowing the reading to settle. Leave zero enabled for the remainder of tests.
6. Connect the Model 196 to the matrix card using the double binding post to BNC adapters, as shown in Figure 5-1. Note that the DMM leads should be connected to the HI (red) terminals of the adapters to test the HI signal pathways. OHMS HI and OHMS SENSE HI should be connected to ROW A, and OHMS LO and OHMS SENSE LO should be connected to COLUMN 1.
7. Turn on the Model 707.
8. Program the mainframe to close crosspoint A1 (ROW A, COLUMN 1). Verify that the resistance of this pathway is <2Ω.



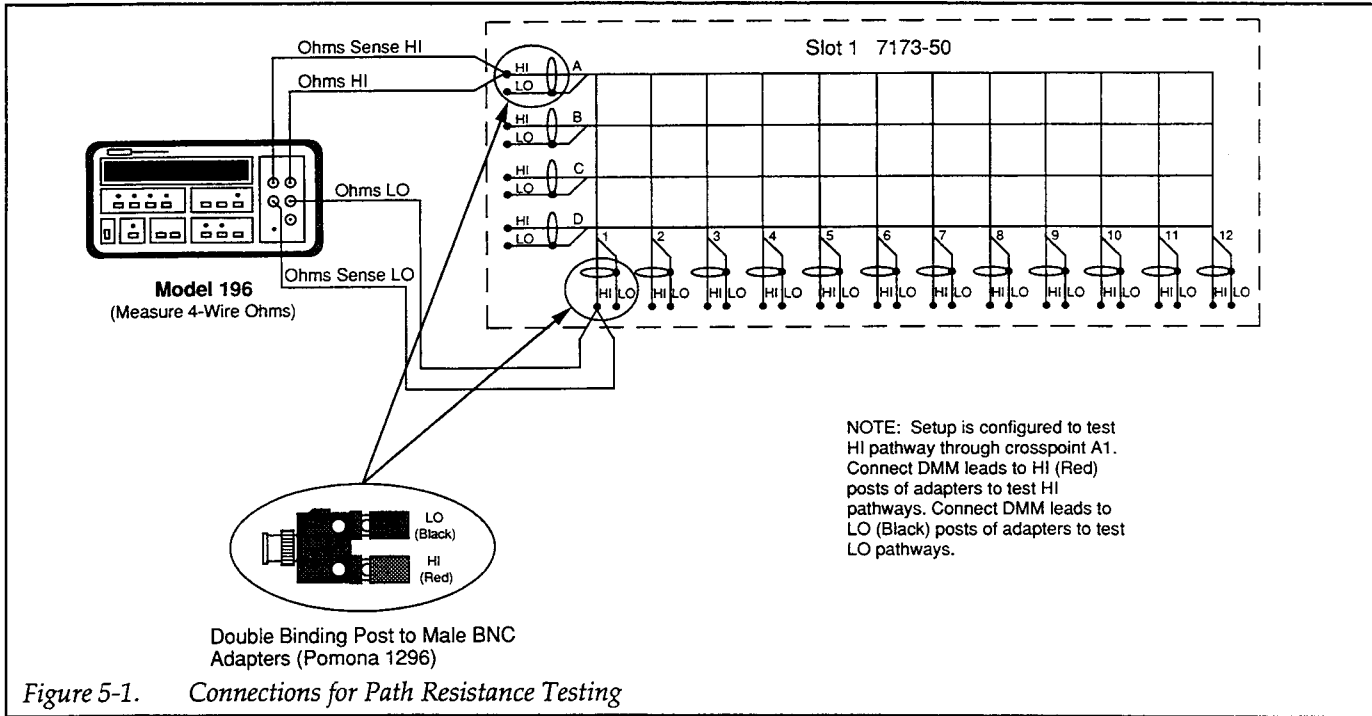


Figure 5-1. Connections for Path Resistance Testing

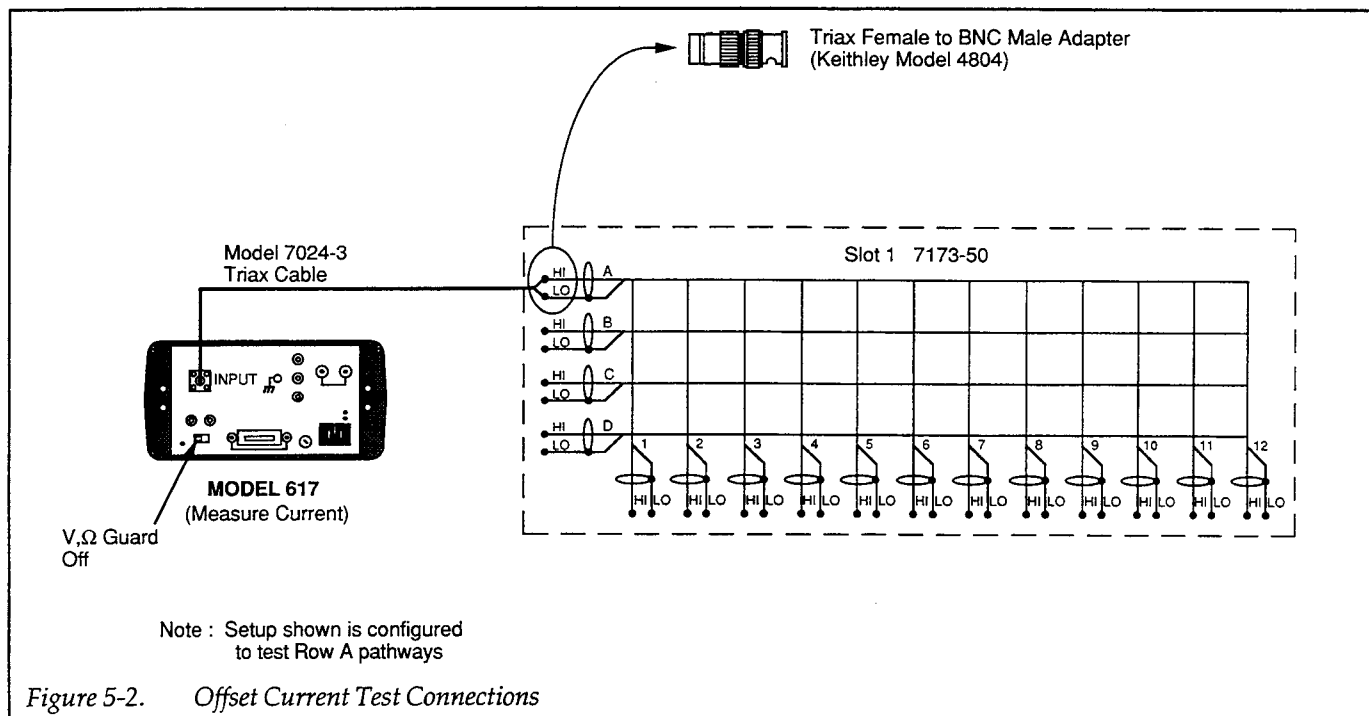
9. Open crosspoint A1, and connect the OHMS HI and OHMS SENSE HI terminals to ROW B of the matrix card.
10. Close crosspoint B1, and verify that the pathway resistance is  $<2\Omega$ .
11. Repeat the basic procedure of steps 8 through 10 to check the path resistance through C1 and D1. Make sure that only one crosspoint is closed at any given time and that OHMS HI and OHMS SENSE HI are connected to the row being tested.
12. Connect the OHMS SENSE LO and OHMS LO test leads to the COLUMN 2 input jack, and verify that the path resistance through A2 to D2 is  $<2\Omega$ . Again, make certain that only the appropriate crosspoint is closed and that OHMS HI and OHMS SENSE HI are connected to the row being tested.
13. Repeat the basic procedure of connecting test leads to the appropriate row and column, and check the remainder of the matrix crosspoints. Make sure that only the crosspoint being tested is closed and that the DMM is connected to the appropriate ROW and COLUMN jacks. Each HI pathway resistance value should be  $<2\Omega$ .
14. Connect the DMM leads to the LO (black) posts of the BNC to double binding post adapters. OHMS HI and OHMS SENSE HI should be connected to LO of one adapter, and OHMS LO and OHMS SENSE LO should be connected to LO of the other adapter. Repeat the entire test procedure above for all LO signal pathways. The path resistance for all LO signal pathways should be  $<0.5\Omega$ .

### 5.3.4 Offset Current Tests

The offset current tests measure the leakage current between the HI and LO terminals of each ROW input connector for each possible crosspoint closure. These tests are performed by simply measuring leakage current with a Keithley Model 617 Electrometer. Test connections are shown in Figure 5-2.

Perform the following procedure to check offset current:

1. Turn off the Model 707 power if the mainframe is presently turned on.
2. Install the Model 7173-50 in slot 1 of the Model 707.
3. Set all Model 7173-50 ROW ISOLATOR CONTROL switches to the AUTO position.
4. Connect the Model 617 to ROW A of the Model 7173-50, as shown in Figure 5-2.
5. Turn on the Model 617 power, and allow the unit to warm up for one hour before measuring the card offset currents.
6. Select the Model 617 200pA range, then enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
7. Turn on the Model 707.
8. Program the Model 707 mainframe to close crosspoint A1.
9. Disable Model 617 zero check, and allow the reading to settle. Verify that the current reading, which represents the offset current, is  $<200\text{pA}$ .



10. Enable Model 617 zero check, and open crosspoint A1.
  11. Repeat the basic procedure in steps 8 through 10 to check the remaining pathways of the row (crosspoints A2 through A12).
  12. Repeat the basic procedure for ROWS B through D. The Model 617 should be connected to the row being tested, and only one crosspoint at a time should be closed. In all cases, the offset current should be <math><200\text{pA}</math>.
3. Set all Model 7173-50 ROW ISOLATOR CONTROL switches to the AUTO position.
  4. Turn on the Model 182, and allow it to warm up for one hour before beginning the tests.
  5. Temporarily connect the cables and adapters together and to the Model 182 INPUT jack, as shown in Inset A of Figure 5-3. This step shorts the HI and LO signal paths through the cables to allow nulling of offsets.
  6. Select the Model 182 3mV range, and allow the reading to settle. Enable REL READING to null out any offsets. Leave REL READING enabled for the remainder of the tests.

### 5.3.5 Contact Potential Tests

These tests check the contact potential generated by thermal EMFs for each set of crosspoint contacts. These tests are performed by directly measuring the contact potential voltage using a Model 182 Sensitive Digital Voltmeter.

Perform the procedure below to check the contact potential of each path. Connections for these tests are shown in Figure 5-3.

1. Turn the Model 707 power off if it is presently turned on.
2. Install the Model 7173-50 in slot 1 of the Model 707.

#### NOTE

Keep ambient temperature changes to a minimum (<math>< \pm 2^{\circ}\text{C}</math>) after performing the nulling procedure in steps 5 and 6 above. If in doubt, repeat steps 5 and 6 before each measurement to minimize the effects of thermal drift and maximize contact potential measurement accuracy.

7. Disconnect the BNC adapter and shorting wire from the connecting cables, then connect the Model 182 to the matrix card, as shown in Figure 5-3. The alligator clips of the low thermal cable are connected to the alligator clips of the BNC cable, and the clips are thermally insulated with non-conductive foam to mini-

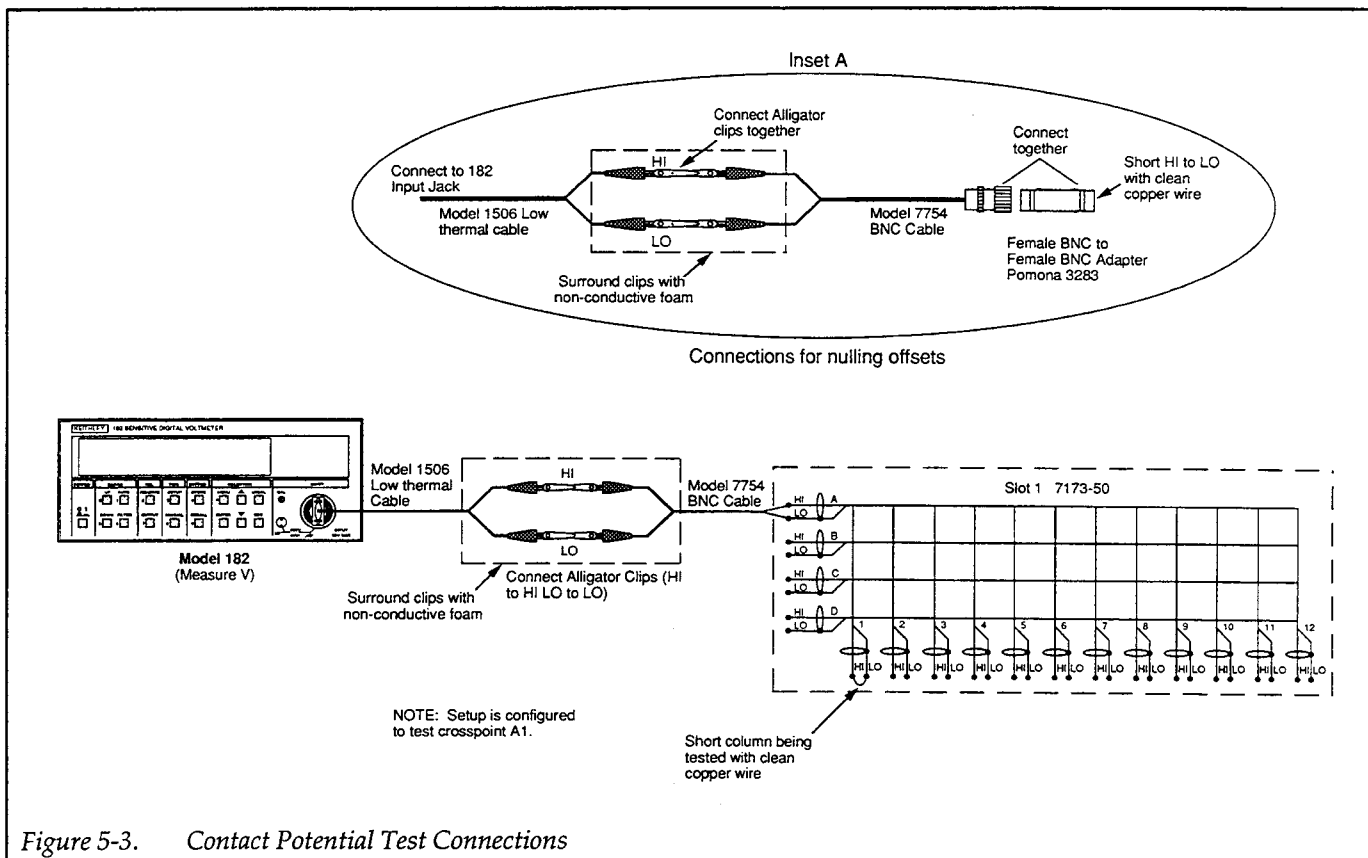


Figure 5-3. Contact Potential Test Connections

mize thermal drift. Note that the BNC cable is connected to ROW A, and a clean copper wire shorts HI and LO of COLUMN 1.

