

KEITHLEY

Model 7075 General Purpose Multiplexer Card

Eight 1 × 12

Instruction Manual

A GREATER MEASURE OF CONFIDENCE

WARRANTY

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

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

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

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

LIMITATION OF WARRANTY

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

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.



Keithley Instruments, Inc. • 28775 Aurora Road • Cleveland, OH 44139 • 440-248-0400 • Fax: 440-248-6168 • <http://www.keithley.com>

BELGIUM:	Keithley Instruments B.V.	Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02/363 00 40 • Fax: 02/363 00 64
CHINA:	Keithley Instruments China	Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-62022886 • Fax: 8610-62022892
FRANCE:	Keithley Instruments Sarl	3, allée des Garays • 91127 Palaiseau Cedex • 01-64 53 20 20 • Fax: 01-60 11 77 26
GERMANY:	Keithley Instruments GmbH	Landsberger Strasse 65 • 82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
GREAT BRITAIN:	Keithley Instruments Ltd	The Minster • 58 Portman Road • Reading, Berkshire RG30 1EA • 0118-9 57 56 66 • Fax: 0118-9 59 64 69
INDIA:	Keithley Instruments GmbH	Flat 2B, WILOCRISSA • 14, Rest House Crescent • Bangalore 560 001 • 91-80-509-1320/21 • Fax: 91-80-509-1322
ITALY:	Keithley Instruments s.r.l.	Viale S. Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
NETHERLANDS:	Keithley Instruments B.V.	Postbus 559 • 4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
SWITZERLAND:	Keithley Instruments SA	Kriesbachstrasse 4 • 8600 Dübendorf • 01-821 94 44 • Fax: 01-820 30 81
TAIWAN:	Keithley Instruments Taiwan	1 Fl. 85 Po Ai Street • Hsinchu, Taiwan, R.O.C. • 886-3572-9077 • Fax: 886-3572-903

Model 7075 General Purpose Multiplexer Card
Eight 1 × 12
Instruction Manual

©1990, Keithley Instruments, Inc.
All rights reserved.
Cleveland, Ohio, U.S.A.
Third Printing, March 2001
Document Number: 7075-901-01 Rev. C

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 7075-901-01).....	1990
Revision B (Document Number 7075-901-01).....	October 1992
Addendum B (Document Number 7075-901-02).....	February 1996
Revision C (Document Number 7075-901-01).....	March 2001

SAFETY PRECAUTIONS

The following safety precautions should be observed before using the Model 7075 and the associated instruments.

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

ALWAYS remove power from the entire system (Model 707, test instruments, DUT, etc.) and discharge any capacitors before doing any of the following:

1. Installing or removing the card from the mainframe.
2. Connecting or disconnecting cables from the card. The pins of cable connectors are easily accessible making them extremely hazardous to handle while power is applied.
3. Making internal changes to the card (such as removing or installing jumpers).

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

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

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

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

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

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

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

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

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

Safety Precautions

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

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

The types of product users are:

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

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

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

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

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.

7075 Eight 1×12 2-Pole Multiplexer Card

MULTIPLEX CONFIGURATION: Eight 1×12 banks. Adjacent banks can be connected together. Jumpers can be removed to isolate any bank from the backplane.

CONTACT CONFIGURATION: 2-pole Form A (HI, GUARD).

CONNECTOR TYPE: 25-pin subminiature D connector, eight for bank connection, one for row connection.

MAXIMUM SIGNAL LEVEL:

DC Signals: 110V DC pin to pin, 1A switched, 30VA (resistive load).

AC Signals: 175V AC peak pin to pin, 1A switched, 60VA (resistive load).

COMMON MODE VOLTAGE: 110V DC, 175V AC peak pin-to-pin or pin-to-chassis.

CONTACT LIFE:

Cold Switching: 10⁸ closures.

At Maximum Signal Level: 10⁵ closures.

CHANNEL RESISTANCE (per conductor): <0.50Ω initial, <1.5Ω at end of contact life.

CONTACT POTENTIAL: <5μV per contact pair (HI to GUARD).

OFFSET CURRENT: <100pA.

CROSSTALK (1MHz, 50Ω load):

Bank: <-60dB.

Channel: <-60dB.

INSERTION LOSS (1MHz, 50Ω source, 50Ω load): 0.1dB typical.

ISOLATION:

Bank: >10¹⁰Ω, <3pF

Channel: >10¹⁰Ω, <5pF

Differential:

Configured as 1×12: >10⁹Ω, <100pF nominal.

Configured as 1×96: >10⁸Ω, <600pF nominal.

Common Mode:

Configured as 1×12: >10⁹Ω, <165pF nominal.

Configured as 1×96: >10⁸Ω, <700pF nominal.

3dB BANDWIDTH (50Ω load):

Configured as 1×12: 30MHz typical.

Configured as 1×96: 2.5MHz typical.

RELAY DRIVE CURRENT (per relay): 28mA.

RELAY SETTling TIME: <3ms.

EMC: Conforms to European Union Directive 89/336/EEC.

SAFETY: Conforms to European Union Directive 73/23/EEC (meets EN61010-1/IEC 1010).

ENVIRONMENT:

Operating: 0° to 50°C, up to 35°C at 70% R.H.

Storage: -25° to 65°C.

ACCESSORY SUPPLIED: Jumpers for multiplexer expansion.

ACCESSORIES AVAILABLE:

7076-RMTC High Isolation Row Cable Assembly, 3m (10 ft)

7076-CMTC High Isolation Column/Bank Cable Assembly, 3m (10 ft)

7075-MTC* Row/Column/Bank Standard Cable Assembly, 3m (10 ft)

* Standard cable can be used for either row or column connection.

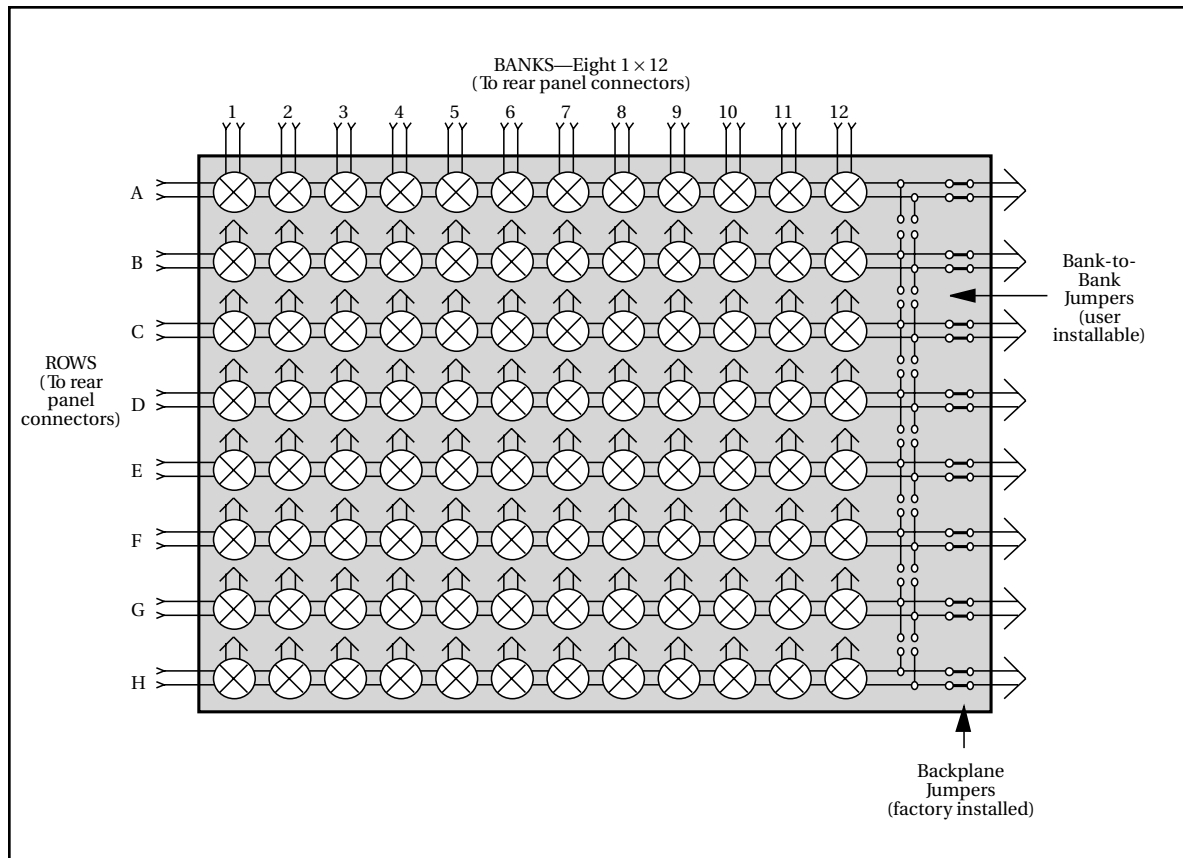


Table of Contents

SECTION 1 — General Information

1.1	INTRODUCTION	1-1
1.2	FEATURES	1-1
1.3	WARRANTY INFORMATION	1-1
1.4	MANUAL ADDENDA	1-1
1.5	SAFETY SYMBOLS AND TERMS	1-1
1.6	SPECIFICATIONS	1-2
1.7	UNPACKING AND INSPECTION	1-2
1.7.1	Inspection for Damage	1-2
1.7.2	Shipment Contents	1-2
1.7.3	Instruction Manual	1-2
1.8	REPACKING FOR SHIPMENT	1-2
1.9	OPTIONAL ACCESSORIES	1-2

SECTION 2 — Operation

2.1	INTRODUCTION	2-1
2.2	HANDLING PRECAUTIONS	2-1
2.3	ENVIRONMENTAL CONSIDERATIONS	2-1
2.4	MULTIPLEXER CARD CONFIGURATION	2-1
2.4.1	Rear Panel	2-1
2.4.2	1 × 12 Multiplexer Banks	2-2
2.4.3	Multiplexer Bank Jumpers	2-2
2.4.4	Backplane Connection Jumpers	2-7
2.4.5	Switching Configurations	2-7
2.5	CARD INSTALLATION AND REMOVAL	2-11
2.6	CONNECTIONS	2-12
2.6.1	Standard Cable (Model 7075-MTC)	2-15
2.6.2	High Isolation Cables (Model 7076-RMTC and Model 7075-CMTC)	2-16
2.7	TYPICAL CONNECTION SCHEMES	2-19
2.7.1	Single Mainframe, Single Multiplexer Card System	2-19
2.7.2	Expanding the Multiplexer Using Multiple Cards	2-19
2.7.3	Using the Multiplexer with Matrix Cards	2-19
2.8	MULTIPLEXER PROGRAMMING	2-25
2.8.1	Banks and Rows	2-25
2.8.2	Front Panel Multiplexer Programming Procedure	2-25
2.8.3	IEEE-488 Bus Programming	2-25
2.9	MEASUREMENT CONSIDERATIONS	2-26
2.9.1	Path Isolation	2-26
2.9.2	Magnetic Fields	2-26
2.9.3	Electromagnetic Interference (EMI)	2-27
2.9.4	Ground Loops	2-27
2.9.5	Keeping Connectors Clean	2-28

2.9.6	Shielding	2-28
2.9.7	Guarding	2-28
2.9.8	Multiple Card Considerations	2-29
2.9.9	Bandwidth and Crosstalk	2-29

SECTION 3 — Applications

3.1	INTRODUCTION	3-1
3.2	RESISTOR TESTING	3-1
3.2.1	2-Wire Resistance Tests	3-1
3.2.2	4-Wire Resistance Tests	3-2
3.2.3	Low-Level Resistance Measurements	3-2
3.2.4	Example Resistor Test Program	3-3
3.3	TRANSISTOR TESTING	3-4
3.3.1	Current Gain Tests	3-4
3.3.2	Common-Emitter Characteristics Tests	3-4
3.3.3	Example Transistor Test Program	3-4
3.4	TESTING WITH MATRIX CARDS	3-7
3.4.1	Multiplexer and Matrix Card Connections	3-7
3.4.2	Resistivity Tests	3-7
3.4.3	Example Resistivity Test Program	3-10

SECTION 4 — Service Information

4.1	INTRODUCTION	4-1
4.2	HANDLING AND CLEANING PRECAUTIONS	4-1
4.3	RELAY TEST PROGRAM SETUP	4-1
4.3.1	Recommended Equipment	4-2
4.3.2	Connections	4-2
4.3.3	Running the Test	4-2
4.4	PERFORMANCE VERIFICATION	4-2
4.4.1	Environmental Conditions	4-2
4.4.2	Recommended Test Equipment	4-2
4.4.3	Performance Record	4-5
4.4.4	Initial Preparation	4-5
4.4.5	Path Resistance Tests	4-6
4.4.6	Offset Current Tests	4-8
4.4.7	Contact Potential Tests	4-9
4.4.8	Bank and Path Isolation Tests	4-10
4.4.9	Differential and Common Mode Isolation Tests	4-13
4.5	SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES	4-15
4.6	TROUBLESHOOTING	4-15
4.6.1	Recommended Equipment	4-15
4.6.2	Using the Extender Card	4-15
4.6.3	Input/Output Connections	4-15
4.6.4	Troubleshooting Procedure	4-16
4.6.5	Relay Replacement Precautions	4-17

4.7	PRINCIPLES OF OPERATION	4-17
4.7.1	Block Diagram	4-17
4.7.2	ID Data Circuits	4-18
4.7.3	Relay Control	4-18
4.7.4	Power-on Safeguard	4-18

SECTION 5 — Replaceable Parts

5.1	INTRODUCTION	5-1
5.2	PARTS LISTS	5-1
5.3	ORDERING INFORMATION	5-1
5.4	FACTORY SERVICE	5-1
5.5	COMPONENT LAYOUT AND SCHEMATIC DIAGRAM	5-1

List of Illustrations

SECTION 2 — Operation

Figure 2-1	Model 7075 Rear Panel	2-2
Figure 2-2	Model 7075 Multiplexer Organization	2-3
Figure 2-3	Model 7075 Jumper Locations	2-4
Figure 2-4	Eight 1 × 12 Multiplexer Configured (No Jumpers Installed)	2-5
Figure 2-5	Four 1 × 24 Multiplexer Configuration	2-5
Figure 2-6	Two 1 × 48 Multiplexer Configuration	2-6
Figure 2-7	One 1 × 96 Multiplexer Configuration	2-6
Figure 2-8	Model 7074 Multiplexers Connected to Model 7071 Rows using Backplane Jumpers	2-7
Figure 2-9	Guarded Switching (Using high isolation cables)	2-8
Figure 2-10	Unguarded Switching (Using high isolation cables)	2-9
Figure 2-11	4-Wire DMM Switching (Using high isolation cables)	2-9
Figure 2-12	SMU Connections	2-10
Figure 2-13	Model 7075 Installation	2-11
Figure 2-14	D-sub Receptacle Contact Assignments	2-13
Figure 2-15	Model 7075-MTC Standard Cable	2-15
Figure 2-16	D-Sub Plug Pin Assignments for High Isolation Cables	2-17
Figure 2-17	Single Card System Example	2-20
Figure 2-18	Multiple Card System Example	2-21
Figure 2-19	Using the Multiplexer with a Model 7076 Matrix Card	2-22
Figure 2-20	Using the Multiplexer with a Model 7071 Matrix Card	2-23
Figure 2-21	Using the Multiplexer with a Model 7071-4	2-24
Figure 2-22	Path Isolation Resistance	2-26
Figure 2-23	Path Isolation Resistance	2-26
Figure 2-24	Power Line Ground Loops	2-27
Figure 2-25	Power Line Ground Loops	2-28
Figure 2-26	Guarded Circuit	2-29
Figure 2-27	-3dB Bandwidth (1 × 96 configuration, Relay H12 closed, $R_S = 50\Omega$, $R_L = 50\Omega$)	2-30
Figure 2-28	3dB Bandwidth (1 × 96 configuration, Relay H12 closed, $R_S = 50\Omega$, $R_L = 1M\Omega$)	2-31
Figure 2-29	Crosstalk (1 × 96 configuration, $R_S = 50\Omega$ on Row A, $R_L = 50\Omega$ on Input 12 (Bank A), Relay A11 closed)	2-32
Figure 2-30	Crosstalk (1 × 96 configuration, $R_S = 50\Omega$ on Row A, $R_L = 1M\Omega$ on Input 12 (Bank A), relay A11 closed)	2-33
Figure 2-31	-3dB Bandwidth (1 × 12 configuration, Relay H1 closed, $R_S = 50\Omega$, $R_L = 50\Omega$)	2-34
Figure 2-32	3dB Bandwidth (1 × 12 configuration, Relay H1 closed, $R_S = 50\Omega$, $R_L = 1M\Omega$)	2-35
Figure 2-33	Crosstalk (1 × 12 configuration, $R_S = 50\Omega$ on Row A, $R_L = 50\Omega$ on Input 12 (Bank A), Relay A11 closed)	2-36
Figure 2-34	Crosstalk (1 × 12 configuration, $R_S = 50\Omega$ on Row A, $R_L = 1M\Omega$ on Input 12 (Bank A), Relay A11 closed)	2-37