8. Turn on the Model 707 power.
9. Program the Model 707 to close crosspoint A1, and verify that the Model 182 reading is  $<15\mu\text{V}$ . This reading represents the contact potential of the closed crosspoint.
10. Open crosspoint A1, and connect the BNC cable to ROW B.
11. Close crosspoint B1, and verify that the contact potential of this pathway is  $<15\mu\text{V}$ . Repeat the basic procedure of steps 9 and 10 to check contact potential through crosspoints C1 and D1. The BNC cable should be connected to the ROW connector of the pathway being tested.
12. Short HI and LO of COLUMN 2 with the copper wire, and check that the contact potential through crosspoints B2 through D2 is  $<15\mu\text{V}$  (make certain the BNC cable is connected to the ROW input jack for the row being tested).
13. Check the remaining crosspoints using the procedure outlined above. The BNC cable should be connected to the ROW connector, and the copper shorting wire should be connected to the COLUMN con-

ductor of the crosspoint being tested. All contact potential measurements should be  $<15\mu\text{V}$ .

### 5.3.6 Path Isolation Tests

These tests check leakage resistance (isolation) between adjacent paths. A path is defined as the circuit from a row to a column that results from closing a particular crosspoint.

Referring to Figure 5-4, perform the following procedure to check path isolation:

1. Turn off the Model 707 if it is currently turned on.
2. Install the Model 7173-50 in slot 1 of the Model 707.
3. Set all matrix card ROW ISOLATOR CONTROL switches to the AUTO position.
4. Turn on the Model 617, and allow the unit to warm up for one hour before continuing.
5. Set the Model 617 to 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
6. Program the Model 617 voltage source for an output voltage of 0V, and place the voltage source in operate.

7. Connect the Model 617 to the matrix card, as shown in Figure 5-4.
8. Disable zero check, and allow the reading to settle. Enable suppress after settling.
9. Select the V/I ohms mode, and enable auto range.
10. Turn on the Model 707.
11. Program the Model 707 to program crosspoints A1 and B2.
12. Program the voltage source for 30V, and allow the reading to settle.
13. Verify that the path isolation resistance reading is  $>10G\Omega$ . This measurement represents the path isolation resistance between ROW A, COLUMN 1 and ROW B, COLUMN 2.
14. Program the Model 707 to open crosspoints A1 and B2.
15. Repeat the above procedure using Table 5-2 as a guide. Be sure that the Model 617 is connected to the indicated ROW connectors. In all cases, the path isolation resistance should be  $>10G\Omega$ .

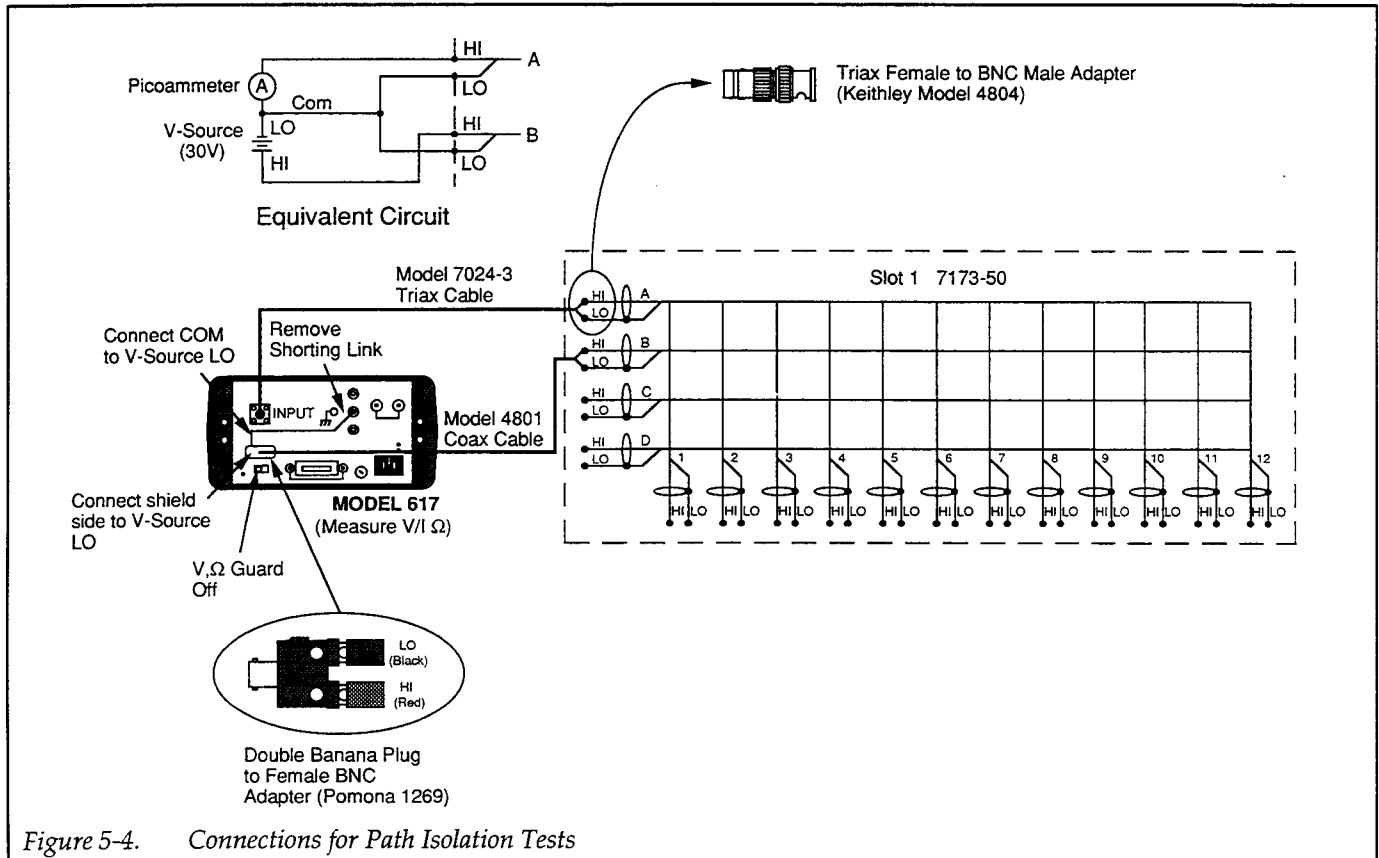


Table 5-2. Path Isolation Tests

Test No.	Path Isolation	Connections	Crosspoints Closed
1	ROW A, COL. 1 to ROW B, COL. 2	ROW A and ROW B	A1 and B2
2	ROW B, COL. 2 to ROW C, COL. 3	ROW B and ROW C	B2 and C3
3	ROW C, COL. 3 to ROW D, COL. 4	ROW C and ROW D	C3 and D4
4	ROW A, COL. 4 to ROW B, COL. 5	ROW A and ROW B	A4 and B5
5	ROW A, COL. 5 to ROW B, COL. 6	ROW A and ROW B	A5 and B6
6	ROW A, COL. 6 to ROW B, COL. 7	ROW A and ROW B	A6 and B7
7	ROW A, COL. 7 to ROW B, COL. 8	ROW A and ROW B	A7 and B8
8	ROW A, COL. 8 to ROW B, COL. 9	ROW A and ROW B	A8 and B9
9	ROW A, COL. 9 to ROW B, COL. 10	ROW A and ROW B	A9 and B10
10	ROW A, COL. 10 to ROW B, COL. 11	ROW A and ROW B	A10 and B11
11	ROW A, COL. 11 to ROW B, COL. 12	ROW A and ROW B	A11 and B12

### 5.3.7 Differential Isolation Tests

These tests check differential isolation resistance between HI and LO of each ROW and COLUMN connector with appropriate crosspoints closed.

Refer to Figure 5-5, and perform the following procedure to check differential isolation:

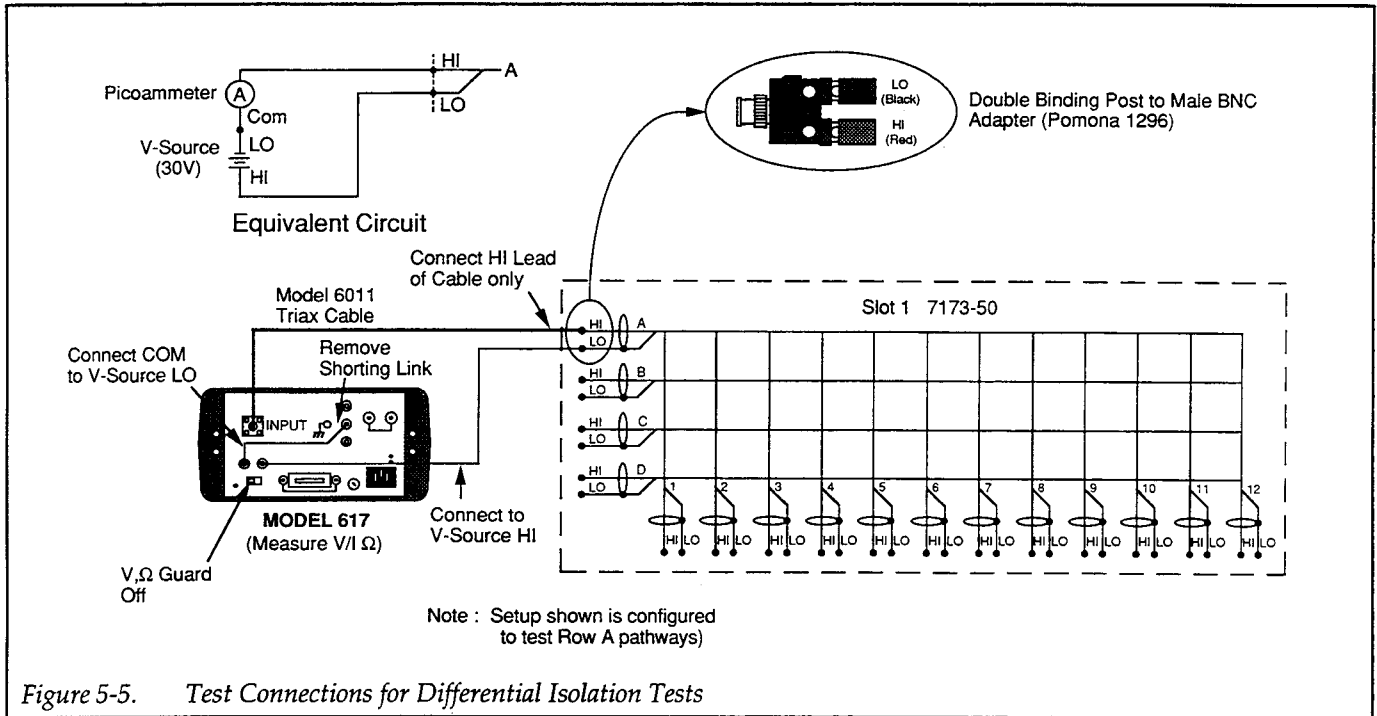
1. Turn off the Model 707 if it is currently on.
2. Install the Model 7173-50 in slot 1 of the mainframe.
3. Set all Model 7173-50 ROW ISOLATOR CONTROL switches to the AUTO position.
4. Turn on the Model 617, and allow the unit to warm up for at least one hour before performing the differential isolation tests.
5. Select the Model 617 2pA range, then enable zero check and zero correct in that order. Leave zero correct enabled for the remainder of the procedure.
6. Connect the Model 617 to the matrix card, as shown in Figure 5-5.
7. Program the voltage source for 0V, and place the source in operate.
8. Disable zero check, and allow the reading to settle. Enable suppress after settling.
9. Select the V/I ohms mode, and enable auto-range.
10. Set the voltage source to 30V.
11. Turn on the Model 707, but do not program any crosspoints to close; all crosspoints must be open at this time.
12. Allow the reading to settle. Verify that the reading is  $>1G\Omega$ . This reading is the differential isolation resistance of ROW A.

13. Program the Model 707 to close crosspoint A1.
14. Allow the reading to settle. Verify that the reading is  $>1G\Omega$ . This measurement is the differential isolation resistance of COLUMN 1.
15. Repeat steps 13 and 14 for the remaining rows and columns listed in Table 5-3. Be sure that only the indicated crosspoint is closed for each measurement and that the electrometer is connected to the ROW jack being tested. All differential isolation resistance measurements should be  $>1G\Omega$ .

**Table 5-3. Differential and Common-mode Isolation Test Summary**

Test No.	Row or Column	Crosspoint Closed*
1	ROW A (B, C, or D)	None
2	COLUMN 1	A1 (B1, C1, D1)
3	COLUMN 2	A2 (B2, C2, D2)
4	COLUMN 3	A3 (B3, C3, D3)
5	COLUMN 4	A4 (B4, C4, D4)
6	COLUMN 5	A5 (B5, C5, D5)
7	COLUMN 6	A6 (B6, C6, D6)
8	COLUMN 7	A7 (B7, C7, D7)
9	COLUMN 8	A8 (B8, C8, D8)
10	COLUMN 9	A9 (B9, C9, D9)
11	COLUMN 10	A10 (B10, C10, D10)
12	COLUMN 11	A11 (B11, C11, D11)
13	COLUMN 12	A12 (B12, C12, D12)

\*Closed crosspoint depends on row-column combination being tested. For example, to test ROW C, COLUMN 9, close C9.



### 5.3.8 Common-mode Isolation Tests

These tests check common-mode isolation resistance between HI and LO of each ROW and COLUMN connector connected together and card chassis ground.

Refer to Figure 5-6, and perform the following procedure to check common-mode isolation:

1. Turn off the Model 707 if it is currently on.
2. Install the Model 7173-50 in slot 1 of the mainframe.
3. Set all Model 7173-50 ROW ISOLATOR CONTROL switches to the AUTO position.
4. Turn on the Model 617, and allow the unit to warm up for at least one hour before performing the input isolation tests.
5. Select the Model 617 2pA range, then enable zero check and zero correct in that order. Leave zero correct enabled for the remainder of the procedure.
6. Connect the Model 617 to the matrix card, as shown in Figure 5-6. Note that the voltage source HI lead is connected to card chassis ground (use the handle or a mounting screw for chassis ground connections). The electrometer HI lead is connected to both HI and LO of the BNC cable connected to the row being tested (the HI and LO alligator clips of the BNC cable should be shorted together).
7. Program the voltage source for 0V, and place the voltage source in operate.
8. Disable zero check, and allow the reading to settle. Enable suppress after settling.
9. Select the V/I ohms mode, and enable auto-ranging.
10. Set the voltage source output to 30V
11. Turn on the Model 707, but do not program any crosspoints to close; all crosspoints must be open at this time.
12. Allow the reading to settle. Verify that the reading is  $>1G\Omega$ . This reading is the common-mode isolation of ROW A.
13. Program the Model 707 to close crosspoint A1.
14. Allow the reading to settle. Verify that the reading is  $>1G\Omega$ . This measurement checks the common-mode isolation of COLUMN 1.
15. Repeat steps 13 and 14 for the remaining rows and columns listed in Table 5-3. Be sure that only the indicated crosspoint is closed for each measurement and that the BNC cable is connected to the ROW jack being tested. All common-mode isolation resistance measurements should be  $>1G\Omega$ .

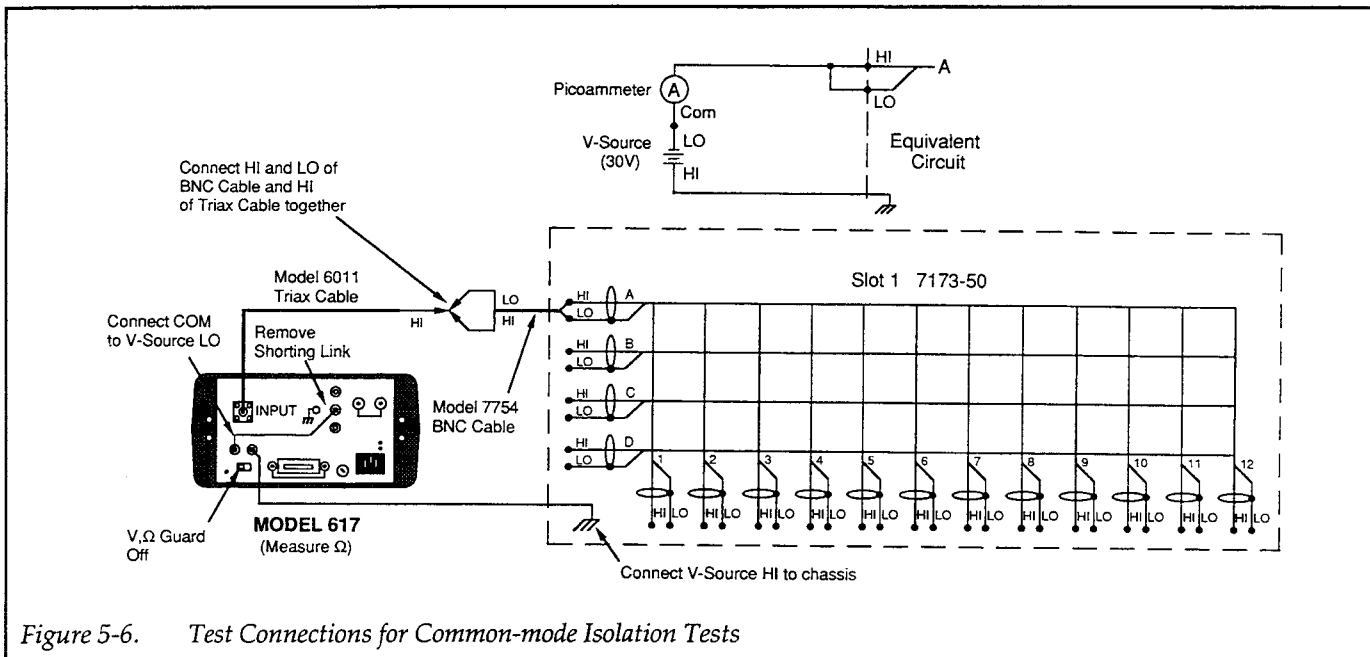


Figure 5-6. Test Connections for Common-mode Isolation Tests

## 5.4 PRINCIPLES OF OPERATION

The following paragraphs discuss the basic operating principles for the Model 7173-50. A schematic diagram of the matrix card may be found on drawing number 7173-50-106, located at the end of Section 6.

### 5.4.1 Block Diagram

Figure 5-7 shows a simplified block diagram of the Model 7173-50. Key elements include the buffer (U113), ID data circuits (U114, U115, U116), relay drivers (U101-U112) and relays (K101-K244), and power-up output disable (U117). The major elements are discussed below.

### 5.4.2 ID Data Circuits

Upon power up, the card identification data information from each card is read by the mainframe. This ID data includes such information as card ID, hardware settling time for the card, a relay configuration table (which tells the mainframe which relays to close for a specific crosspoint), and ROW ISOLATOR CONTROL switch position information (discussed below).

ID data is contained within an on-card ROM, U116. In order to read this information, the sequence below is performed upon power up. Figure 5-8 shows the general timing of this sequence.

1. The CARDSEL line is brought low, enabling the ROM outputs. This line remains low throughout the ID data transmission sequence.
2. The CLRADDR line is pulsed high to clear the address counter and set it to zero. At this point, a ROM address of zero is selected.
3. The NEXTADDR line is set low to load the parallel-to-serial converter with the ROM data at the presently selected address. When NEXTADDR is set high, the address counter is advanced by one to select the next sequential ROM address.
4. The IDCLK line (inverted CLK) clocks the parallel-to-serial converter to shift all eight data bits from the converter to the mainframe via the IDDATA line.

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

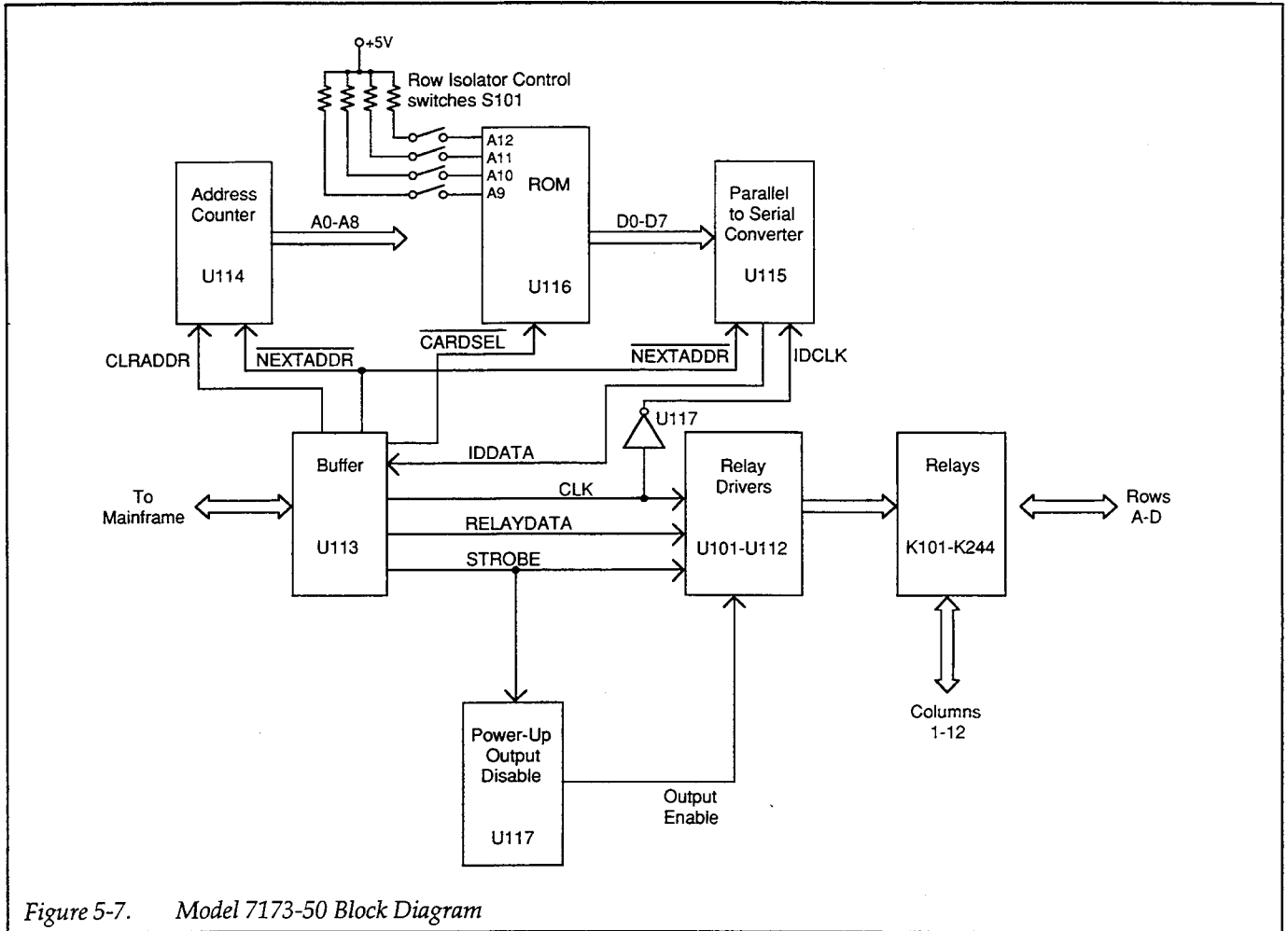


Figure 5-7. Model 7173-50 Block Diagram

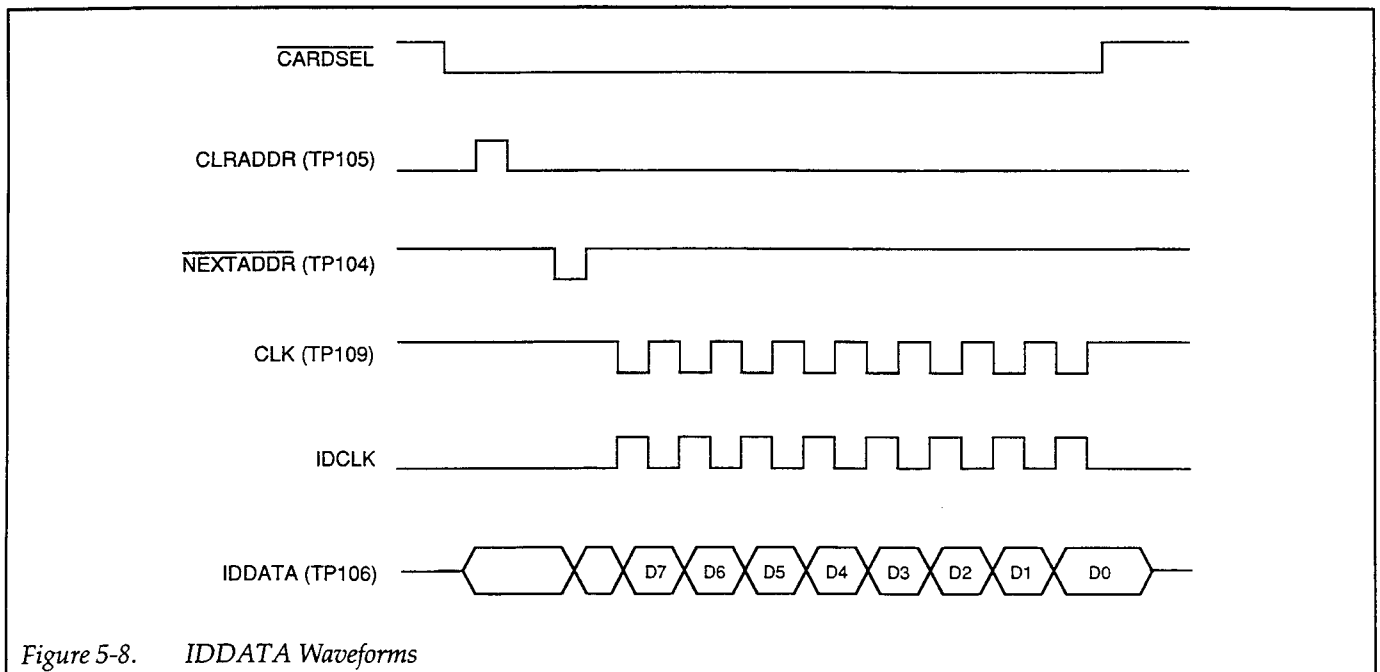


Figure 5-8. IDDATA Waveforms



### 5.4.3 ROW ISOLATOR CONTROL Switch Information

The four ROW ISOLATOR CONTROL switches are connected to the ROM address lines A9 through A12 and actually control which of 16 blocks of ROM data is read by the mainframe as card configuration information upon power-up. These 16 blocks contain information that tells the mainframe which relays to energize when a crosspoint is closed. For example, in automatic mode, both A1 and E1 are energized when A1 is closed. In manual mode, only A1 is energized.