SECTION 3 — Applications

Figure 3-1	2-Wire Resistance Testing	3-1
Figure 3-2	4-Wire Resistance Testing	3-2

Figure 3-3	Low Resistance Testing	3-3
Figure 3-4	Configuration for Current Gain and Common Emitter Test	3-5
Figure 3-5	Typical Common-Emitter Characteristics	3-6
Figure 3-6	Connecting Multiplexer and Matrix Cards Together	3-7
Figure 3-7	Resistivity Test Configurations	3-8
Figure 3-8	Measurement Required for Resistivity Test	3-9

SECTION 4 — Service Information

Figure 4-1	D-sub Plug Pin Assignments for High Isolation Cables	4-3
Figure 4-2	Connecting the Test Cable to the Model 7075	4-4
Figure 4-3	Test Cable Preparation	4-6
Figure 4-4	Connections for Path Resistance Test	4-7
Figure 4-5	Differential Offset Current Test Connections	4-8
Figure 4-6	Common Mode Offset Current Test Connections	4-9
Figure 4-7	Contact Potential Test Connections	4-10
Figure 4-8	Bank isolation Test Connections	4-11
Figure 4-9	Path isolation Test Connections	4-12
Figure 4-10	Differential Isolation test Connections	4-14
Figure 4-11	Connections for Common Mode Isolation Test	4-14
Figure 4-12	ID Data Timing	4-16
Figure 4-13	Model 7075 Block Diagram	4-17

List of Tables

SECTION 2 — Operation

Table 2-1	Available Cables and Connectors	2-14
Table 2-2	Cable Conductor Identification (Model 7075-MTC)	2-16
Table 2-3	Model 7076-RMTC Conductor Identification	2-18
Table 2-4	Model 7076-CMTC Conductor Identification	2-18

SECTION 4 — Service Information

Table 4-1	Recommended Verification Equipment	4-4
Table 4-2	Performance Record	4-5
Table 4-3	Bank Isolation Test Summary	4-12
Table 4-4	Path Isolation Test Summary*	4-13
Table 4-5	Differential and Common Mode Isolation Test Summary	4-15
Table 4-6	Recommended Troubleshooting Equipment	4-15
Table 4-7	Troubleshooting Procedure	4-16

SECTION 1

General Information

1.1 INTRODUCTION

This section contains general information about the Model 7075.

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 7075 General Purpose Multiplexer Card consists of eight banks of 1 × 12 multiplexers that can be configured in various combinations. Two-pole switching (HI and guard) is provided for any of the 96 inputs.

Key features of the Model 7075 include:

- Easy jumper configuration of single, dual, quad, or octal multiplexer banks.
- Each of the eight multiplexer banks can be connected to the 3-pole general-purpose backplane pathways with user-installed jumpers, allowing simple internal connections to the rows of those matrix cards.
- Nine 25-pin D-sub receptacles located on the rear panel for quick-disconnect input and output connections.

1.3 WARRANTY INFORMATION


Warranty information is located on the inside front cover of this instruction manual. Should your Model 7075 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.


1.4 MANUAL ADDENDA

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

1.5 SAFETY SYMBOLS AND TERMS

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

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

The  symbol on an instrument shows that 1kV or greater may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

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

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

1.6 SPECIFICATIONS

Model 7075 specifications may be found at the front of this manual. Note that some specifications, such as contact life, path resistance, and contact potential, differ between the two versions of the card. These specifications are exclusive of the matrix mainframe specifications, which are located in the Model 707 Instruction Manual.

1.7 UNPACKING AND INSPECTION

1.7.1 Inspection for Damage

Upon receiving the Model 7075, carefully unpack it from its shipping carton and inspect the card for any obvious signs of physical damage. Report any such damage to the shipping agent immediately. Save the original packing carton for possible future reshipment.

1.7.2 Shipment Contents

The following items are included with every Model 7075 order:

- Model 7075 Multiplexer Card
- Model 7075 Instruction Manual
- 14 spare configuration jumpers
- Additional accessories as ordered

1.7.3 Instruction Manual

The Model 7075 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 multiplexer card instruction manual.

If an additional instruction manual is required, order the manual package, Keithley part number 7075-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 REPACKING FOR SHIPMENT

Should it become necessary to return the Model 7075 for repair, carefully pack the unit in its original packing car-

ton or the equivalent, and include the following information:

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

1.9 OPTIONAL ACCESSORIES

The following paragraphs describe optional cables that are available for use with the Model 7075.

Model 7075-MTC Standard Row/Column/Bank Cable Assembly

The Model 7075-MTC is a three-meter (10-feet), 24 conductor cable terminated with a 25-pin D-sub connector on both ends. This cable connects to either the ROW or BANK receptacles on the rear panel of the card. This cable assembly is constructed using a general purpose flat cable that is fitted into a round jacket.

This cable is commonly cut at a convenient length to provide two separate cables. The cables can then be used to connect to both the ROW and BANK receptacles. The unterminated ends of the cables can then be connected to instrumentation and DUTs.

Model 7076-RMTC High Isolation Row Cable Assembly

The Model 7076-RMTC is a three-meter (10-feet), 28-conductor cable terminated with a 25-pin D-sub connectors on both ends and is configured to mate to the ROW receptacle of the Model 7075. Each conductor pair (signal and drain) of the shielded cable is wrapped with insulated foil to minimize crosstalk between conductor pairs.

This cable can be cut at a convenient length to provide two separate cables. The two cables can then be used to connect to the ROW receptacles of two multiplexer cards. The unterminated ends of the cables can then be connected to instrumentation and DUT.

Model 7076-CMTC High Isolation Column/Bank Cable Assembly

The Model 7076-CMTC is a 3-meter (10 feet), 28-conductor cable terminated with a 25-pin D-sub connector on

both ends. This cable connects to any of the BANK receptacles on the Model 7075. Each conductor pair (signal and drain) of the shielded cable is wrapped with insulated foil to minimize crosstalk between conductor pairs.

This cable is commonly cut at a convenient length to pro-

vide two separate cables. The cables can then be used to connect to two BANK receptacles. The unterminated ends of the cables can then be connected to instrumentation and DUTs.

SECTION 2

Operation

2.1 INTRODUCTION

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

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

2.3 Environmental Considerations: Outlines environmental aspects of using the Model 7075.

2.4 Multiplexer Card Configuration: Discusses the multiplexer rear panel as well as multiplexer configuration and expansion by jumpering two or more multiplexer sections together.

2.5 Card Installation and Removal: Details installation in and removal from the Model 707 Switching Matrix mainframe.

2.6 Connection Methods: Discusses card receptacles, cables, and the basic methods to connect the card to other instruments and DUT.

2.7 Typical Connection Schemes: Gives typical connections to other cards, mainframes, and test instrumentation.

2.8 Multiplexer Programming: Summarizes programming steps to control the multiplexer card from the Model 707 Switching Matrix.

2.9 Measurement Considerations: Reviews a number of considerations when making measurements using the Model 7075.

WARNING

The information in this section is intended for qualified personnel who have experience with potentially hazardous voltages. Do not attempt to perform these procedures unless you are qualified to do so. Carefully read the safety precautions located at the front of this manual before using the multiplexer card.

2.2 HANDLING PRECAUTIONS

To maintain high impedance isolation, care should be taken when handling the multiplexer 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, components, or edge connectors.

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 4. Also, the performance verification procedures in Section 4 can be used to test the card for low leakage resistances that could indicate contamination.

2.3 ENVIRONMENTAL CONSIDERATIONS

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

2.4 MULTIPLEXER CARD CONFIGURATION

The following paragraphs discuss the rear panel of the card, the eight 1×12 multiplexers of the Model 7075, as well as how to connect two or more multiplexer banks together to make multiplexers as large as 1×96 .

2.4.1 Rear Panel

The rear panel of the Model 7075 is shown in Figure 2-1. The rear panel has a total of nine receptacles for input/output connections. The eight BANK connectors would normally be used for multiplexer inputs and are labeled with multiplexer bank letters (BANKs A through H). The eight multiplexer bank outputs are located on the ROW A-H receptacle. Detailed connection information can be found in paragraphs 2.6 and 2.7.

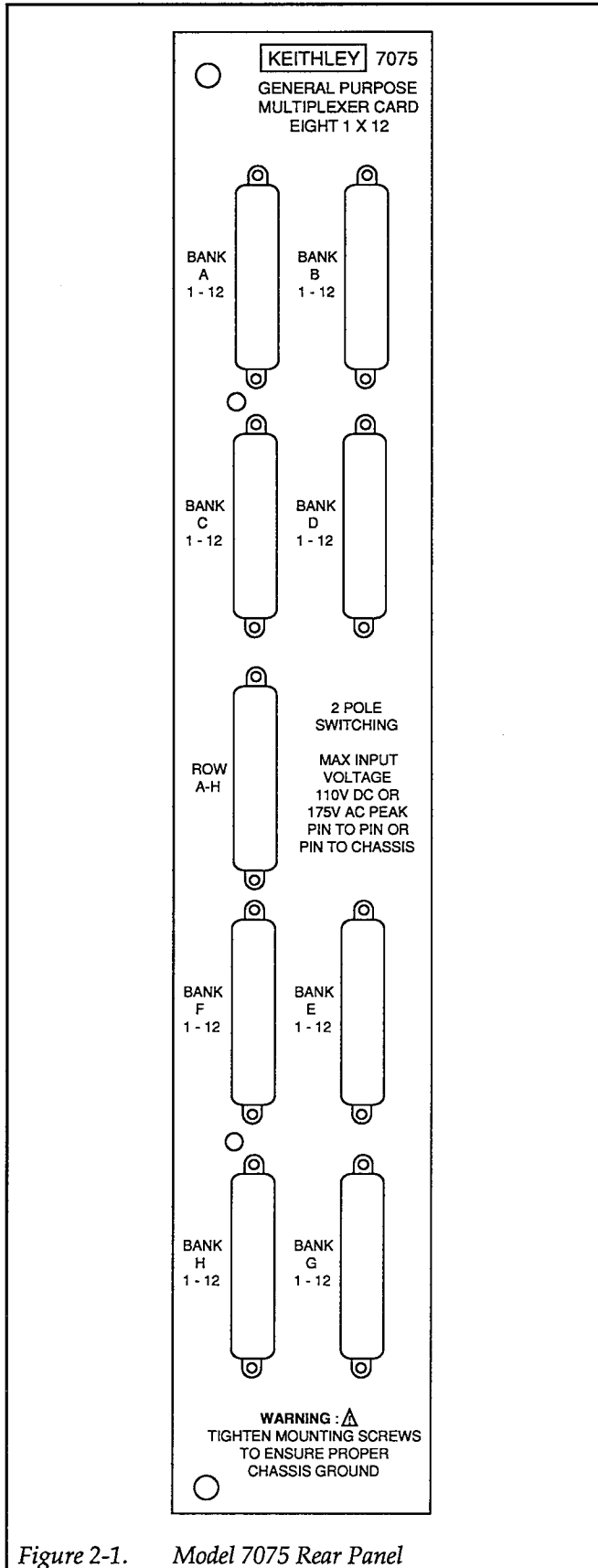


Figure 2-1. Model 7075 Rear Panel

2.4.2 1 × 12 Multiplexer Banks

As shown in Figure 2-2, the Model 7075 is organized as eight 1 × 12 multiplexer banks. These multiplexer banks are labeled rows A through H in order to conform to Model 707 Switching Matrix commands.

The inputs for each row are labeled 1 through 12 inclusive, and these numbers correspond to mainframe columns. Note that 2-pole switching is provided for each multiplexer input, with HI and guard switched. Two or more banks can be jumpered together to expand multiplexer inputs, as discussed below.

2.4.3 Multiplexer Bank Jumpers

Jumpers can be installed on the card in order to connect multiplexer banks together to form multiplexers as large as 1 × 96. To connect adjacent multiplexer banks, simply install the jumpers between the adjacent bank jumper pins, which are shown in Figure 2-3. These jumpers are included with the Model 7075, but they are not installed at the factory. Note that you should install the jumpers for both signal paths (HI and guard).

By installing the jumpers in the appropriate places, you can configure the multiplexer card in a variety of ways. Typical examples include:

- Eight 1 × 12 multiplexers: no jumpers installed (Figure 2-4).
- Four 1 × 24 multiplexers: jumper A to B, C to D, E to F, G to H (Figure 2-5).
- Two 1 × 48 multiplexers: jumper all except D to E (Figure 2-6).
- One 1 × 96 multiplexer: install all bank jumpers (Figure 2-7).

Many other combinations are possible, including multiplexers of various sizes (in multiples of 12 channels) by installing jumpers as required. For example, you could install jumpers to configure the card as two 1 × 24 multiplexers and one 1 × 48 multiplexer.

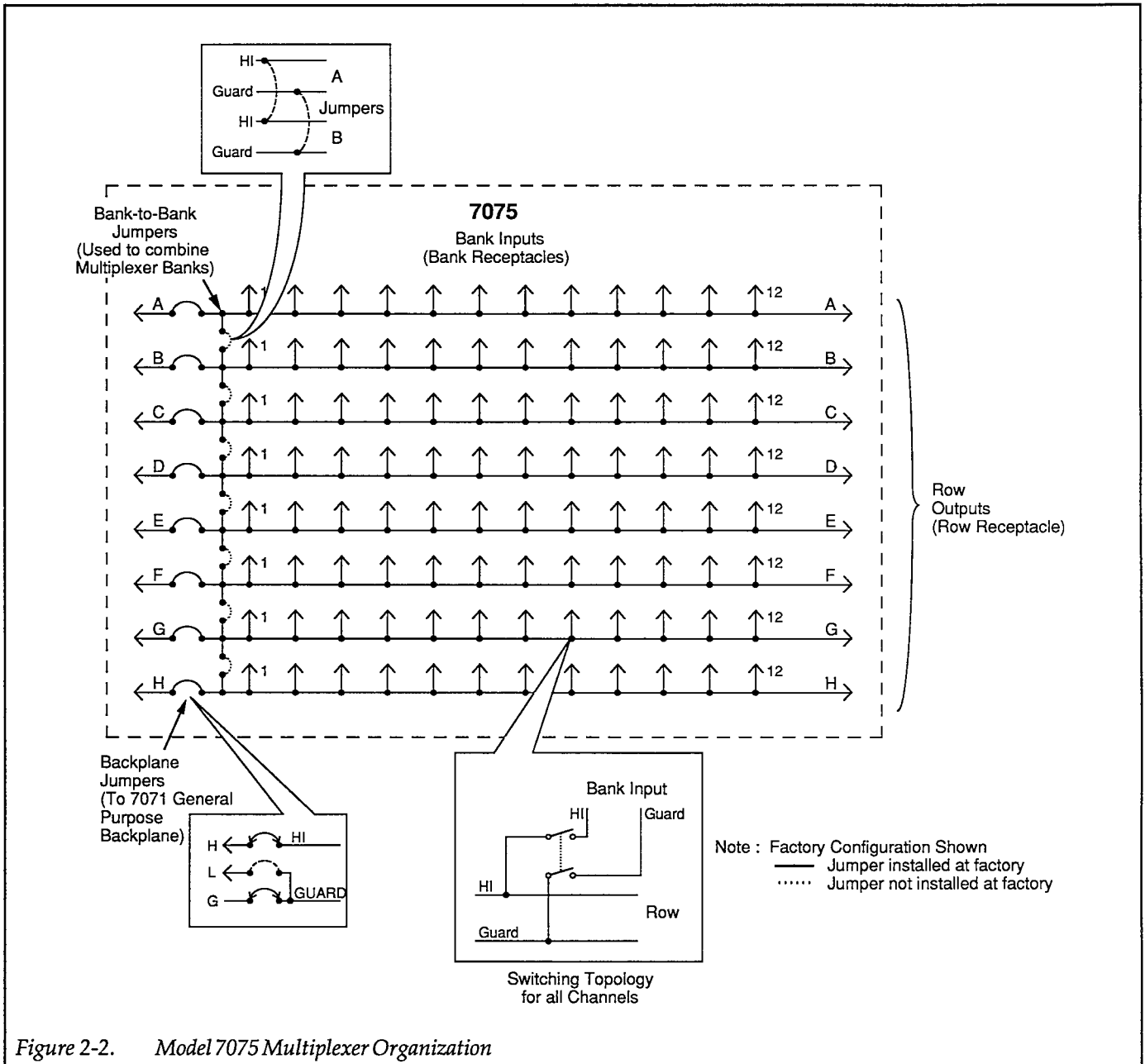


Figure 2-2. Model 7075 Multiplexer Organization

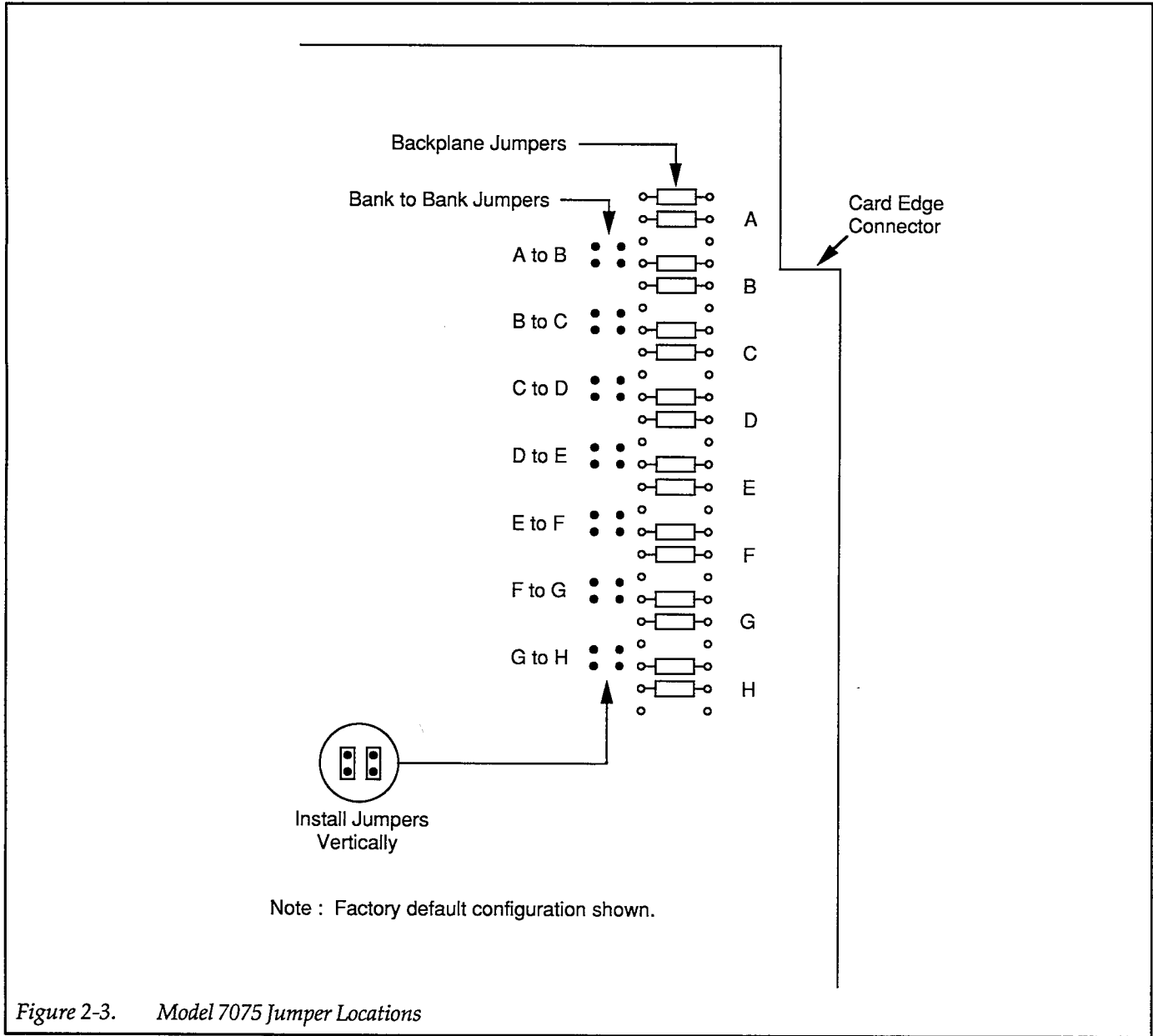
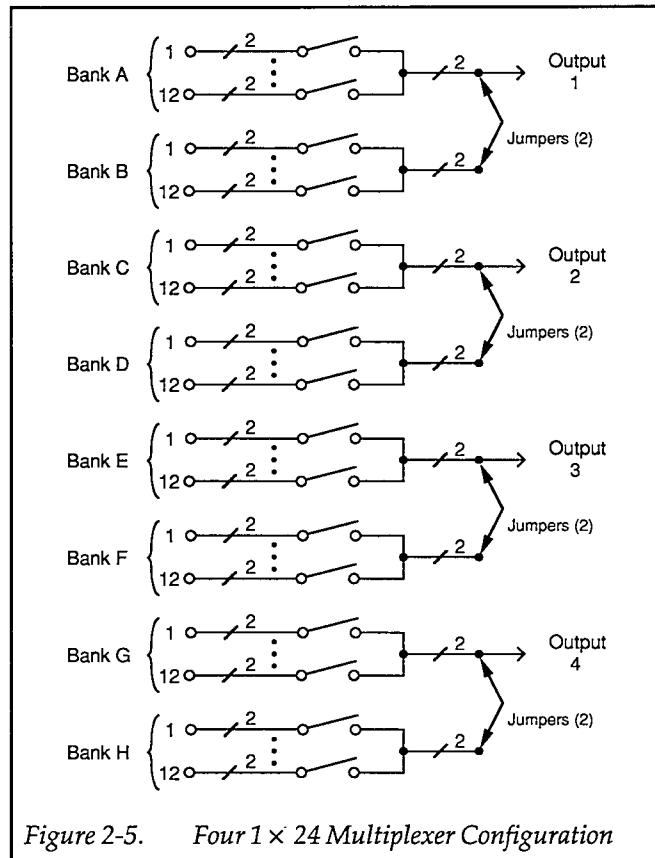
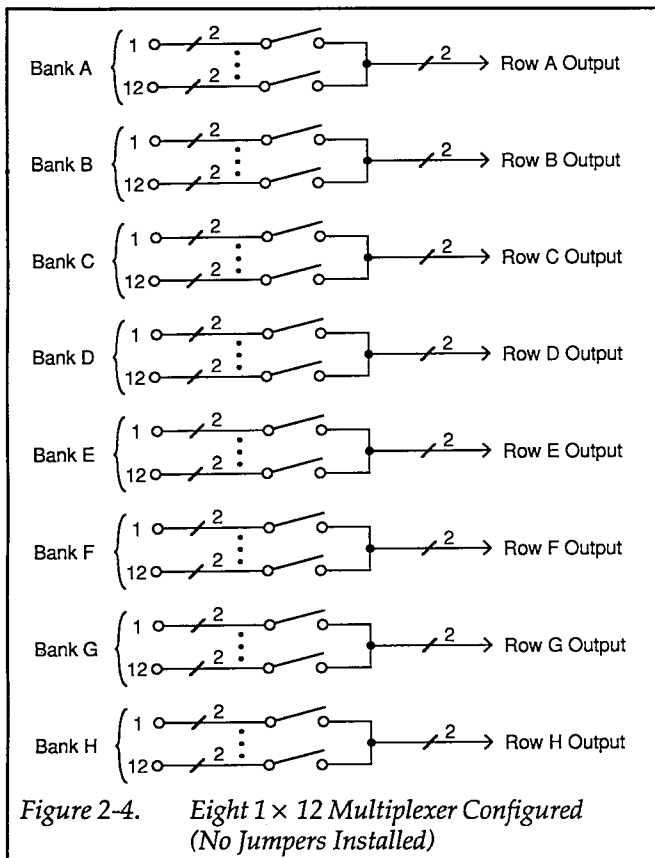
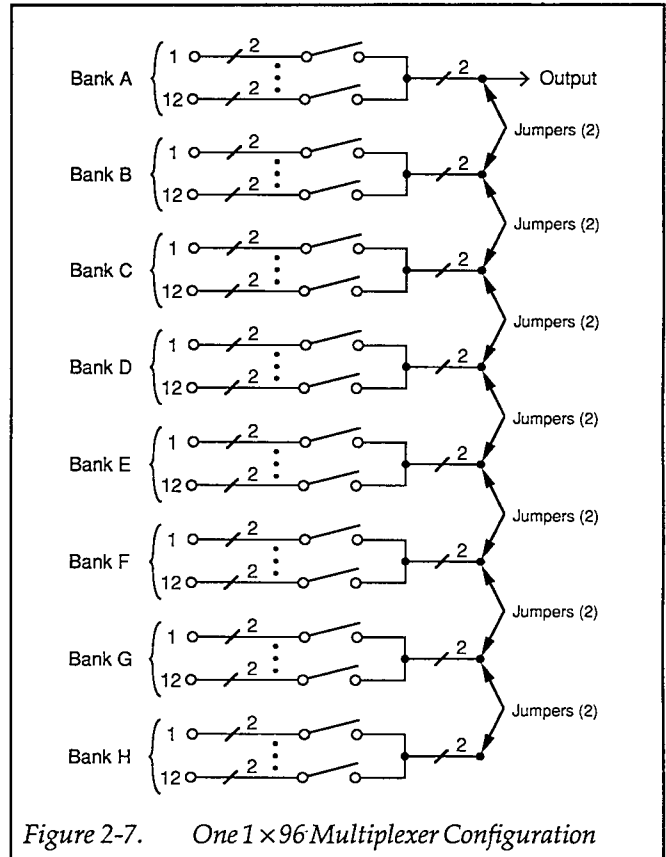
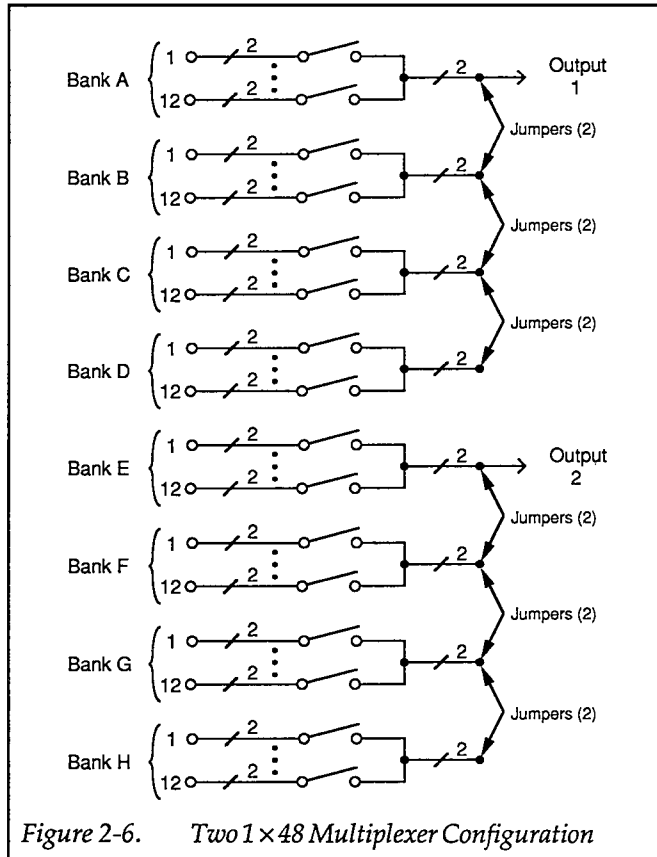


Figure 2-3. Model 7075 Jumper Locations





2.4.4 Backplane Connection Jumpers

The multiplexer banks on the Model 7075 can be connected to the 3-pole, general-purpose backplane pathways of the matrix mainframe by installing the appropriate backplane jumpers. These pathways provide connection to rows A through H of any Model 7071 General Purpose Matrix Card, Model 7071-4 Dual 4 × 12 Matrix Card, Model 7076 Dual 4 × 12 Two-pole Matrix Card or Model 7074 General Purpose Multiplexer Card installed in the mainframe. Figure 2-8 shows multiplexer bank rows A through H of the Model 7075 connected through the mainframe backplane to rows A through H of the matrix card. Appendix B provides additional card-backplane information.

The backplane jumpers can also be used to expand the multiplexer banks using other Model 7075 cards installed in the same mainframe. For example, three Model 7075 cards installed in a mainframe with the proper bank and

backplane jumper configuration would result in a 1 × 288 or 2 × 144 multiplexer configuration.

The backplane jumpers are shown in Figure 2-3. Note that HI and guard for a particular bank would normally be jumpered to the corresponding row of the 3-pole, general-purpose backplane.

2.4.5 Switching Configurations

Guarded Switching

Each multiplexer switch is a 2-pole relay that switches HI and guard, allowing 2-pole switching. An example is shown in Figure 2-9. In this case, a driven guard is provided by the measuring/sourcing instrument (guarding helps to minimize the effects of leakage resistance and capacitance, especially where long pathways are involved; see paragraph 2.9).