As summarized in Table 5-4, a suffix character, appended to the card ID number identifies the positions of the four ROW ISOLATOR CONTROL switches.

**Table 5-4. ROW ISOLATOR CONTROL Switch Positions**

Card ID	ROW ISOLATOR CONTROL Switch Positions			
	A	B	C	D
7173*0	M	M	M	M
7173*1	A	M	M	M
7173*2	M	A	M	M
7173*3	A	A	M	M
7173*4	M	M	A	M
7173*5	A	M	A	M
7173*6	M	A	A	M
7173*7	A	A	A	M
7173*8	M	M	M	A
7173*9	A	M	M	A
7173*A	M	A	M	A
7173*B	A	A	M	A
7173*C	M	M	A	A
7173*D	A	M	A	A
7173*E	M	A	A	A
7173*F	A	A	A	A

NOTE:A = Automatic; M = Manual

### 5.4.4 Relay Control

The relays are controlled by serial data transmitted via the RELAY DATA line. A total of 12 bytes are shifted in serial fashion into latches located in the 12 relay drivers, U101-U112 (16 bytes of relay control information per card are actually shifted, but only 12 are used by the Model 7173-50). The serial data is fed in through the relay driver DATA lines under control of the CLK signal. As data

overflows one register, it is fed out the Q'S line of that register to the next IC down the chain.

Once all 12 bytes have been shifted into the card, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate relays are energized (assuming the driver outputs are enabled, as discussed below). Logic convention is such that the corresponding relay driver output must be low to energize the associated relay, while the output is high when the relay is de-energized.

### 5.4.5 Power-up Output Disable

A power-up output disable circuit, made up of two sections of U117 and associated components, ensures that relays do not randomly energize upon power-up. The two NAND gates, U117, make up an R-S flip-flop. Initially, the Q output of the flip-flop (pin 3 of U117) is set high upon power up. Since the OE terminals of the relay drivers U101-U112 are held high, their outputs are disabled, and all relays remain de-energized regardless of the relay data information present at that time.

The first STROBE pulse that comes along (in order to load relay data) clears the R-S flip-flop, setting the OE lines of U101-U112 low to enable their outputs. This action allows the relays to be controlled by the transmitted relay data information.

A nominal hold-off period is included in the output disable circuit to guard against premature enabling of the relays. The time constant of the hold-off period is determined by the relative values of R106 and C120.

### 5.4.6 Row Isolator Relays

Row isolator relays are necessary in addition to the crosspoint relays in order to maintain a nominal 50Ω characteristic impedance for each pathway through the card. In the automatic row isolator mode, these relays automatically open up when the corresponding crosspoints are closed.

For example, when crosspoint D2 (Row D, Column 2) is closed, the contacts in K204 and K115 close (and the column-blocking contacts in K115 open). In the automatic row isolator mode, the normally-closed contacts of row isolator relay K116 open at the same time. In the manual row isolator mode, the normally-closed contacts of K116

remain closed, but K116 can be manually controlled by mainframe programming.

## 5.5 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

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

### NOTE

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

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

## 5.6 TROUBLESHOOTING

### 5.6.1 Recommended Equipment

Table 5-5 summarizes the recommended equipment for general troubleshooting.

### 5.6.2 Using the Extender Card

In order to gain access to the test points and other circuitry on the Model 7173-50, the card must be plugged

**Table 5-5. Recommended Troubleshooting Equipment**

Description	Application
DMM (Keithley 196)	Measure DC voltages
Dual-trace, triggered-sweep, 50MHz oscilloscope	Check clock and logic pulses
Extender Card (Keithley 7070)	Allow circuit access

into the Model 7070 Extender Card, which, in turn, must be plugged into the desired slot of the mainframe. The Model 7070 must be configured as an extender card by placing the configuration jumper in the EXTEND position. See the documentation supplied with the Model 7070 for complete details on using the card.

### 5.6.3 Shield Removal

To remove the bottom shield for board access for repair or troubleshooting, simply remove the screws that secure the shield to the PC board, then remove the shield. Be careful not touch the board surface after the shield has been removed.

### NOTE

One of the screws that secures the bottom shield is an electrical connection to the small baby board and must be in place for the card to operate properly.

### 5.6.4 Troubleshooting Procedure

Table 5-6 summarizes the troubleshooting procedure for the matrix card. Some of the troubleshooting steps refer to the ID data timing diagram shown in Figure 5-8. Also, refer to paragraph 5.4 for an overview of operating principles.

Table 5-6. Troubleshooting Procedure

Step	Item/Component	Required Condition	Comments
1	TP102		All voltages and signals referenced to TP102 (digital common)
2	TP101	+6VDC	Relay supply voltage
3	TP103	+5VDC	Logic supply voltage
4	TP104	NEXTADDR pulses	Power-up only (Figure 5-8)
5	TP105	CLR ADDR pulses	Power-up only (Figure 5-8)
6	TP106	IDDATA pulses	Power-up only (Figure 5-8)
7	TP107	STROBE pulse	End of relay data sequence
8	TP108	RELAY DATA pulses	Present when updating relays
9	TP109	CLK pulses	Present during relay data or ID data
10	TP110	HI on power-up until first STROBE sets LO	Power-up output disable
11	U101-U112, pins 11-18	LO with relay energized, HI with relay de-energized	Relay driver outputs

# SECTION 6

## Replaceable Parts

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### 6.1 INTRODUCTION

This section contains a list of replaceable electrical and mechanical parts for the Model 7173-50, as well as a component layout drawing and schematic diagram of the matrix card.

### 6.2 PARTS LIST

Electrical parts are listed in order of circuit designation in Table 6-1. Table 6-2 summarizes mechanical parts.

### 6.3 ORDERING INFORMATION

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

1. Matrix card model number (7173-50)
2. Card serial number
3. Part description
4. Circuit designation, if applicable

5. Keithley part number

### 6.4 FACTORY SERVICE

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

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

Note that it is not necessary to return the matrix mainframe with the card.

### 6.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

7173-50-100 is the component layout for the Model 7173-50. 7173-50-106 shows a schematic diagram of the card on three separate sheets.

**TABLE 6-1. MODEL 7173-50 ELECTRICAL PARTS LIST**

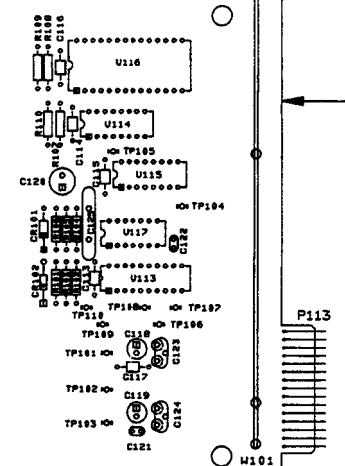
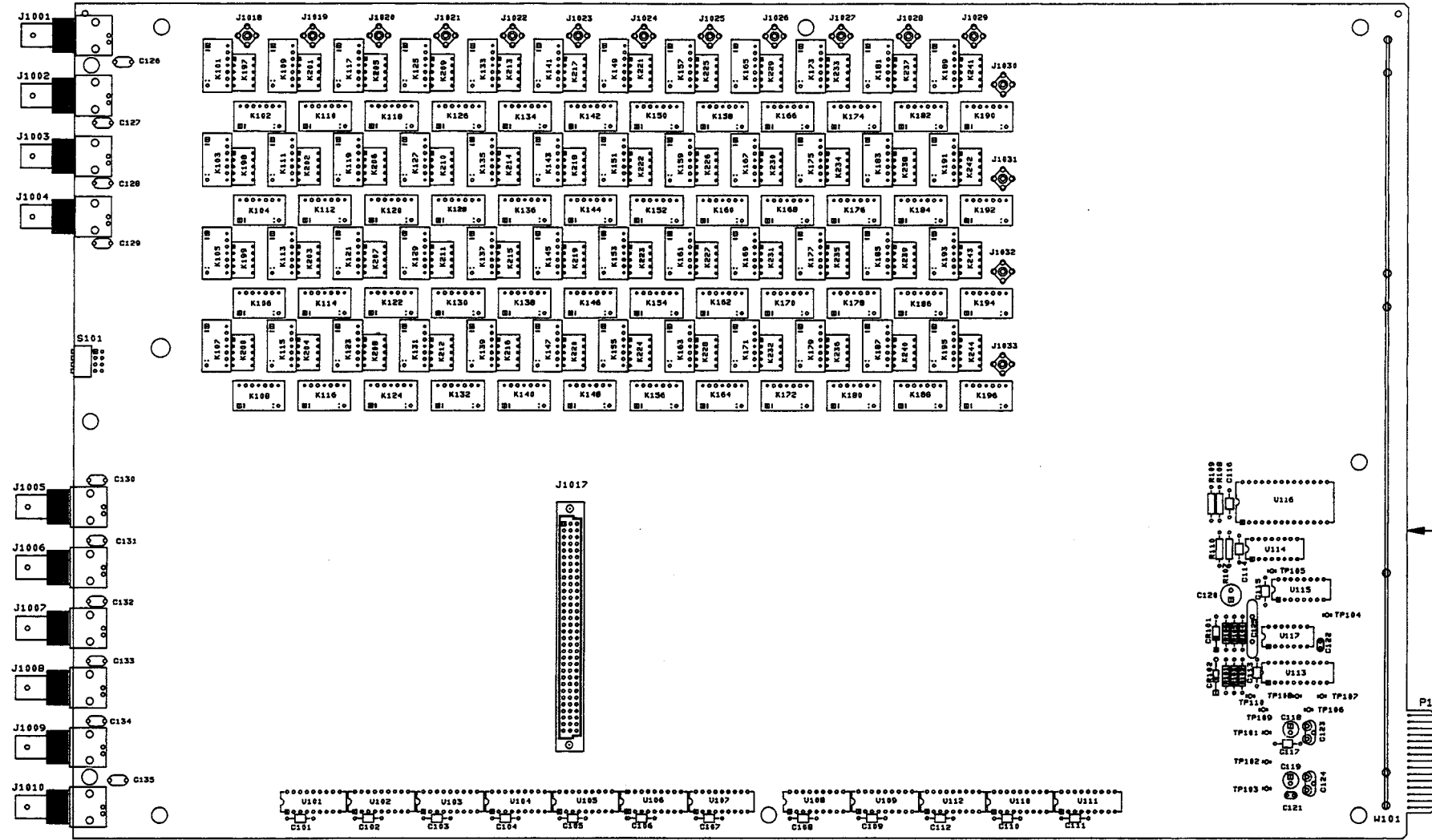
<b>CIRCUIT DESIG.</b>	<b>DESCRIPTION</b>	<b>KEITHLEY PART NO.</b>
	RELAY, ULTRA-SMALL POLARIZED TQ2E-5V	RL-136
C101...117	CAP,.1 $\mu$ F,20%,50V,CERAMIC	C-365-.1
C118,119	CAP, 10 $\mu$ F,-20+100%,25V,ALUM ELEC	C-314-10
C120	CAP, 47 $\mu$ F,10%,16V,ALUM ELEC	C-321-47
C121,122	CAP,.01 $\mu$ F,20%,50V,CERAMIC	C-237-.01
C123,124	CAP,270PF,20%,100V,CERAMIC/FERRITE	C-386-270P
C125	CAP,.01 $\mu$ F,10%,1000V,CERAMIC	C-64-.01
C126..135	CAP, 4700PF, 20%, 500V CERAMIC	C-22-.0047
C136...141	CAP, 4700PF, 20%, 500V, CERAMIC	C-22-.0047
CR101	DIODE,SILICON,IN4148 (DO-35)	RF-28
CR102	DIODE,SCHOTTKY, IN5711	RF-69
J1001...J1016	CONN, BNC RIGHT ANGLE PLASTIC	CS-506
J1018...J1033	CONN,SMB,MALE,P.C. MOUNT	CS-545
K101..196	RELAY, HI-FREQ, RK1E-5V	RL-147
P1017	CONNECTOR, 96-PIN	CS-748-1
R101	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R102	RES,11K,5%,1/4W,COMPOSITION OR FILM	R-76-11K
R103	RES,120K,5%,1/4W,COMPOSITION OR FILM	R-76-120K
R104	RES,200,5%,1/4W,COMPOSITION OR FILM	R-76-200
R105	RES,910,5%,1/4W,COMPOSITION OR FILM	R-76-910
R106...110	RES,47K,5%,1/4W,COMPOSITION OR FILM	R-76-47K
S101	HORIZONTAL MOUNT DIP SWITCH, SPST	SW-449-4
TP101...TP110	CONN,TEST POINT	CS-553
U101..112	IC, 8 STAGE SHIFT/STORE REGISTER,4094	IC-536
U113	IC, OCTAL BUFFER/LINE DRIVER, 74HC244	IC-489
U114	IC, 12 STAGE BINARY COUNTER,74HCT4040	IC-545
U115	IC,8-BIT PARALLEL TO SERIAL,74HCT165	IC-548
U116	PROGRAMMD EPROM	7173-50-800B1
U117	IC, QUAD 2 INPUT NAND, 74HCT00	IC-399
W101	STIFFENER, BOARD	J-16