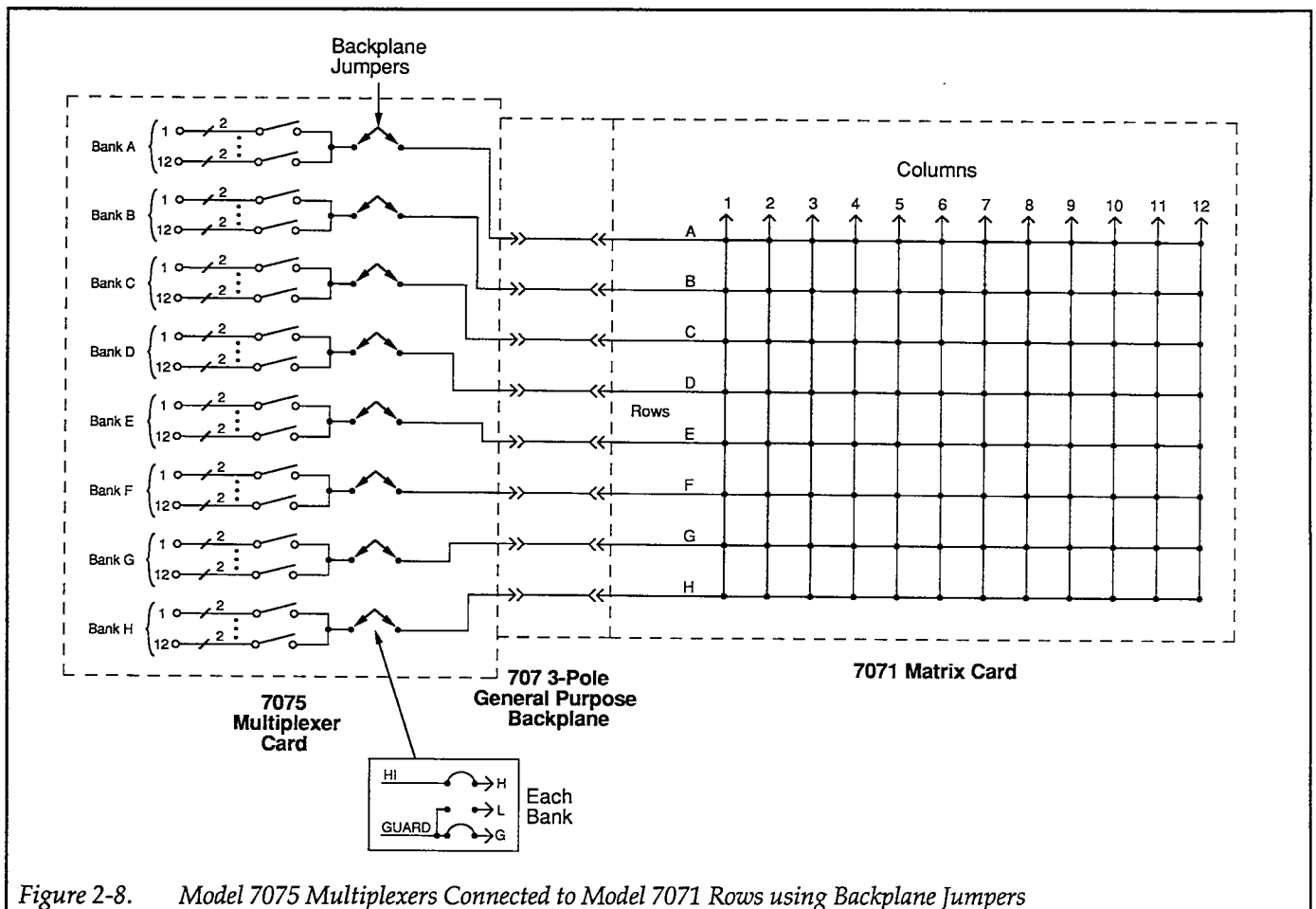
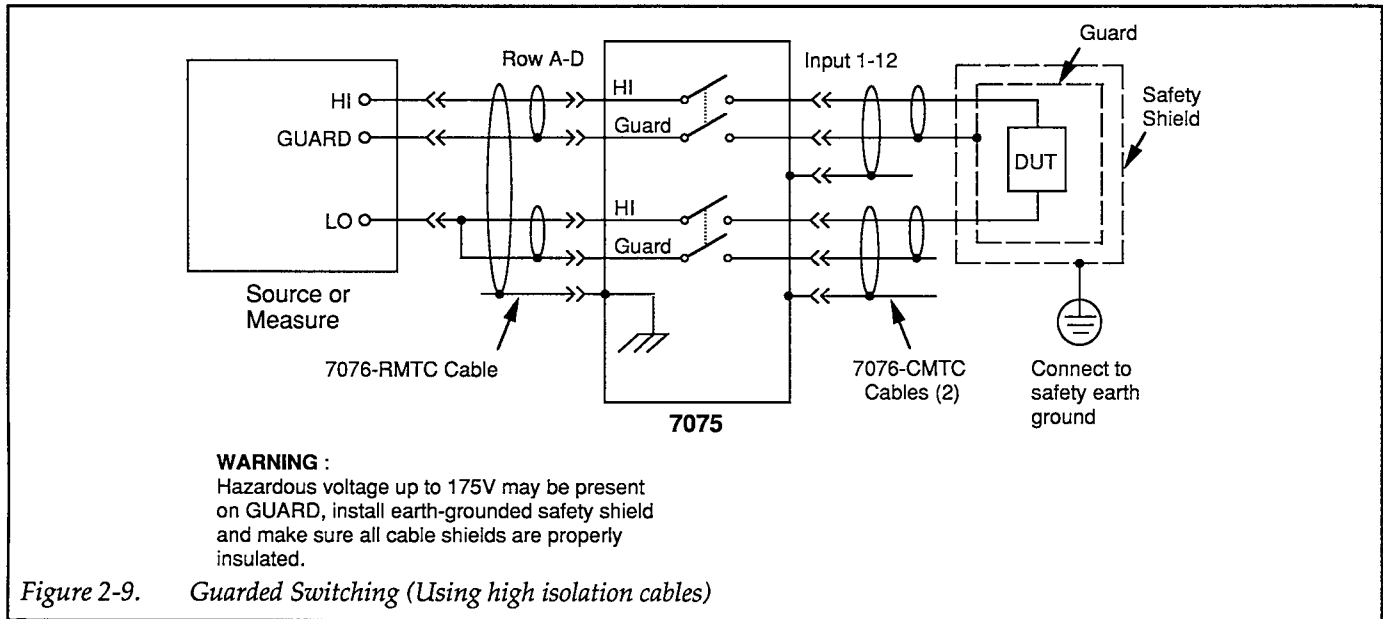


Figure 2-8. Model 7075 Multiplexers Connected to Model 7071 Rows using Backplane Jumpers



WARNING
Hazardous voltages up to 175V may be present on GUARD. Install an earth-grounded safety shield around the DUT and make sure all cable shields are properly insulated.

Unguarded Switching

In cases where no guard is required or available, the guard path can be connected to signal LO at the source/measurement instrument and will serve as a shield for the HI signal pathway. Such an arrangement is shown in Figure 2-10. Additional shielding will be provided by the outer shield of the cables. An additional safety shield (connected to earth ground) should also be included as shown.

Multiple-pole Switching

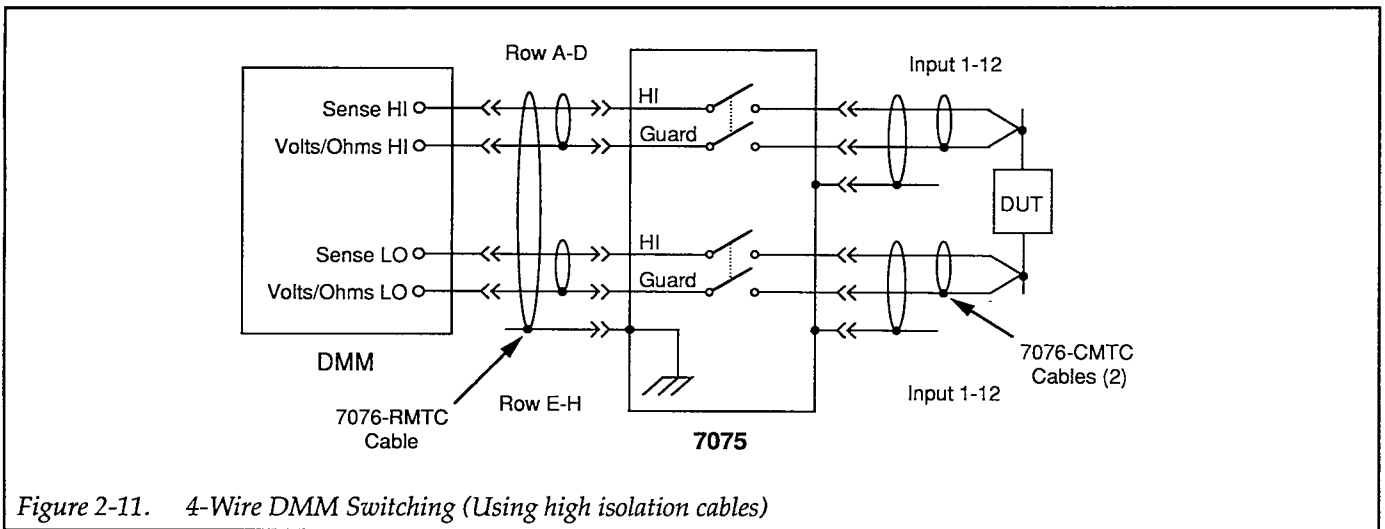
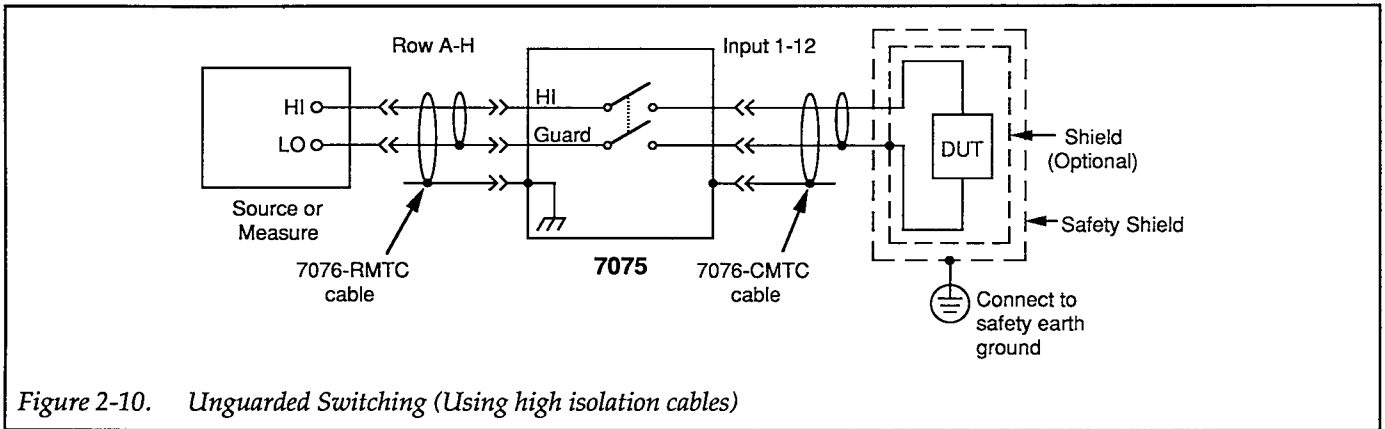
In some cases, it may be necessary to switch more than three poles for a given input or output channel. Two such cases are four-wire resistance measurements, or when using SMUs (source/measure units). Since the Model

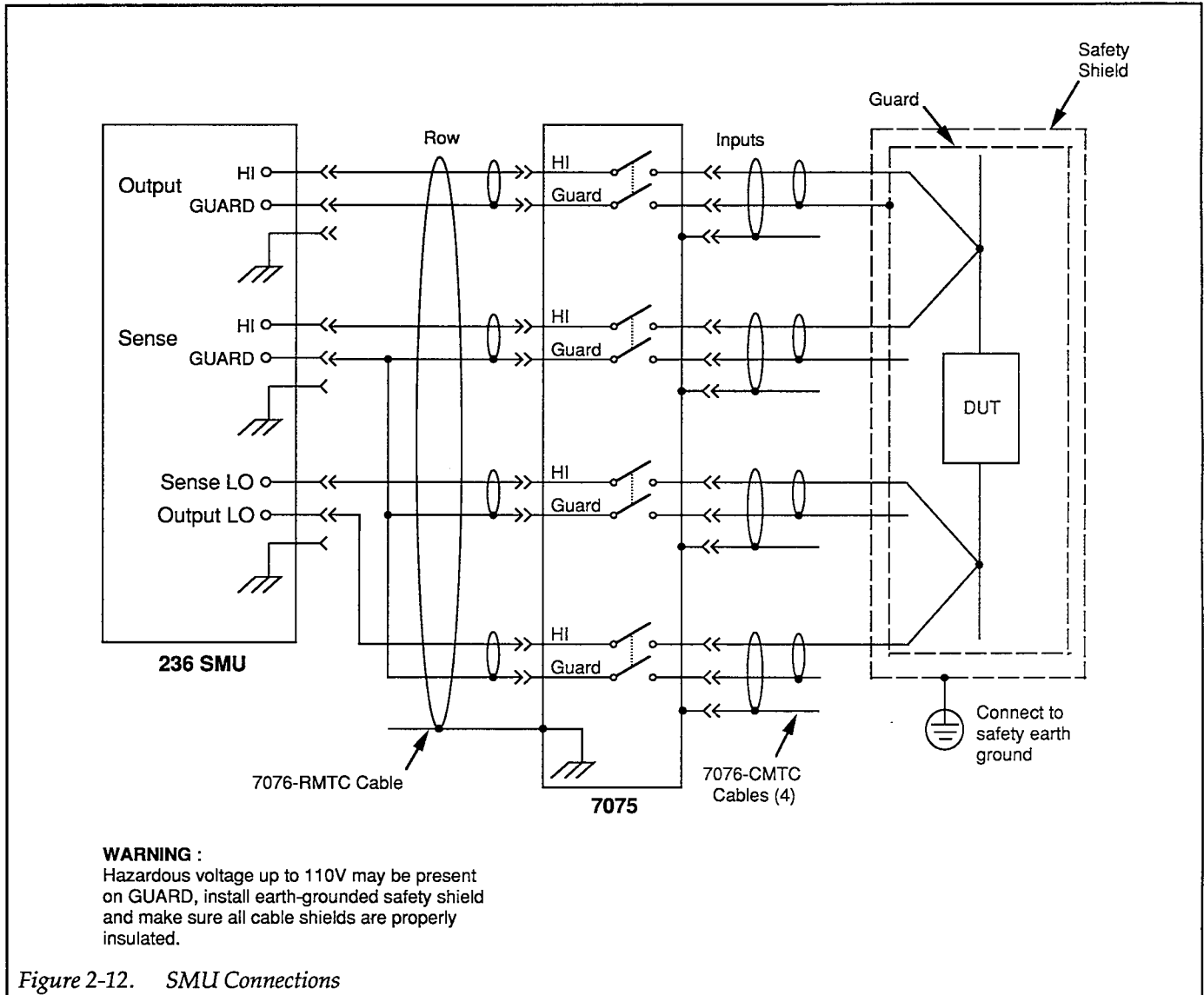
7075 can be split up into several multiplexers, two or more multiplexer banks can be used together to add the desired number of poles.

Figure 2-11 shows an example for 4-wire resistance measurements using a DMM. Note that VOLTS/OHMS HI and SENSE HI are routed through one bank, while VOLTS/OHMS LO and SENSE LO are routed through a second bank.

Figure 2-12 demonstrates a typical configuration when using a Model 236 Source Measure Unit. Here all four poles (OUTPUT HI, SENSE HI, OUTPUT LO and SENSE LO) are routed through separate banks. If a guard shield surrounding the DUT is to be used, a safety shield connected to earth ground must also be incorporated.

WARNING
Hazardous voltages up to 175V may be present on GUARD. Install an earth-grounded safety shield around the DUT and make sure all cable shields are properly insulated.





2.5 CARD INSTALLATION AND REMOVAL

After selecting the jumper configuration, the Model 7075 should be installed within the Model 707 Switching Matrix, as summarized below. Figure 2-13 shows the installation procedure.

WARNING

Turn off the mainframe power and disconnect the line cord before installing or removing cards.

CAUTION

Disconnect all connecting cables before installing or removing the multiplexer card.

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 back 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.

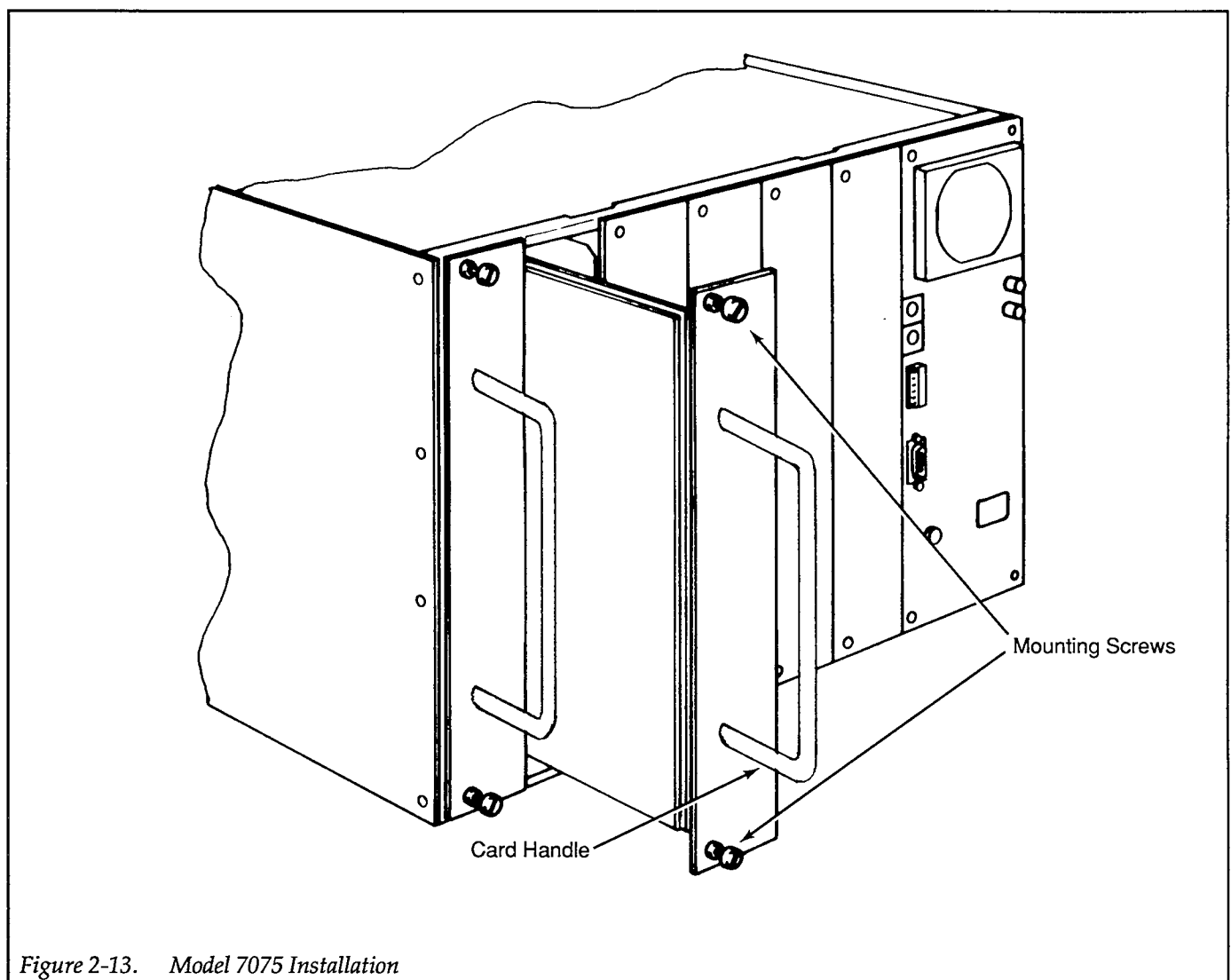


Figure 2-13. Model 7075 Installation

CAUTION

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

3. Slide the card into the mainframe until it is properly seated in the edge connectors at the back of the slot. Once the card is properly seated, secure it to the mainframe by finger tightening the spring-loaded screws.

WARNING

The mounting screws must be secured to ensure 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.

4. To remove a card, first turn off the power and disconnect the line cord from the mainframe. Disconnect all cables from the multiplexer card. 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 rear of the card.

2.6 CONNECTIONS

The Model 7075 has nine 25-pin D-sub receptacles mounted on the rear panel. Eight receptacles are used for BANK input connections, and one receptacle is used for ROW connections.

NOTE

The term receptacle refers to a connector mounted on the rear panel of the multiplexer card. The term plug refers to a connector that attaches to a cable that will mate to a receptacle.

CAUTION

To prevent damage (not covered by the warranty) and a possible safety hazard, do not exceed the maximum allowable limits of the Model 7075. Maximum signal levels are listed in the specifications located at the front of the manual.

Pin identification for the D-sub receptacles is provided in Figure 2-14. Adjacent to the each contact designation of the D-sub receptacles is the corresponding row or bank input that it is internally connected to.

Cable Connections

There are two basic cable types available to make connections to the multiplexer card; the standard cable (Model 7075-MTC), and high isolation cables (Model 7076-RMTC and Model 7076-CMTC). Basically, the standard cable is a general purpose cable that will mate to either the ROW or BANK receptacles. The high isolation cables provide better isolation between paths. The Model 7076-RMTC is used to connect to the ROW receptacle, while the Model 7076-CMTC is used to connect to the BANK receptacles.

The available cables, as well as some miscellaneous connectors for customized user-supplied terminations, are summarized in Table 2-1. The available cables are described in more detail in paragraphs 2.6.1 and 2.6.2.

Use the following procedure to connect a cable terminated with a 25-pin D-sub plug to the multiplexer card:

WARNING

To avoid electrical shock that could result in injury or death, ALWAYS remove power from the entire system (Model 707, test instruments, DUT, etc.) and discharge any capacitors before connecting or disconnecting cables from the multiplexer card. The pins of the cable connectors are easily accessible making them extremely hazardous to handle while power is applied.

1. Install the multiplexer card in the Model 707 mainframe as explained in paragraph 2.5.
2. Push the plug of the cable onto the appropriate receptacle of the multiplexer card. The cable plug and multiplexer card receptacle will only mate one way.
3. Using a slotted screwdriver, turn the two locking screws clockwise until the plug is fully mated to the receptacle.

The same basic procedure applies for connecting the cable plug to a test fixture receptacle.

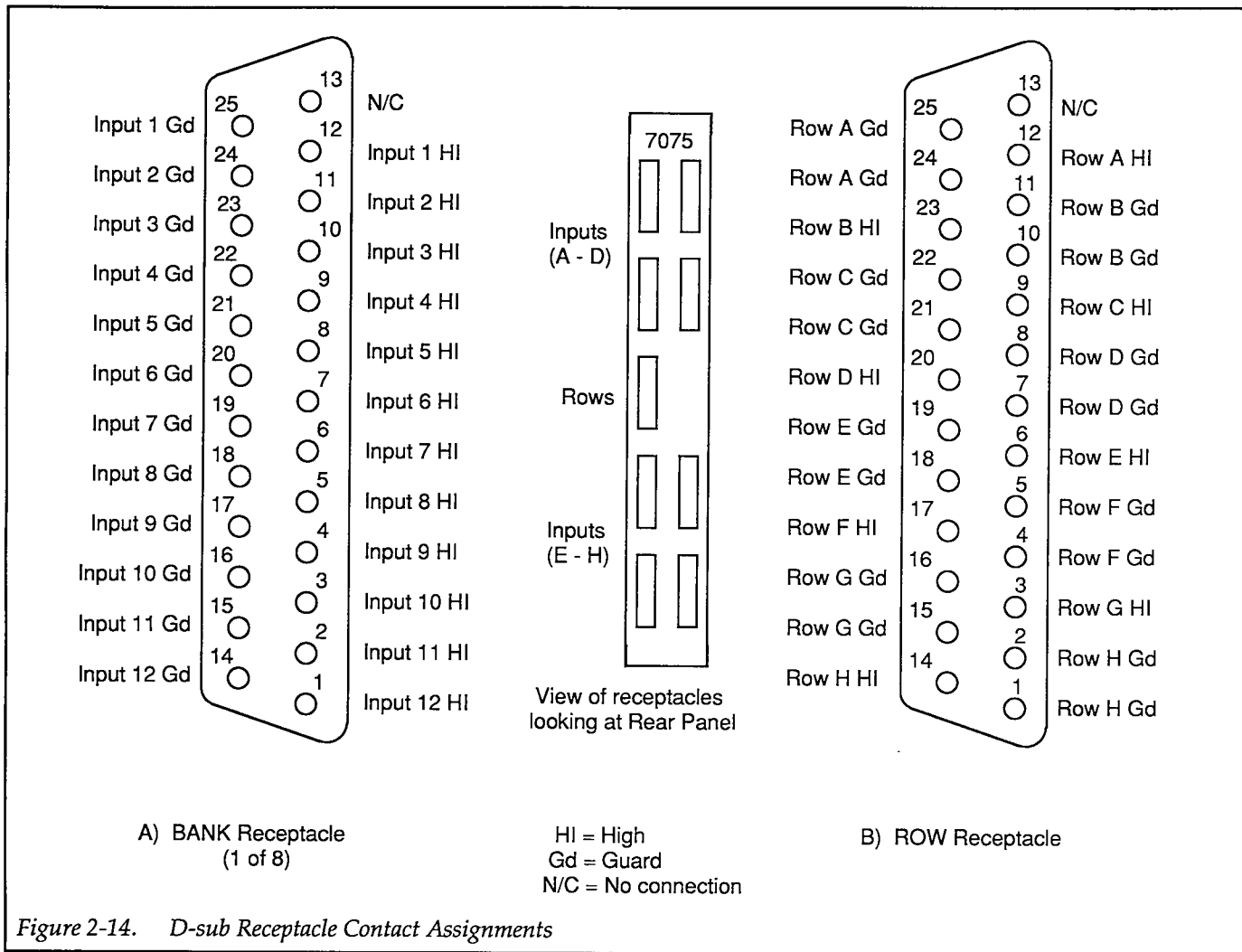


Figure 2-14. D-sub Receptacle Contact Assignments

Table 2-1. Available Cables and Connectors

Manufacturer	Model or Part Number	Description
Keithley	Model 7075-MTC Standard Cable	Standard three-meter (10 feet) cable assembly terminated with 25-pin D-sub plugs on both ends. Mates to either the ROW or BANK receptacles of the card.
Keithley	Model 7076-CMTC High Isolation Columns/Bank Cable	Three-meter (10 feet), high isolation (for high isolation) cable assembly terminated with 25-pin D-sub plugs on both ends. Use to mate to the BANK receptacles of the card.
Keithley	Model 7076-RMTC High Isolation Rows Cable	Three-meter (10 feet), high isolation (for high isolation) cable assembly terminated with 25-pin D-sub plugs on both ends. Use to mate to the ROW receptacle of the card.
Keithley	CS-400	25-pin D-sub plug that will mate to the ROW and BANK receptacles of the card. Solder-cup connections simplify the building of custom cables.
Keithley	CS-401	25-contact D-sub receptacle that will mate to the cables terminated with a 25-pin D-sub plug.
Keithley	CS-590	Plastic backshell housing for CS-400.
Belden	9868	High isolation cable. Same cable used for the Models 7076-RMTC and 7076-CMTC cable assemblies.
3M	8225-7000	25-pin D-sub plug for customized ribbon cable assemblies.
3M	3357-9225	Junction shell for 3M 8225-7000 D-sub plug.

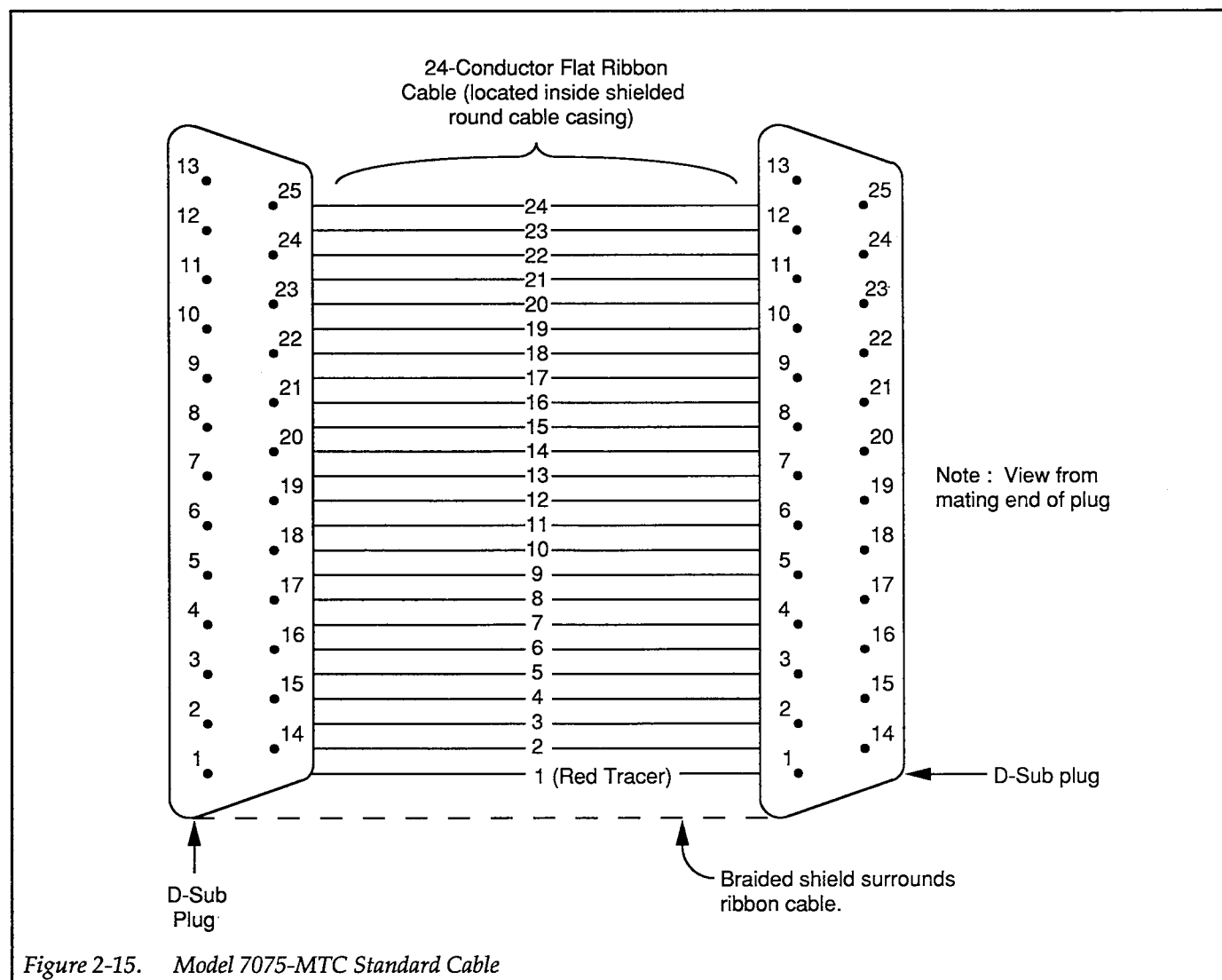
2.6.1 Standard Cable (Model 7075-MTC)

The standard cable (Model 7075-MTC) is a three-meter (10 feet), general purpose 24-conductor, shielded cable that is terminated with a 25-pin D-sub male plug on each end that will connect to either the ROW or BANK receptacles on the multiplexer card.