## TABLE 6-2. MODEL 7173-50 MECHANICAL PARTS LIST

DESCRIPTION	KEITHLEY PART NO.
HANDLE	HH-33-1
REAR PANEL	7173-50-303A
TOP CLAMP	7173-50-304A
BOTTOM CLAMP	7173-50-305A
LUG	LU-116-1
SERIAL NUMBER LABEL	MC-285

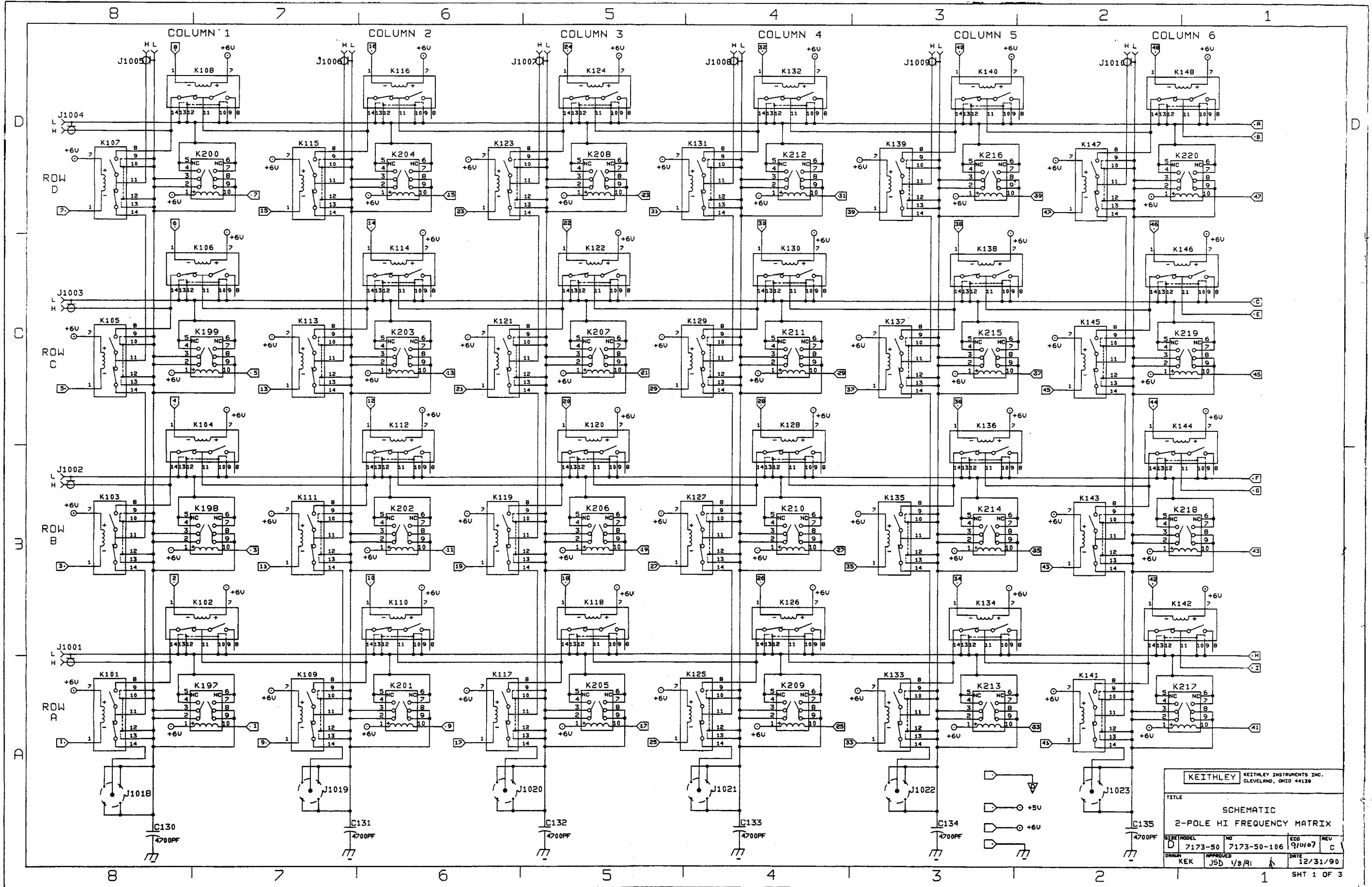
001-05-2212  
ON

LTR.	ECO NO.	REVISION	ENG.	DATE
C	910107	RELEASED	JK	1-7-79



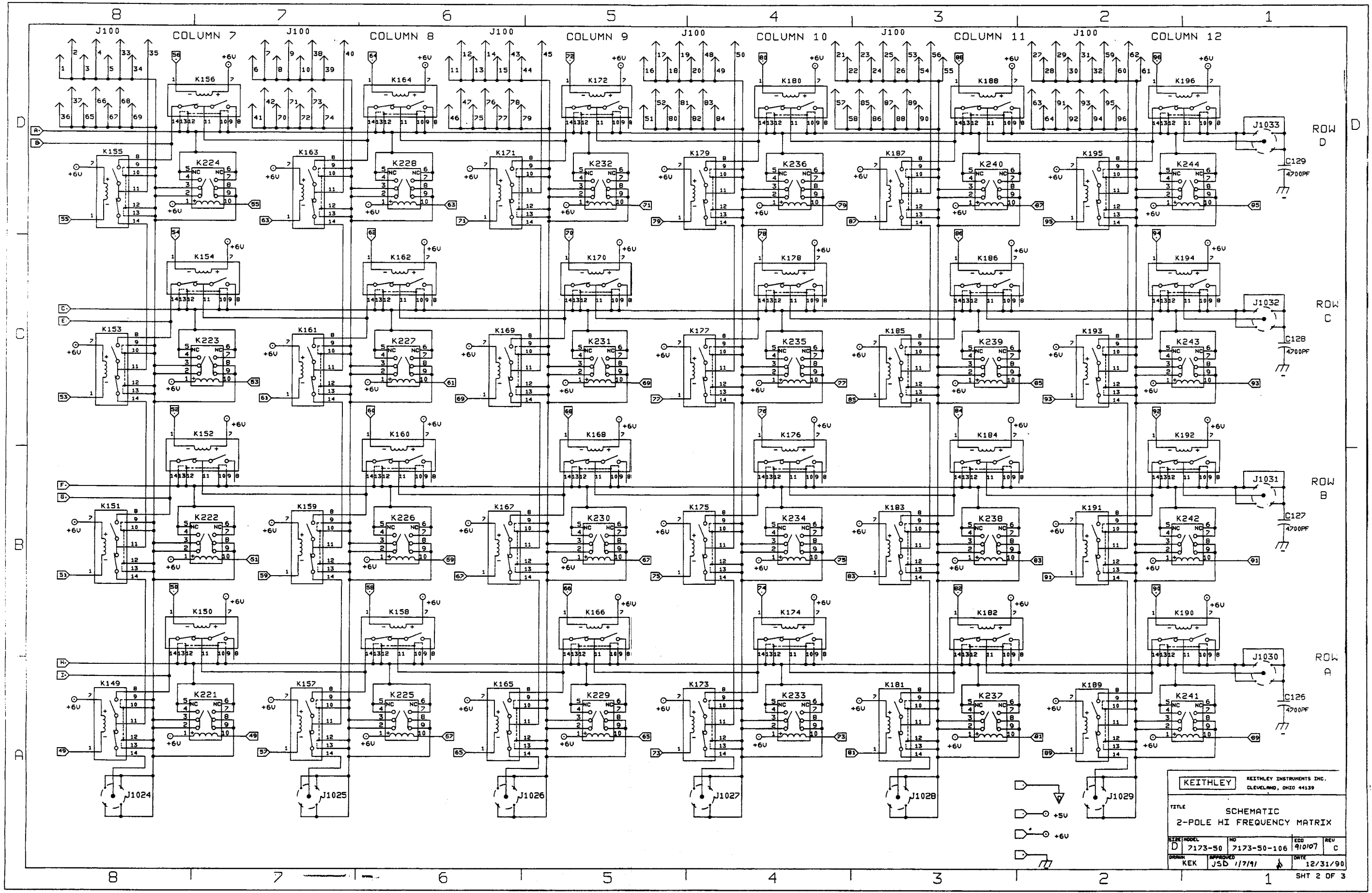
NOTE:  
FOR COMPONENT INFORMATION,  
REFER TO PRODUCT STRUCTURE

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SURFACE FIN. 63				FINISH
COMPONENT LAYOUT				NO. 7173-50-100
2-POLE HIGH FREQUENCY MATRIX				USED ON



<b>KEITHLEY</b> KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139			
TITLE <b>SCHEMATIC</b> <b>2-POLE HI FREQUENCY MATRIX</b>			
REVISION D	NO 7173-50	ECO 9/10/67	REV C
DRAWN KEK	APPROVED JSB 1/8/91	DATE 12/31/90	



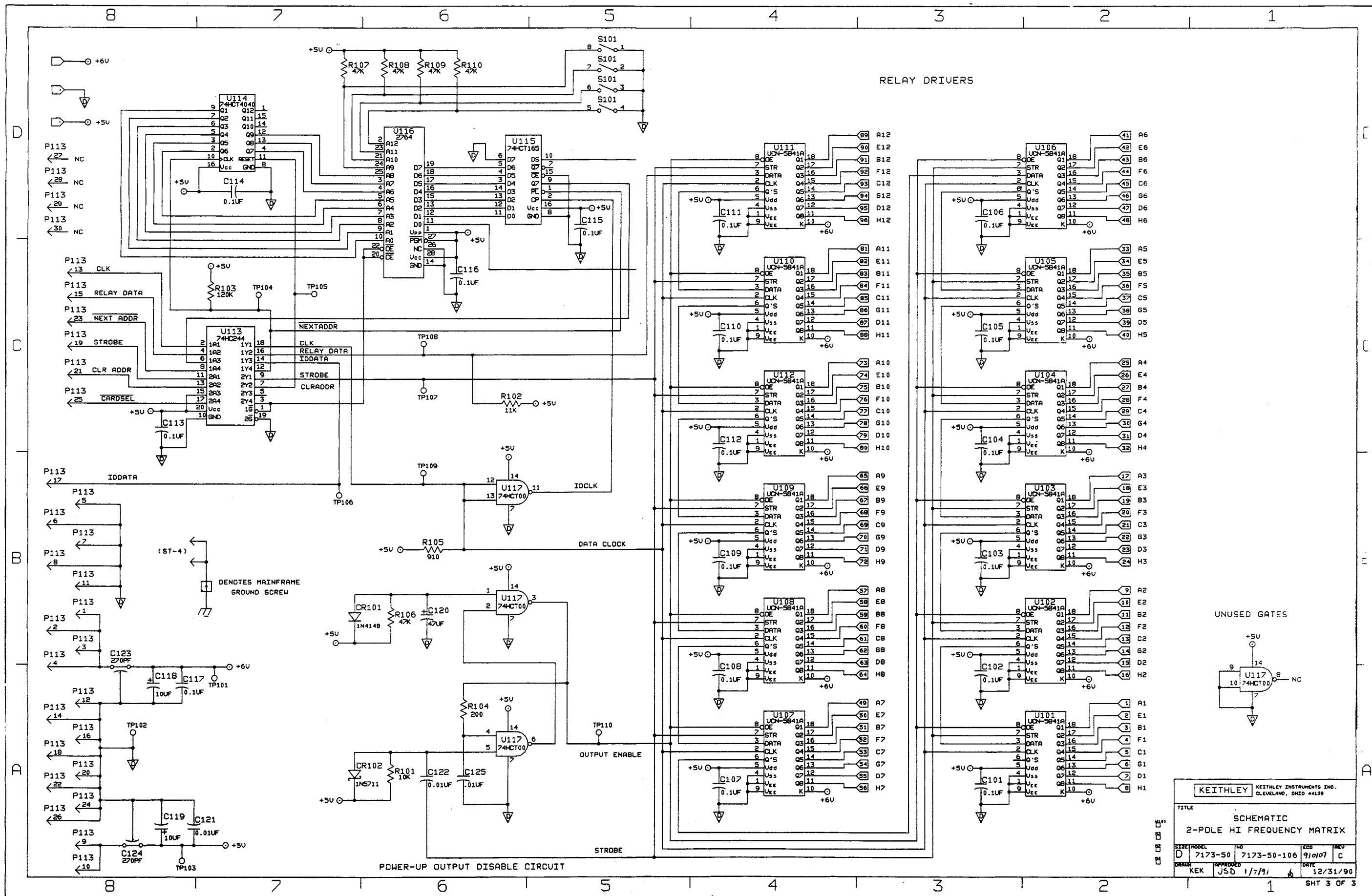


KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

TITLE SCHEMATIC  
2-POLE HI FREQUENCY MATRIX

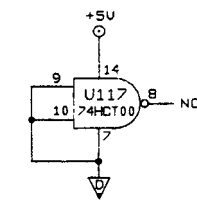
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D 7173-50	7173-50-106	9/10/67	C
DRAWN	APPROVED	DATE	
KEK	JSD	1/7/91	12/31/90

SHT 2 OF 3



KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139			
TITLE SCHEMATIC 2-POLE HI FREQUENCY MATRIX			
DATE D 7173-50	NO 7173-50-106	EDS 9/01/07	REV C
DESIGN KEK	APPROVED JSD 1/7/91	DATE 12/31/90	SHT 3 OF 3

UNUSED GATES



091-05-2212 ON

LTR.	ECO NO.	REVISION	ENG.	DATE
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1

1

2

2

3

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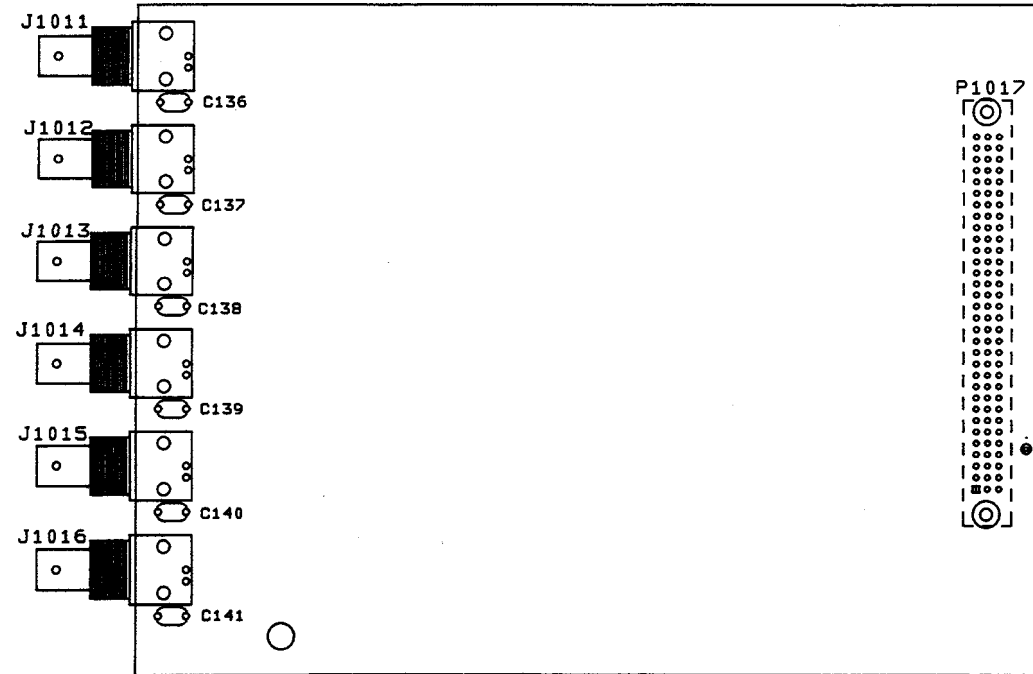
4

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6

6



MODEL	NEXT ASSEMBLY	QTY.

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 8-23-90	SCALE 1:1	TITLE COMPONENT LAYOUT
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±2° XXX=±.005 FRAC.=±1/64	DRN. CB	ENG. APPR. JSO	BNC CONNECTOR BOARD
SURFACE MAX. <input checked="" type="checkbox"/>			FINISH	NO. 7173-50-160

A B C D E F G



# APPENDIX A

## Typical Data

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### INTRODUCTION

This appendix contains typical data for insertion loss, crosstalk, VSWR, and rise time for various card configurations. Configurations for  $4 \times 36$  and  $12 \times 12$  matrix tests are shown in Figures A-1 and A-2. Plotted data for these test configurations are shown in Figures A-3 through A-13.

#### Notes on Insertion Loss, Crosstalk, and VSWR Plots

- All measurements performed using Hewlett-Packard Model 4195A Network Analyzer.
- All Model 7173-50 rows in automatic mode.

- $50\Omega$  source and  $50\Omega$  load (or  $75\Omega$  source and  $75\Omega$  load) used for VSWR and insertion loss measurements.
- Crosstalk measurements made with  $50\Omega$  source on one row and  $50\Omega$  measurement on second row, and with dummy load on column connected to source.

#### Notes on Rise Time Plots

- Measurements performed using TEK Model 7512 TDR Sampler with S-6 sampling head and S-52 pulse generator.
- $50\Omega$  source and  $50\Omega$  load used for all measurements.
- All Model 7173-50 rows in automatic mode.

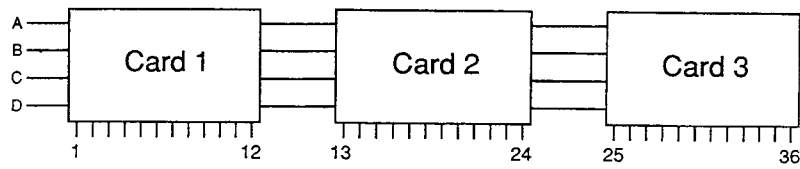


Figure A-1. 4 x 36 Test Configuration

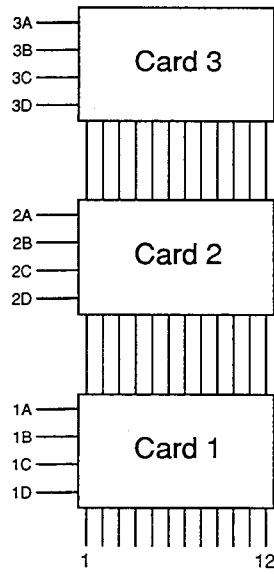
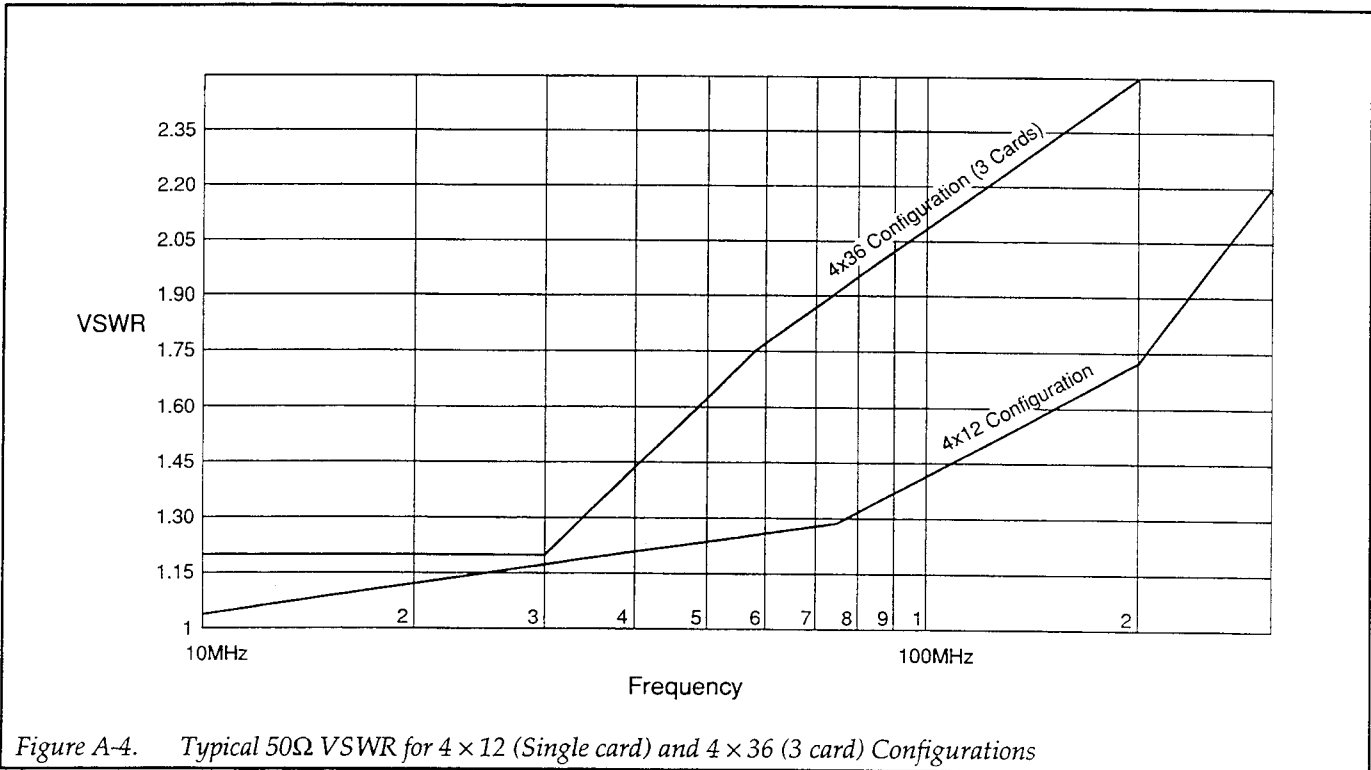
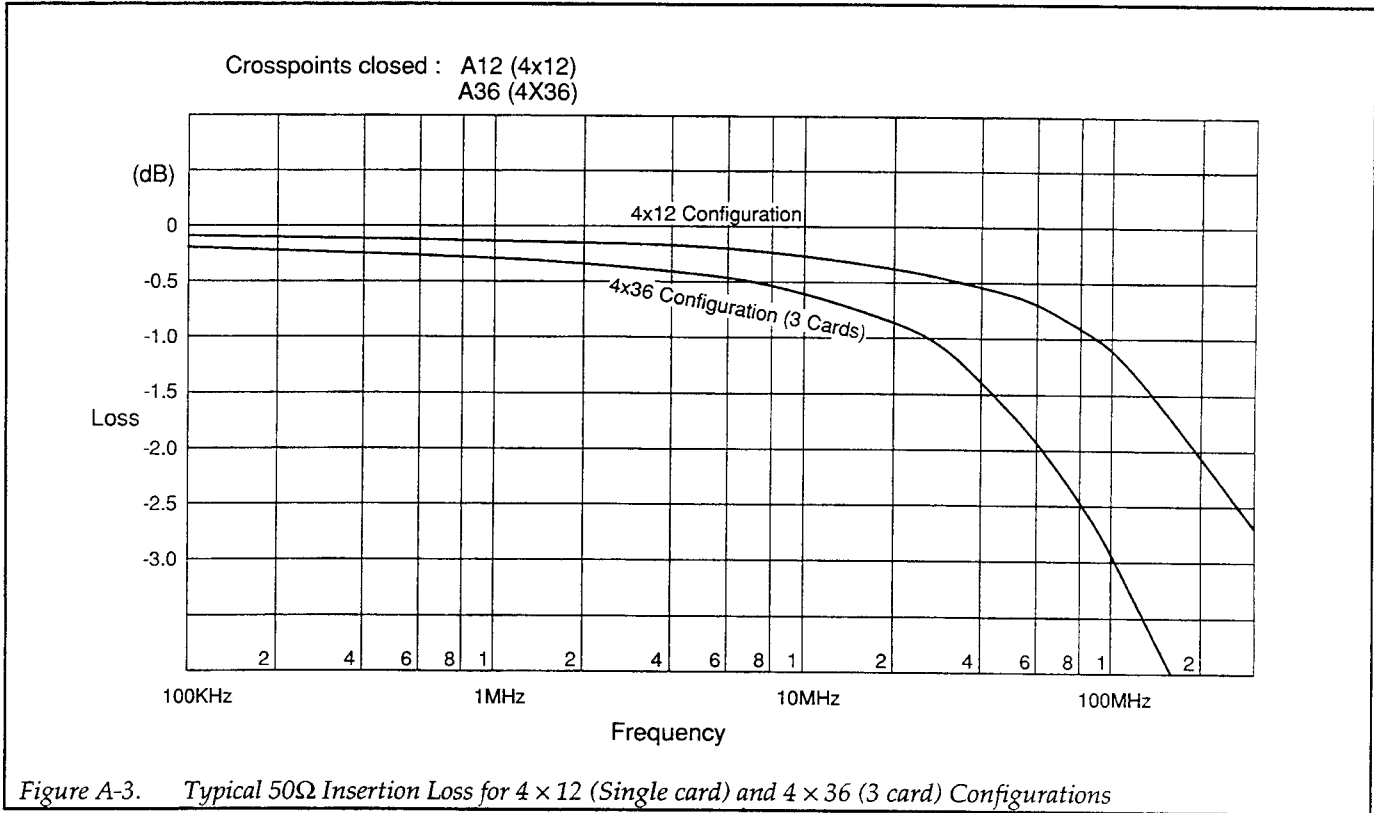