The standard cable (shown in Figure 2-15) is comprised of a flat ribbon cable that is located inside a shielded, round cable casing. The braided shield of the cable surrounds the ribbon cable and is subsequently connected to chassis ground when the cable is connected to a Model 7075 that is installed in a Model 707 mainframe.

Pin designations on the D-sub plugs of the standard cable correspond to the contact designations on the D-sub receptacles of the multiplexer card. Thus, if connecting the standard cable to a BANK receptacle, refer to Figure 2-14A for bank input identification. If connecting the standard cable to the ROW receptacle, refer to Figure 2-14B for row identification.

To connect the multiplexer to instrumentation and DUT, a test fixture using a D-sub receptacle can be used to mate to the D-sub plug of the cable. The Keithley part number for the D-sub receptacle is listed in Table 2-1.



Modifying the Standard Cable

A common way to use the standard cable is to cut it at a convenient length. The result is two cables that are unterminated at one end. The flat ribbon cables at the unterminated ends of the cables can then be connected to instrumentation and DUT, while the other ends will mate to the ROW and BANK receptacles of the multiplexer card. The conductor designations of the ribbon cable are shown in Figure 2-15. The red tracer identifies conductor #1 of the ribbon cable. Table 2-2 is provided to correspond the ribbon cable conductors to the multiplexer card ROW or BANK input terminal. For example, if the standard cable is connected to the ROW receptacle, ribbon cable conductor #24 will correspond to Row A Guard of the multiplexer card. If the cable was instead connected to the BANK B receptacle, ribbon cable conductor #24 will correspond to BANK B Input 1 Guard of the multiplexer card.

Table 2-2. Cable Conductor Identification (Model 7075-MTC)

Ribbon Cable Conductor	Matrix Row/Column Terminal	
	Connected to ROW Receptacle	Connected to BANK Receptacle
1*	ROW H, Guard	INPUT 12, HI
2	ROW H, HI	INPUT 12, Guard
3	ROW H, Guard	INPUT 11, HI
4	ROW G, Guard	INPUT 11, Guard
5	ROW G, HI	INPUT 10, HI
6	ROW G, Guard	INPUT 10, Guard
7	ROW F, Guard	INPUT 9, HI
8	ROW F, HI	INPUT 9, Guard
9	ROW F, Guard	INPUT 8, HI
10	ROW E, Guard	INPUT 8, Guard
11	ROW E, HI	INPUT 7, HI
12	ROW E, Guard	INPUT 7, Guard
13	ROW D, Guard	INPUT 6, HI
14	ROW D, HI	INPUT 6, Guard
15	ROW D, Guard	INPUT 5, HI
16	ROW C, Guard	INPUT 5, Guard
17	ROW C, HI	INPUT 4, HI
18	ROW C, Guard	INPUT 4, Guard
19	ROW B, Guard	INPUT 3, HI
20	ROW B, HI	INPUT 3, Guard
21	ROW B, Guard	INPUT 2, HI
22	ROW A, Guard	INPUT 2, Guard
23	ROW A, HI	INPUT 1, HI
24	ROW A, Guard	INPUT 1, Guard

*Conductor #1 of the ribbon cable is identified by the red tracer.

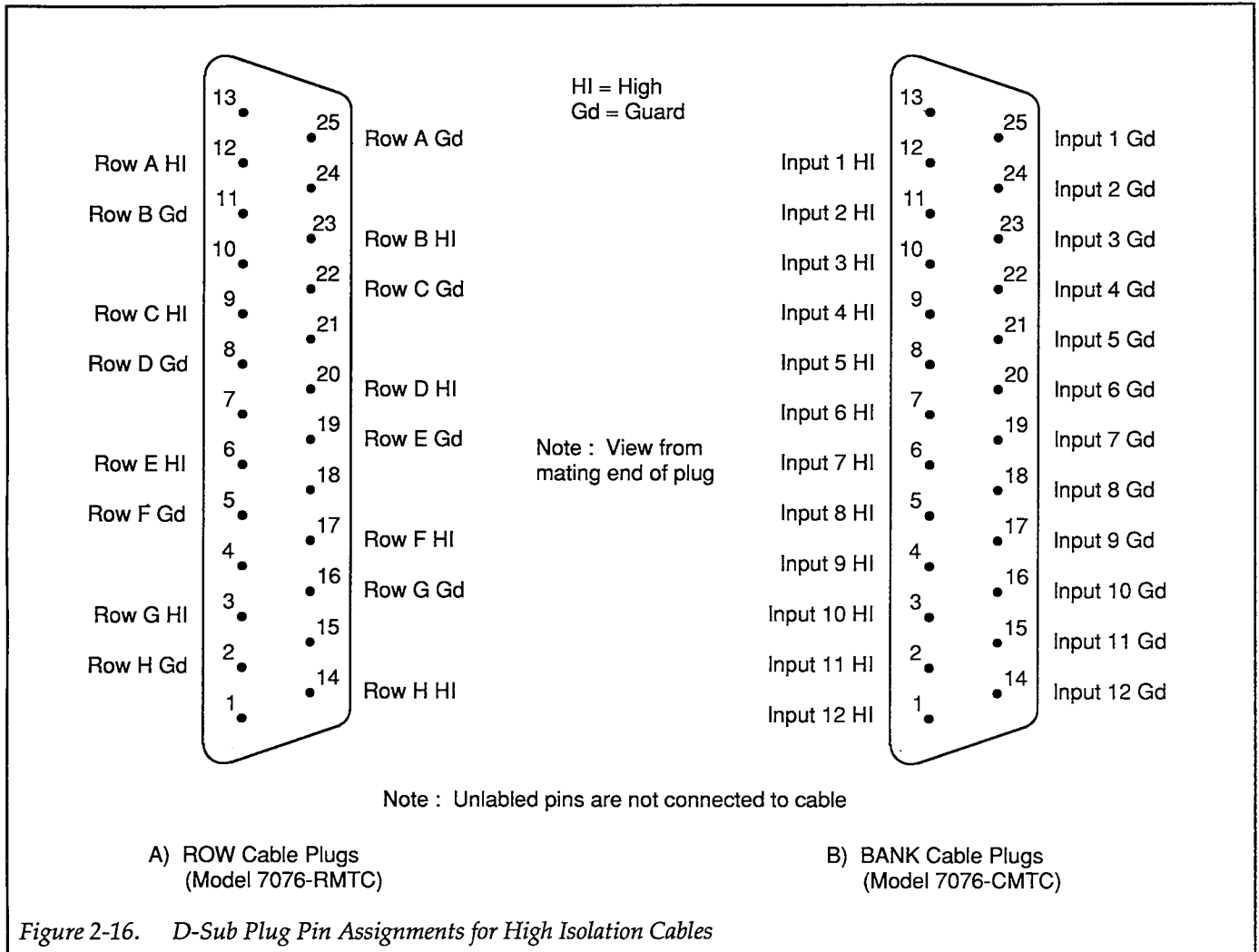
2.6.2 High Isolation Cables (Model 7076-RMTC and Model 7076-CMTC)

Shielded high isolation cables (Model 7076-RMTC and Model 7076-CMTC) are available to optimize performance by minimizing crosstalk between signal paths. Each HI signal path in the cable is completely surrounded by Guard (insulated foil) to maximize the effects of guarding. The outer foil shield of the cable is connected to the housings of the D-sub plugs. This shield is connected to chassis ground when the cable is connected to a Model 7075 that is properly installed in the Model 707 mainframe.

The Model 7076-RMTC is a 3-meter (10 feet) 28-conductor cable terminated with a D-sub plug on each end. The plug pin assignment for this cable is configured to mate with the ROW receptacle of the multiplexer card. Pin identification for this cable is shown in Figure 2-16A.

The Model 7076-CMTC is a 3-meter (10 feet) 28-conductor cable terminated with a D-sub plug on each end. The plug pin assignment for this cable is configured to mate with the BANK receptacles of the multiplexer card. Pin identification for this cable is shown in Figure 2-16B.

For connections to instrumentation and DUT, a test fixture using D-sub receptacles can be used to mate to the D-sub plugs of the cables. The Keithley part number for the D-sub receptacle is listed in Table 2-1.



Modifying the High Isolation Cable

Another way to use the Model 7076-RMTC or Model 7076-CMTC is to cut the cable at a suitable length and add appropriate user termination. Each cable can then be mated to the multiplexer card while the unterminated ends can be wired to another connector or directly to instrumentation and DUT.

Each cable contains 12 conductor pairs each of which corresponds to a row or bank input. Each pair contains a color-coded insulated wire (HI), and a bare drain wire (Guard). Each pair is wrapped in an insulated, color-coded foil which is also connected to Guard. The color combination of the HI conductor insulator and the surrounding foil is used for identification. Table 2-3 identifies the conductors of the Model 7076-RMTC cable, while Table 2-4 provides identification for the Model 7076-CMTC cable. Note that for both cables, the black with red foil and white with blue foil pairs (as well as the main outer shield) are connected to chassis ground at the housing of the D-sub plugs.

CAUTION

When terminating a cable that has been cut, make sure that all exposed conductors are properly insulated using Teflon® or PVC tubing and/or heat shrink material. The conductive side of the foil and drain wire of each wire pair must be electrically isolated from the other wire pairs.

Table 2-3. Model 7076-RMTC Conductor Identification

Row	Cable Wire Color Combination
Row A	Brown (HI), Red Foil w/Drain (Guard)
Row B	Red (HI), Red Foil w/Drain (Guard)
Row C	Orange (HI), Red Foil w/Drain (Guard)
Row D	Yellow (HI), Red Foil w/Drain (Guard)
Row E	Blue (HI), Red Foil w/Drain (Guard)
Row F	White (HI), Red Foil w/Drain (Guard)
Row G	Brown (HI), Blue Foil w/Drain (Guard)
Row H	Red (HI), Blue Foil w/Drain (Guard)
Chassis	Black (Chassis), Red Foil w/Drain (Chassis)
Chassis	White (Chassis), Blue Foil w/Drain (Chassis)
Chassis	Main outer shield w/Drain (Chassis)

Table 2-4. Model 7076-CMTC Conductor Identification

BANK Input	Cable Wire Color Combination
Input 1	Brown (HI), Red Foil w/Drain (Guard)
Input 2	Red (HI), Red Foil w/Drain (Guard)
Input 3	Orange (HI), Red Foil w/Drain (Guard)
Input 4	Yellow (HI), Red Foil w/Drain (Guard)
Input 5	Blue (HI), Red Foil w/Drain (Guard)
Input 6	White (HI), Red Foil w/Drain (Guard)
Input 7	Brown (HI), Blue Foil w/Drain (Guard)
Input 8	Red (HI), Blue Foil w/Drain (Guard)
Input 9	Orange (HI), Blue Foil w/Drain (Guard)
Input 10	Yellow (HI), Blue Foil w/Drain (Guard)
Input 11	Blue (HI), Blue Foil w/Drain (Guard)
Input 12	Black (HI), Blue Foil w/Drain (Guard)
Chassis	Black (Chassis), Red Foil w/Drain (Chassis)
Chassis	White (Chassis), Blue Foil w/Drain (Chassis)
Chassis	Main outer shield w/Drain (Chassis)

2.7 TYPICAL CONNECTION SCHEMES

The following paragraphs discuss typical schemes to connect Model 7075 cards to other instrumentation. Single card and multiple-card systems are discussed as are typical connections to other Keithley cards. These include the Model 7076 Dual 4 × 12 Two-pole Matrix Card, the Model 7074 General Purpose Multiplexer Card, and the Models 7071 and 7071-4 General Purpose Matrix Cards.

2.7.1 Single Mainframe, Single Multiplexer Card System

Figure 2-17 shows typical connections for a single multiplexer card system. In this example, the instruments are connected to the row outputs, and the DUTs are connected to the bank inputs. This configuration would allow you to test a large number of devices with the same instrument or group of instruments.

Note that four Model 7075-MTC or 7076-CMTC cables cut in half are used for the DUT connections. A single Model 7075-MTC or 7076-RMTC cable with one plug cut off is used to connect the instruments to the bank outputs. As an alternative to this arrangement, you could wire D-sub receptacles to the DUT and then connect unmodified cables to those receptacles.

2.7.2 Expanding the Multiplexer Using Multiple Cards

The number of input channels on the multiplexer can be expanded by adding more multiplexer cards to the system. For example, three multiplexer cards, properly configured, will give you one of the following configurations switching:

- One 1 × 288 multiplexer
- Two 1 × 144 multiplexers
- Four 1 × 72 multiplexers
- Eight 1 × 36 multiplexers

Figure 2-18 shows a system using two Model 7075 Multiplexer Cards and one Model 7074 Multiplexer Card. This example shows how the Model 7075 (two-pole card) can be used with a three-pole card (Model 7074). In this instance, the DUTs are connected to the multiplexer inputs,

while the instruments are connected to the row outputs. This arrangement provides one 1 × 288 multiplexer.

The backplane jumpers on each card must be installed for each set of banks to be paralleled. The backplane connections are shown in Figure 2-18C. Note that with the jumpers configured as shown, only the HI and Guard paths are used. The LO path of the Model 7074 is not used. By moving the Guard backplane jumpers of the Model 7075 to the alternate position, instrumentation will be re-routed to the LO paths of the Model 7074.

2.7.3 Using the Multiplexer with Matrix Cards

The Model 7075 can be used in conjunction with the Model 7076, Model 7071 or Model 7071-4 matrix cards to add additional switching capabilities to their matrices. Figure 2-19 shows the Model 7076 (configured as an 8 × 12 matrix) being used with the multiplexer. With the backplane jumpers of each card installed, connections from row outputs of the multiplexer card to the rows of the Model 7076 Matrix Card are made internally through Model 707 backplane.

Figure 2-20 shows how a three-pole matrix card (Model 7071) can be used with the Model 7075. With the backplane jumpers configured as shown in Figure 2-20C, instrumentation would have to be connected to the HI and Guard terminals of the matrix card to route signals through the multiplexer card. In this case, matrix card LO paths would not be used. To use the LO paths, the Guard jumpers of the Model 7075 would have to be moved to the alternate position.

If the two cards are located in different mainframes, the necessary connections between the two cards can be made by using a Model 7075-MTC or Model 7076-RMTC cable, as shown in Figure 2-21. In this example, the multiplexer card is being used with a Model 7071-4 Dual 4 × 12 Multiplexer Card, which is configured as a 4 × 24 multiplexer using on-card jumpers (the Model 7071-4 can also be used as one 8 × 12 or two separate 4 × 12 matrices).

CAUTION

To avoid shorting matrix card rows, make sure all Model 7075 bank-to-bank jumpers are removed.