Figure A-2. 12 x 12 Test Configuration



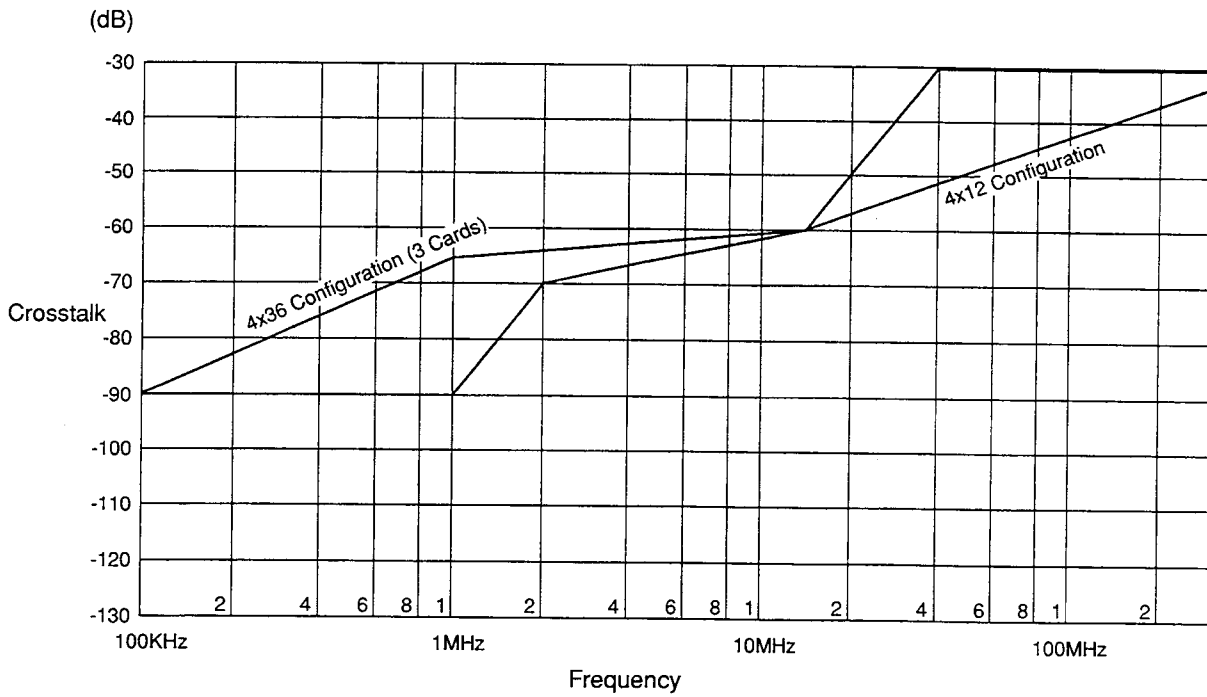


Figure A-5. Typical 50Ω Crosstalk for 4 × 12 (Single card) and 4 × 36 (3 card) Configurations

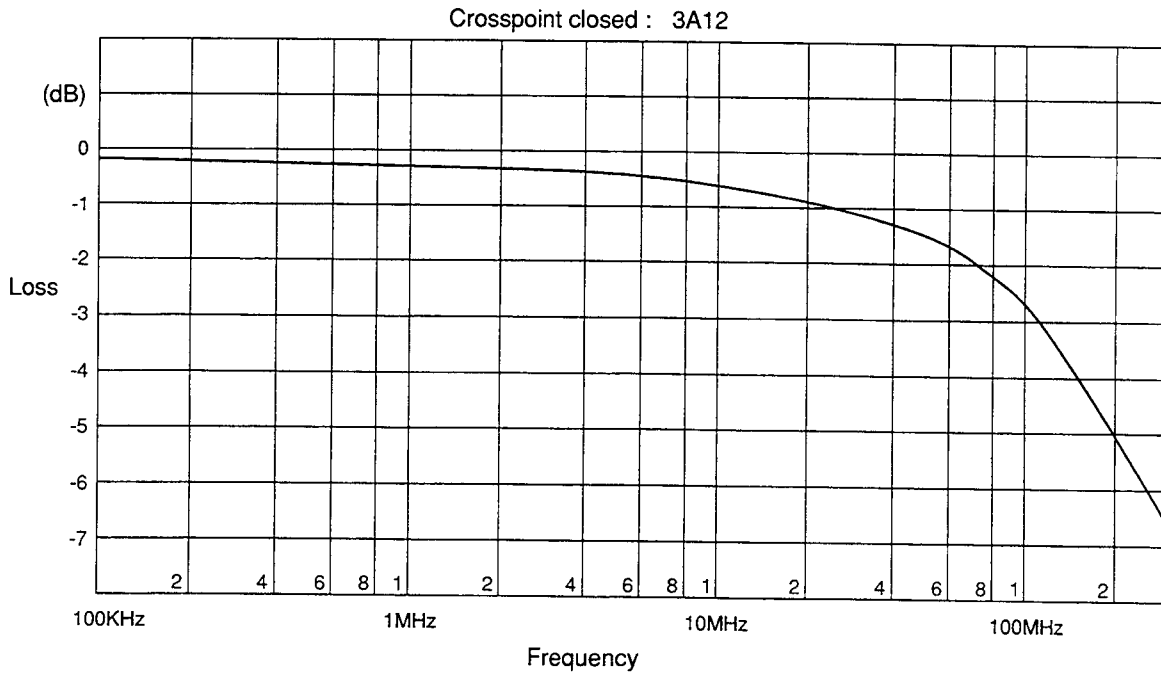


Figure A-6. Typical 50Ω Insertion Loss for 12 × 12 Matrix Configuration



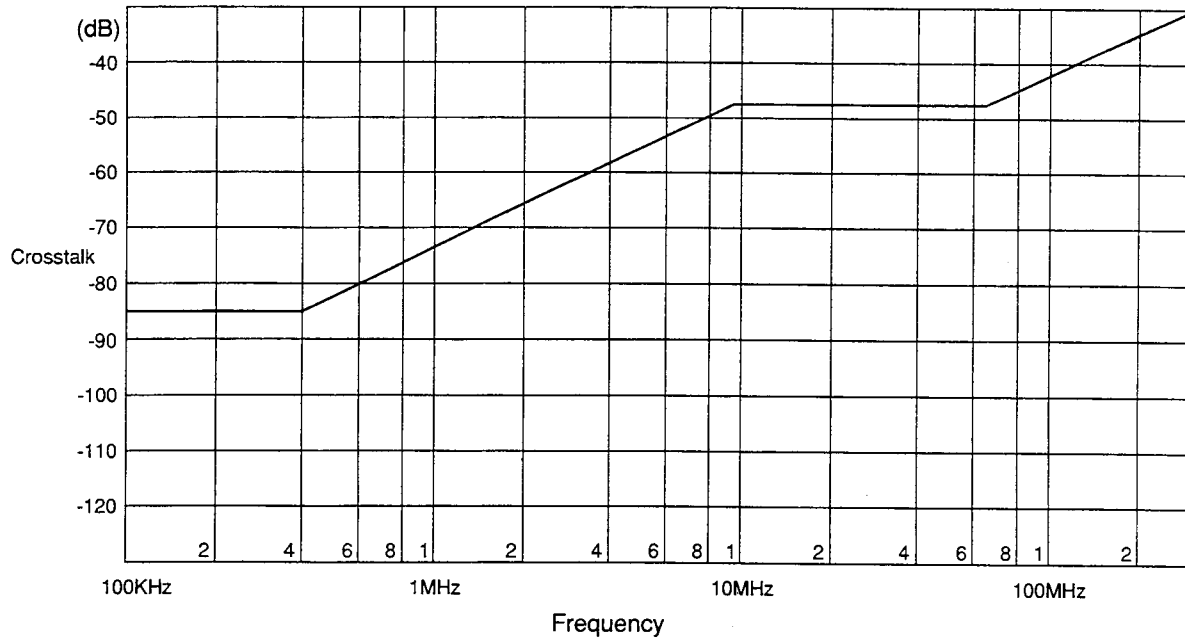


Figure A-7. Typical 50Ω Crosstalk for 12 × 12 Matrix Configurations

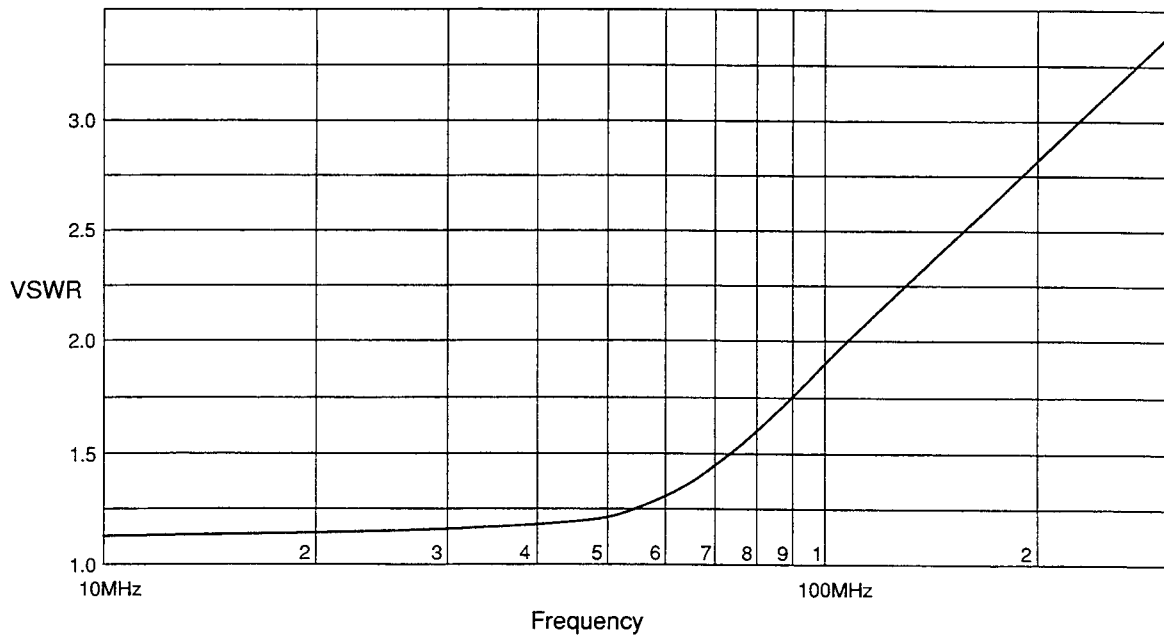
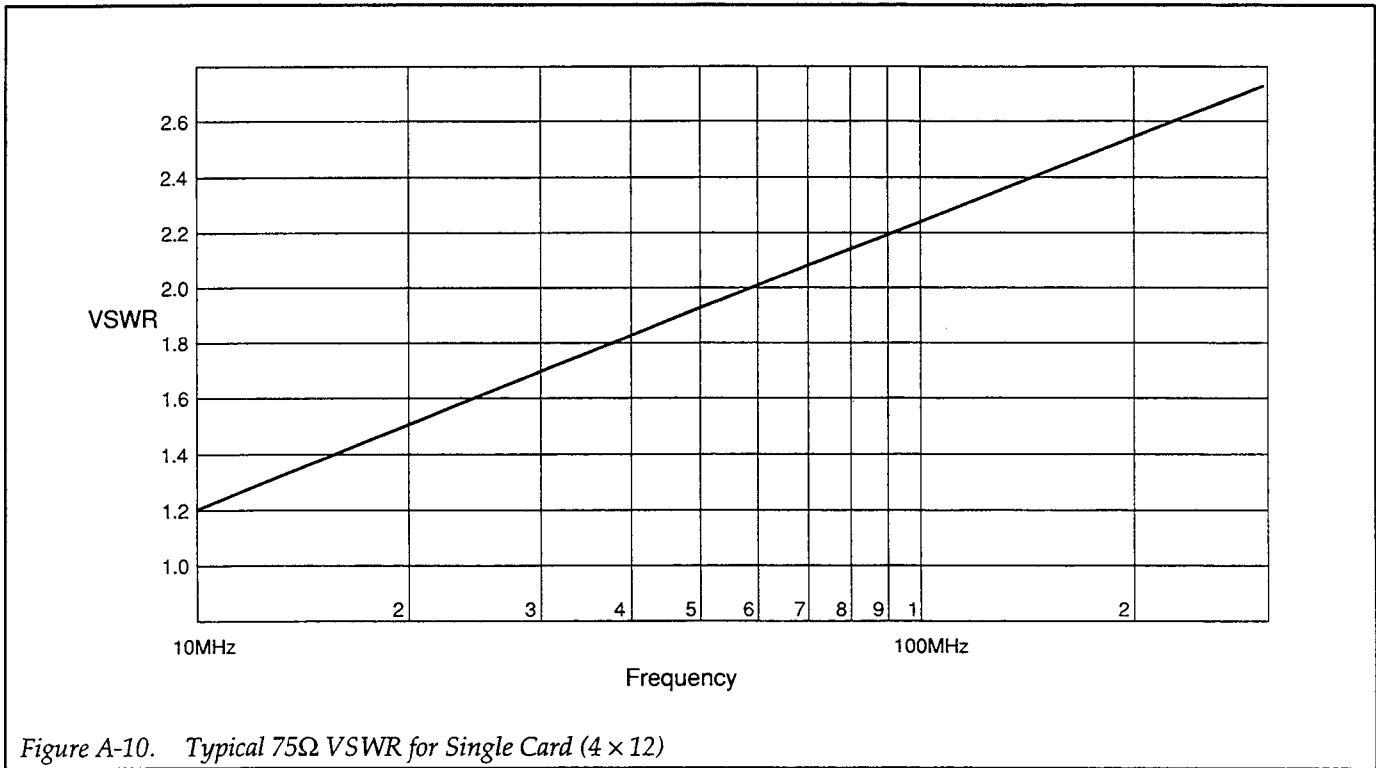
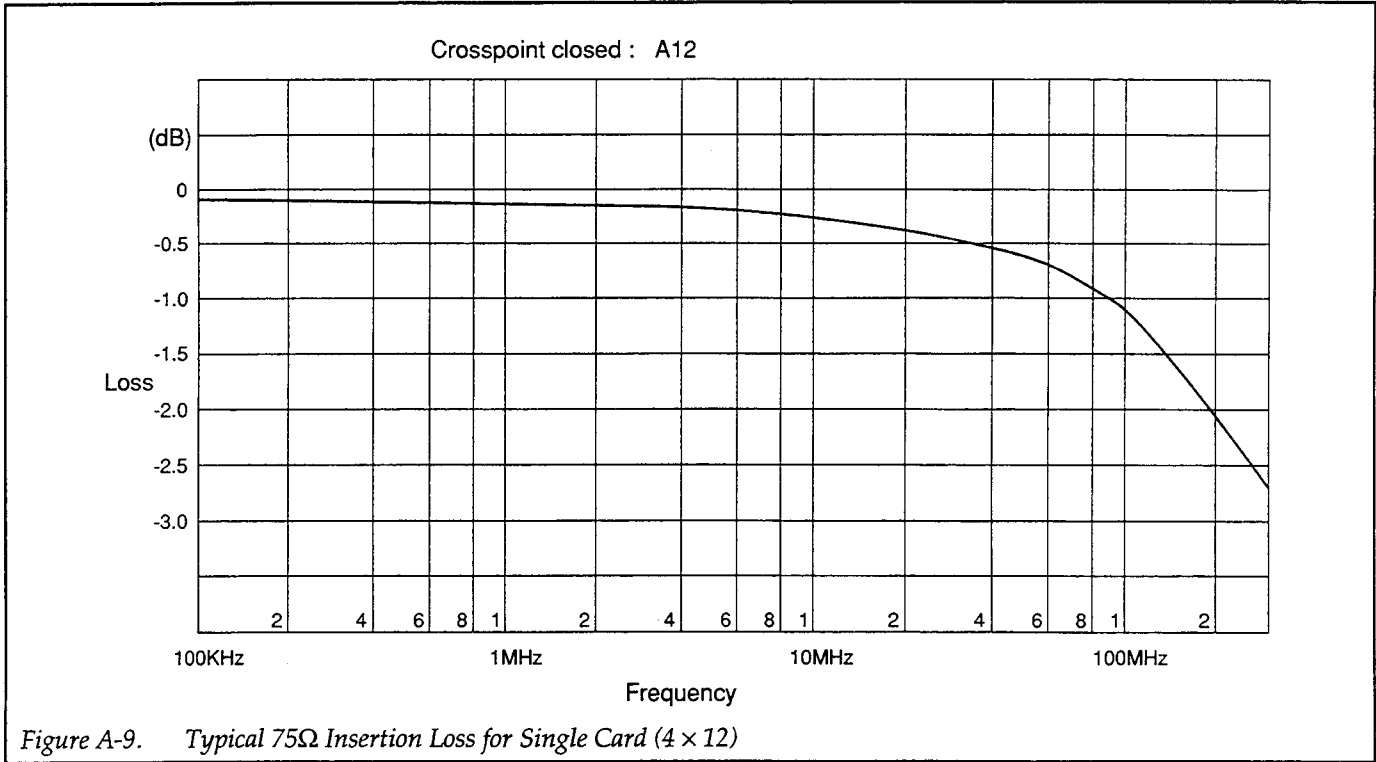