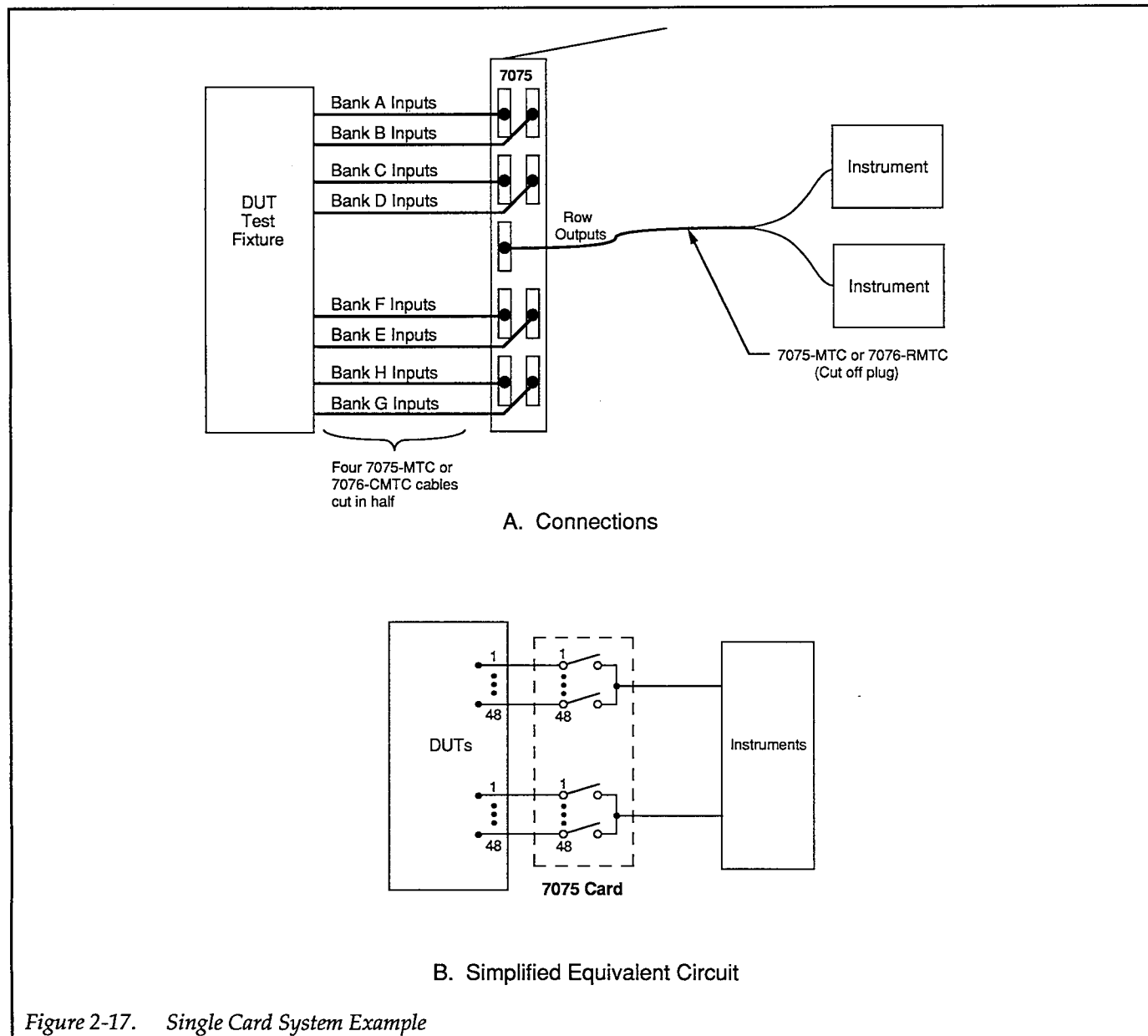


Figure 2-17. Single Card System Example

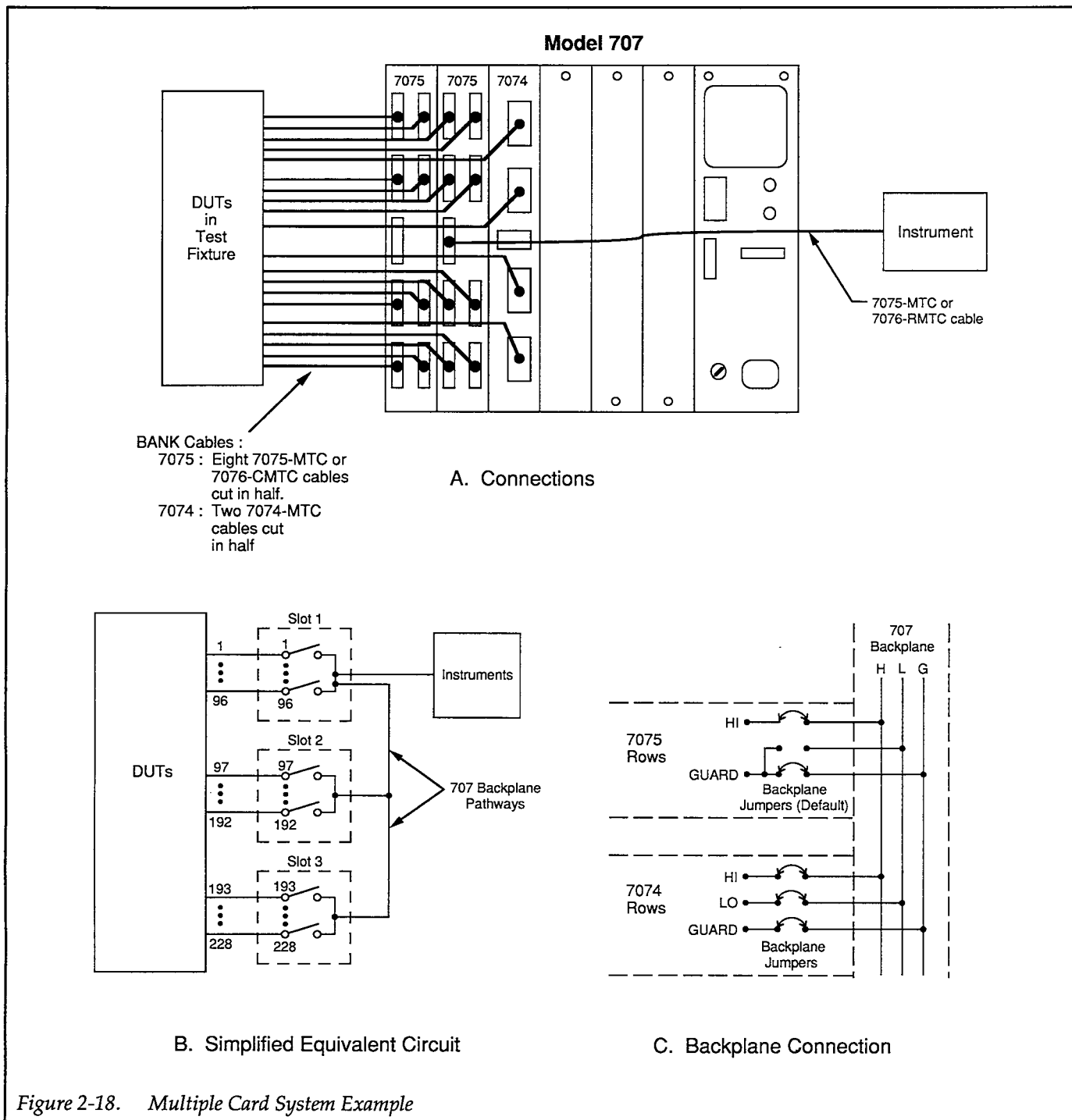
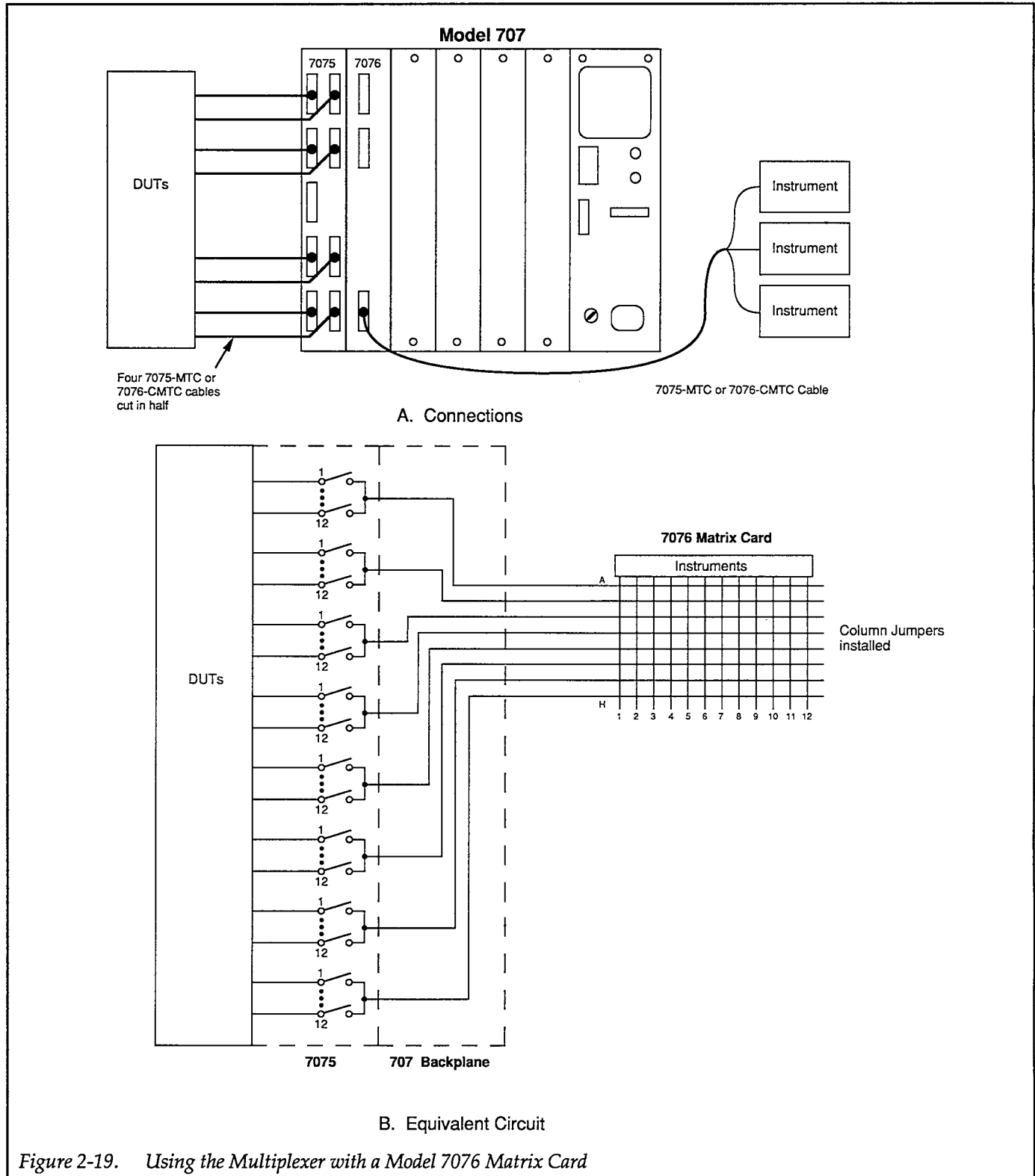