Figure A-8. Typical 50Ω VSWR for 12 × 12 Matrix Configuration



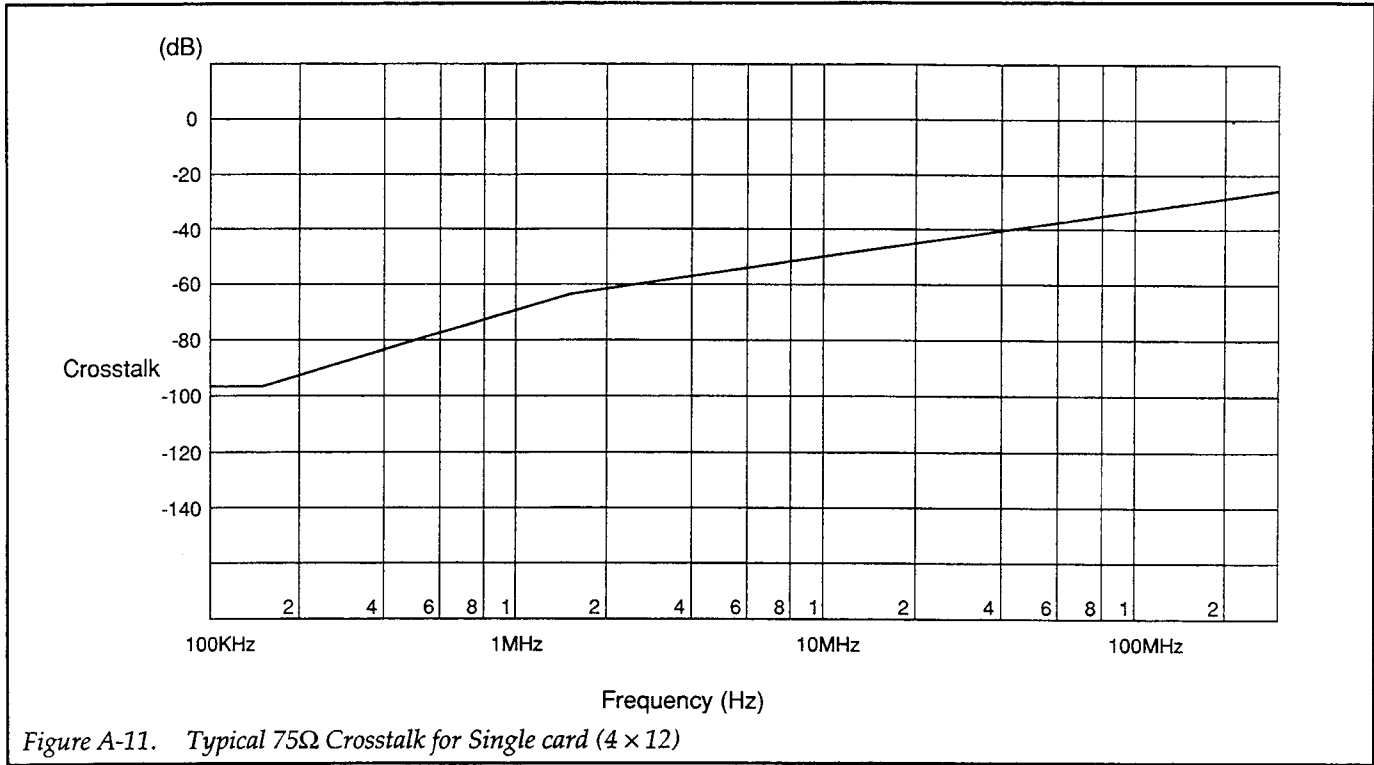


Figure A-11. Typical 75Ω Crosstalk for Single card (4 × 12)

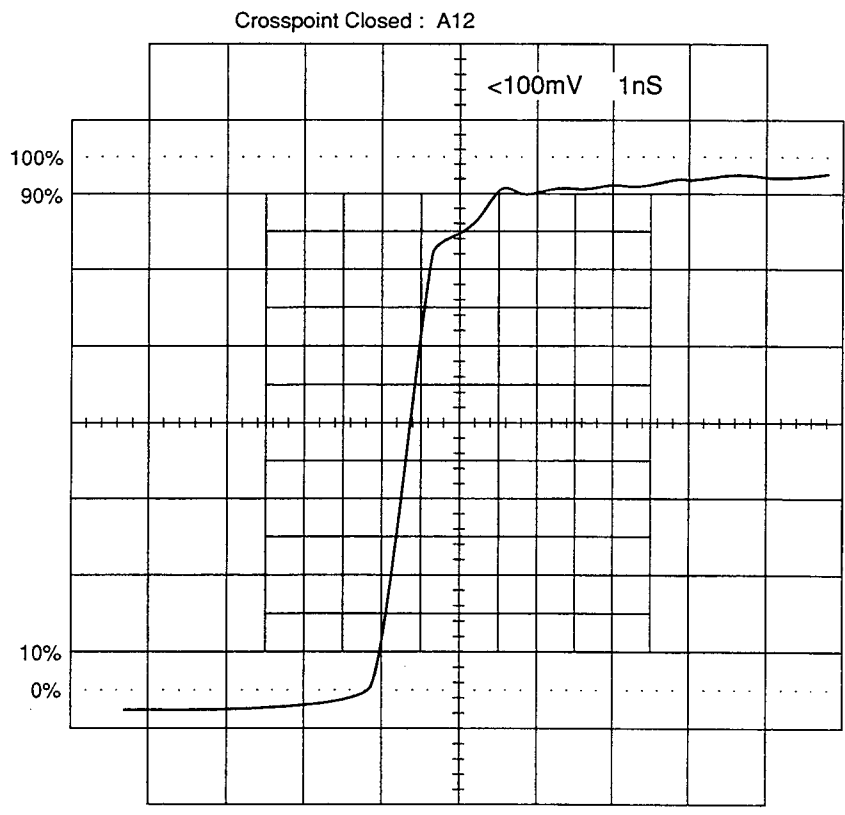


Figure A-12. Typical  $50\Omega$  Rise Time for Single Card ( $4 \times 12$ )

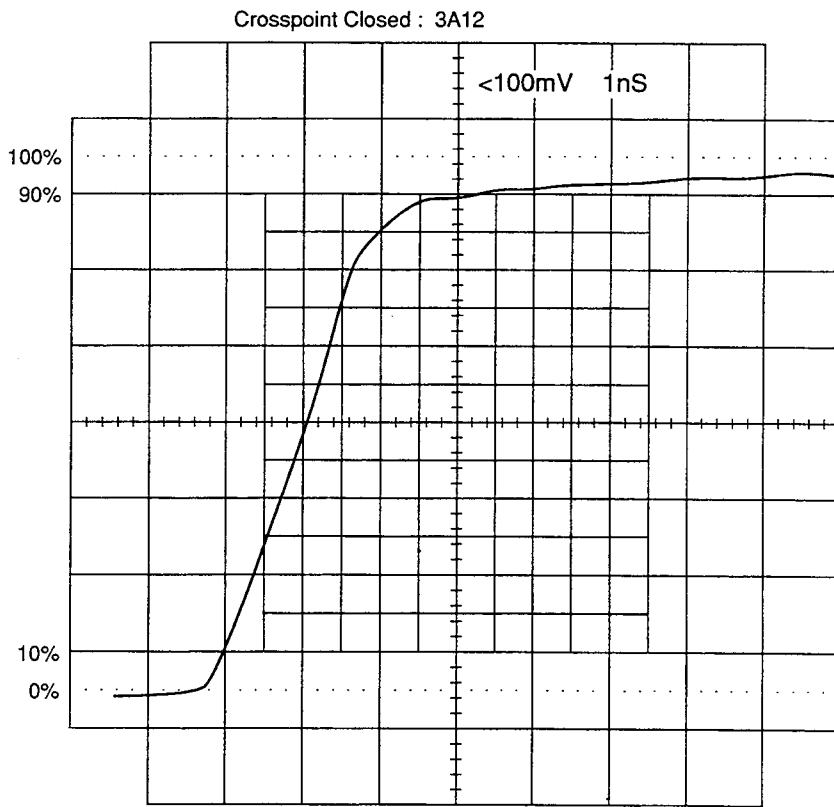


Figure A-13. Typical  $50\Omega$  Rise Time for  $12 \times 12$  Matrix

# 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. \_\_\_\_\_

- |                                                  |                                                          |                                                                          |
|--------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------|
| <input type="checkbox"/> Intermittent            | <input type="checkbox"/> Analog output follows display   | <input type="checkbox"/> Particular range or function bad; specify _____ |
| <input type="checkbox"/> IEEE failure            | <input type="checkbox"/> Obvious problem on power-up     | <input type="checkbox"/> Batteries and fuses are OK                      |
| <input type="checkbox"/> Front panel operational | <input type="checkbox"/> All ranges or functions are bad | <input type="checkbox"/> Checked all cables                              |

Display or output (check one)

- |                                           |                                                              |
|-------------------------------------------|--------------------------------------------------------------|
| <input type="checkbox"/> Drifts           | <input type="checkbox"/> Unable to zero                      |
| <input type="checkbox"/> Unstable         | <input type="checkbox"/> Will not read applied input         |
| <input type="checkbox"/> Overload         |                                                              |
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of calibration required |
| <input type="checkbox"/> 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.

Specifications are subject to change without notice.

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