Figure 2-18. Multiple Card System Example



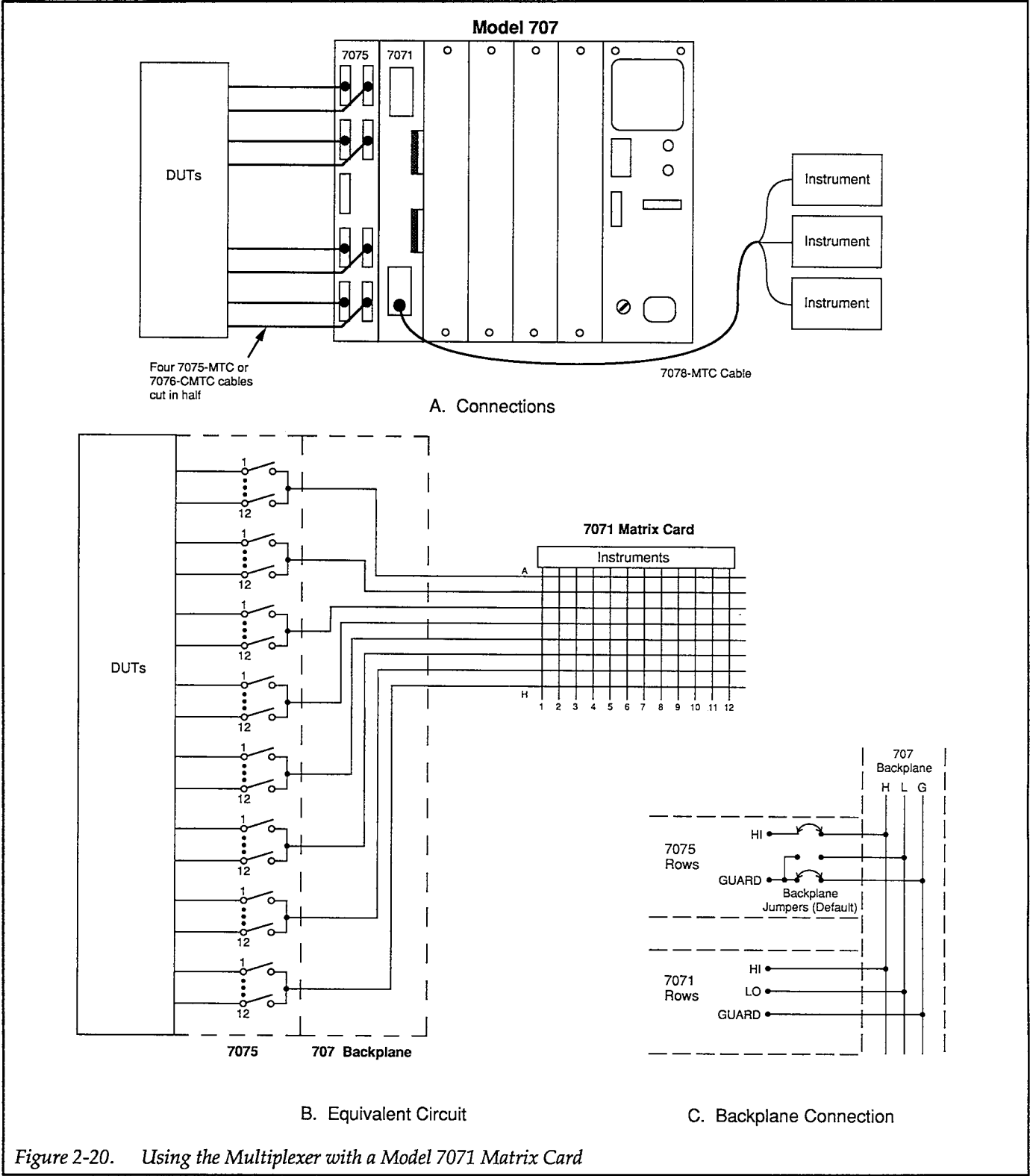


Figure 2-20. Using the Multiplexer with a Model 7071 Matrix Card

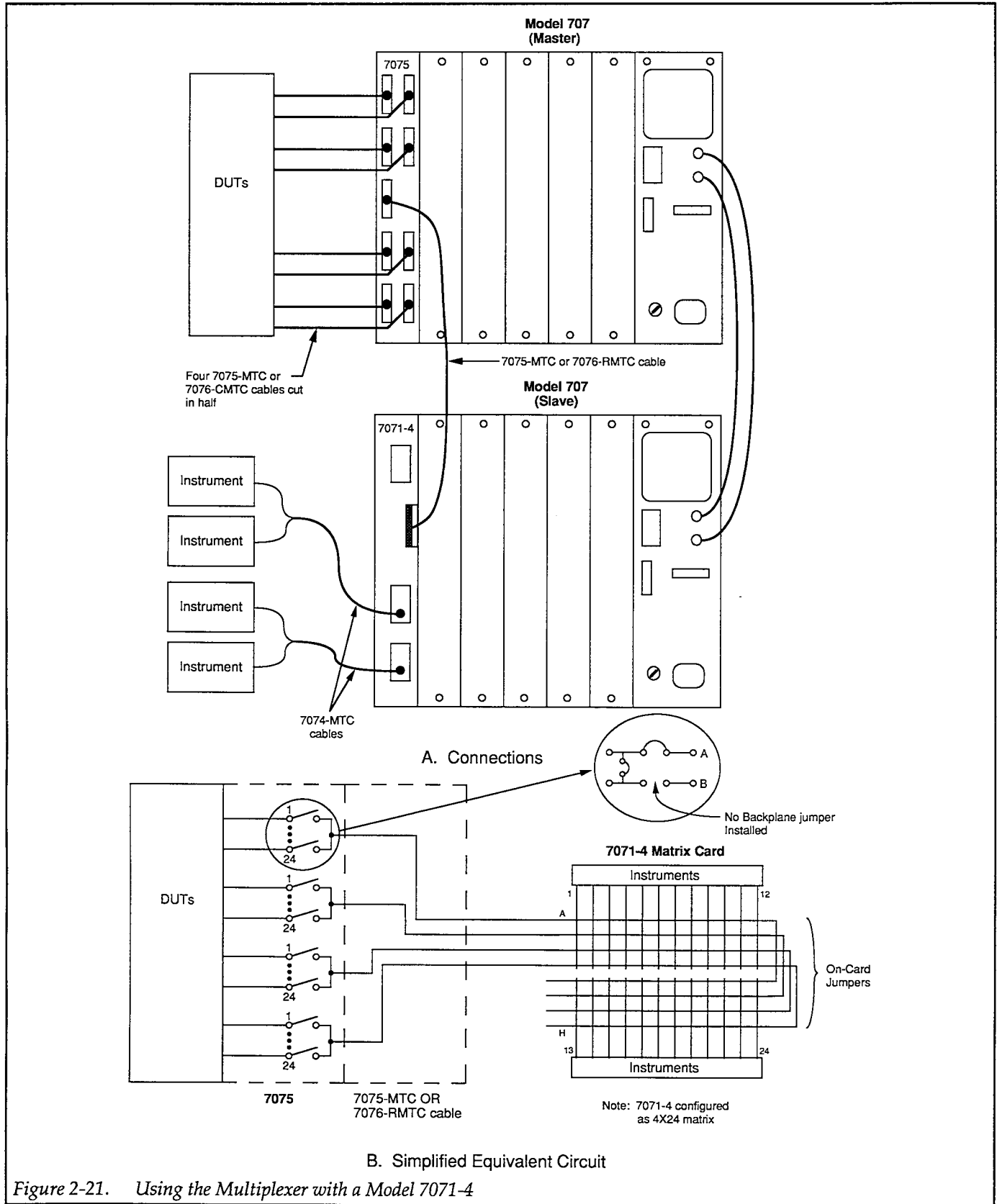


Figure 2-21. Using the Multiplexer with a Model 7071-4

2.8 MULTIPLEXER PROGRAMMING

Use the following general procedure to program the multiplexer card from the Model 707 Switching Matrix either from the front panel, or over the IEEE-488 bus. For detailed programming information, refer to the Model 707 Instruction Manual.

2.8.1 Banks and Rows

As discussed in paragraph 2.4.2, the Model 7075 is configured as eight banks of multiplexers, each of which has 12 inputs. The banks are in rows A through H, and the inputs are 1 through 12 inclusive.

When programming the multiplexer card from the Model 707 Switching Matrix, keep in mind that bank rows on the Model 7075 correspond to rows on the mainframe. Similarly, bank inputs on the multiplexer correspond to columns on the mainframe. For example, assume that you wish to close the bank D, input 8 relay. You would then select row D, column 8 for closure on the mainframe.

2.8.2 Front Panel Multiplexer Programming Procedure

Follow the general procedure below to manually close and open specific bank, input relays. For automatic sequencing from the front panel, store each bank and input as a setup in successive memory locations; see the Model 707 Instruction Manual for complete details.

1. Press RESET to return the Model 707 to default operating conditions.
2. Select AUTOMATIC relay operation.
3. Using the front panel buttons, key in the desired bank and input, then press the CLOSE key. For example, to close bank A, input 12, press: A 1 2 CLOSE. Note that the mainframe displays the closed bank and input in row-column format on the front panel display.
4. To open the presently selected bank and input, simply press the OPEN key.
5. Repeat steps 3 and 4 for all required bank inputs and rows in the desired sequence.

2.8.3 IEEE-488 Bus Programming

Send the commands in the sequence below to close specific bank inputs and rows on the Model 7075. Refer to Section 4 of the Model 707 Instruction Manual for detailed IEEE-488 programming information.

1. Send the command "R0X" to return the Model 707 to default operating conditions.
2. Send the command letter "C" followed by the row, input combination to be closed. For example, to close row A, input 11, send the command string "CA11X". Note that relay will close when the command is received.
3. To open the relay, use the "N" command followed by the row and input. For example, send "NA12X" to open row A, input 12. The relay will open when the command is received by the mainframe.

Example Program 1: Single-bank Scanning

The program below demonstrates the basic techniques for scanning through all 12 channels of a specific bank (bank A in this example). The program, which is written in Hewlett-Packard BASIC 4.0, incorporates a fixed delay of one second for DUT settling time. Typically, code for the measurement instrument would be placed immediately after the WAIT statement used for the delay.

PROGRAM	COMMENTS
10 REMOTE 718	Put 707 in remote.
20 OUTPUT 718; "R0X"	Reset 707.
30 FOR I=1 TO 12	Loop for all 12 channels.
40 OUTPUT 718; "CA";I; "X"	Close row A, input I.
50 WAIT 1	One second settling time.
60 REM USER'S MEASUREMENT CODE	Insert measurement code here.
70 OUTPUT 718; "NA";I; "X"	Open row A, input I.
80 NEXT I	Loop back for next channel.
90 END	

Example Program 2: Multiple-bank Scanning

The program below, which is also written in HP BASIC 4.0, demonstrates how to scan through all 96 channels in sequence. The sequence starts with bank A, scans through all 12 inputs, and then continues with banks B through H in sequence. Again, a fixed settling time of one second is included after the relay is closed. Code for the measurement instrument would typically be added immediately after the WAIT statement that defines the settling time.

PROGRAM	COMMENTS
10 REMOTE 718	Put 707 in remote.
20 FOR I=65 TO 72	Loop for A-H ASCII values.
30 FOR J=1 TO 12	Loop for all 12 inputs.
40 OUTPUT 718; "C"; CHR\$(I); J; "X"	Close row CHR\$(I), input J. Wait one second settling time.
50 WAIT 1	Insert measurement code here.
60 REM USER'S MEASURE- MENT CODE	Open row CHR\$(I), input J.
70 OUTPUT 718; "N";CHR\$(I); J; "X"	Loop back for next channel. Loop back for next bank.
80 NEXT J	
90 NEXT I	
100 END	

2.9 MEASUREMENT CONSIDERATIONS

Many measurements made with the Model 7075 are subject to various types of noise that can affect measurement accuracy. The following paragraphs discuss possible noise sources that might affect these measurements and ways to minimize their effects.

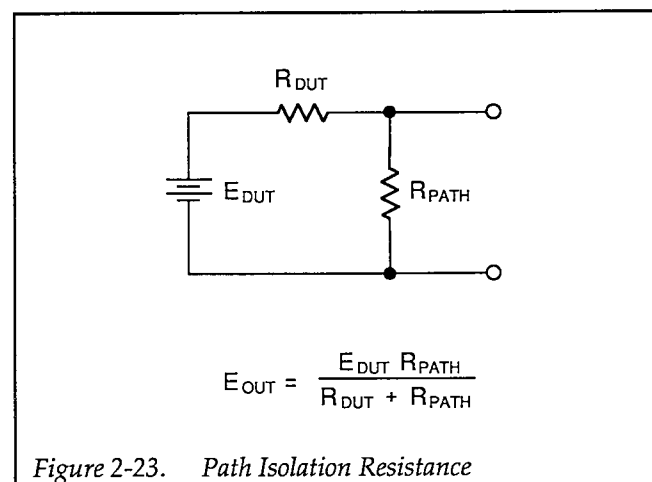
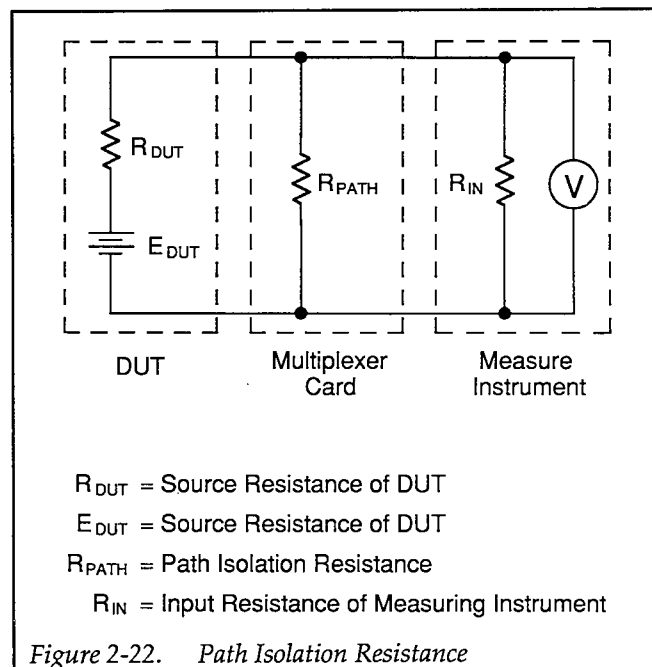
2.9.1 Path Isolation

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

Path isolation resistance forms a signal path that is in parallel with the equivalent resistance of the DUT, as shown in Figure 2-22. For low-to-medium device resistance values, path isolation resistance is seldom a consideration; however, it can seriously degrade measurement accuracy when testing high-impedance devices. The voltage measured across such a device, for example, can be substantially attenuated by the voltage divider action of the device source resistance and path isolation resistance, as shown in Figure 2-23. Also, leakage currents can be generated through these resistances by voltage sources in the system.

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

The effects of path resistance and capacitance can be minimized by using guarding whenever possible. Paragraph 2.9.7 discusses guarding in more detail.



2.9.2 Magnetic Fields

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

are moved, they are usually more pronounced with AC sources.

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

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

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

2.9.3 Electromagnetic Interference (EMI)

The electromagnetic interference characteristics of the Model 7075 General Purpose Multiplexer Card comply with the electromagnetic compatibility (EMC) requirements of the European Union as denoted by the CE mark. However, it is still possible for sensitive measurements to be affected by external sources. In these instances, special precautions may be required in the measurement setup.

Sources of EMI include:

- radio and television broadcast transmitters
- communications transmitters, including cellular phones and handheld radios
- devices incorporating microprocessors and high speed digital circuits
- impulse sources as in the case of arcing in high-voltage environments

The effect on instrument performance can be considerable if enough of the unwanted signal is present.

The equipment and signal leads should be kept as far away as possible from any EMI sources. Additional shielding of the multiplexer card, measuring instrument, signal leads, and sources will often reduce EMI to an acceptable level. In extreme cases, a specially con-

structed screen room may be required to sufficiently attenuate the troublesome signal. Connecting unused shields to earth ground may also help.

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

2.9.4 Ground Loops

When two or more instruments are connected together, care must be taken to avoid unwanted signals caused by ground loops. Ground loops usually occur when sensitive instrumentation is connected to other instrumentation with more than one signal return path such as power line ground. As shown in Figure 2-24, the resulting ground loop causes current to flow through the instrument LO signal leads and then back through power line ground. This circulating current develops a small but undesirable voltage between the LO terminals of the two instruments. This voltage will be added to the source voltage, affecting the accuracy of the measurement.

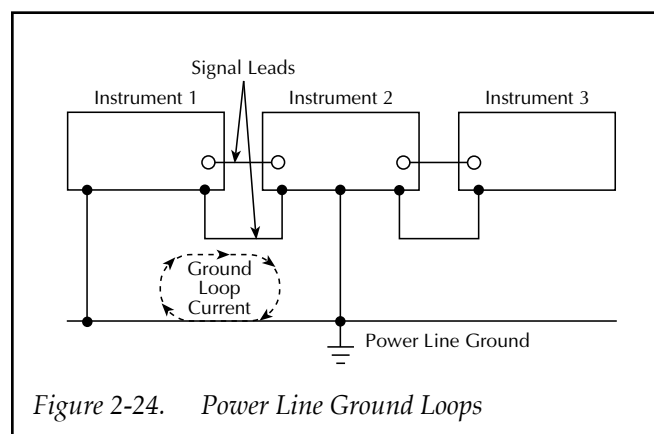


Figure 2-24. Power Line Ground Loops

Figure 2-25 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, only one instrument is connected to power line ground.

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

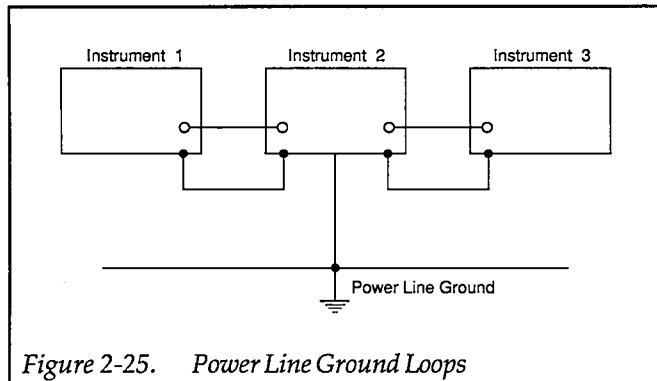


Figure 2-25. Power Line Ground Loops

2.9.5 Keeping Connectors Clean

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

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

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

2.9.6 Shielding

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

In order for shielding to be effective, the shield surrounding the HI signal path should be connected to signal LO at the test instrument (or chassis ground for instruments

without isolated LO terminals). Figure 2-10 shows an example of shielding. The multiplexer card Guard, which serves as the LO signal path, surrounds and shields the HI signal path. Additional shielding is provided by the outer shield of the connecting cables that are connected to chassis.

Note, however, that the shield should not be connected to LO or ground if the shield is to be driven at guard potential; guarding is discussed in the following paragraph. Also, shields should not be allowed to float, even if signal leads are not connected.

2.9.7 Guarding

Guarding is important in high-impedance circuits where leakage resistance and capacitance could have degrading effects on the measurement. Guarding consists of using a shield surrounding the conductors that are carrying the high-impedance signal. This shield is driven by a low-impedance amplifier to maintain the shield at signal potential. For the high isolation cables, the shield that surrounds each HI conductor can be separately guarded.

Guarding minimizes leakage resistance effects by driving the cable shield with a unity-gain amplifier, as shown in Figure 2-26. Since the amplifier has a high input impedance, it minimizes loading on the high-impedance signal lead. Also, the low output impedance ensures that the shield remains at signal potential, so that virtually no leakage current flows through the leakage resistance, R_L .

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

In order to use guarding effectively with the Model 7075, the shield for the conductor to be guarded should be connected to the guard output of the sourcing or measuring instrument. Figure 2-9 shows typical connections. Guard should be properly carried through as close as possible to the device under test to be completely effective. Typically, a guard shield around the DUT is used, as shown in Figure 2-9.

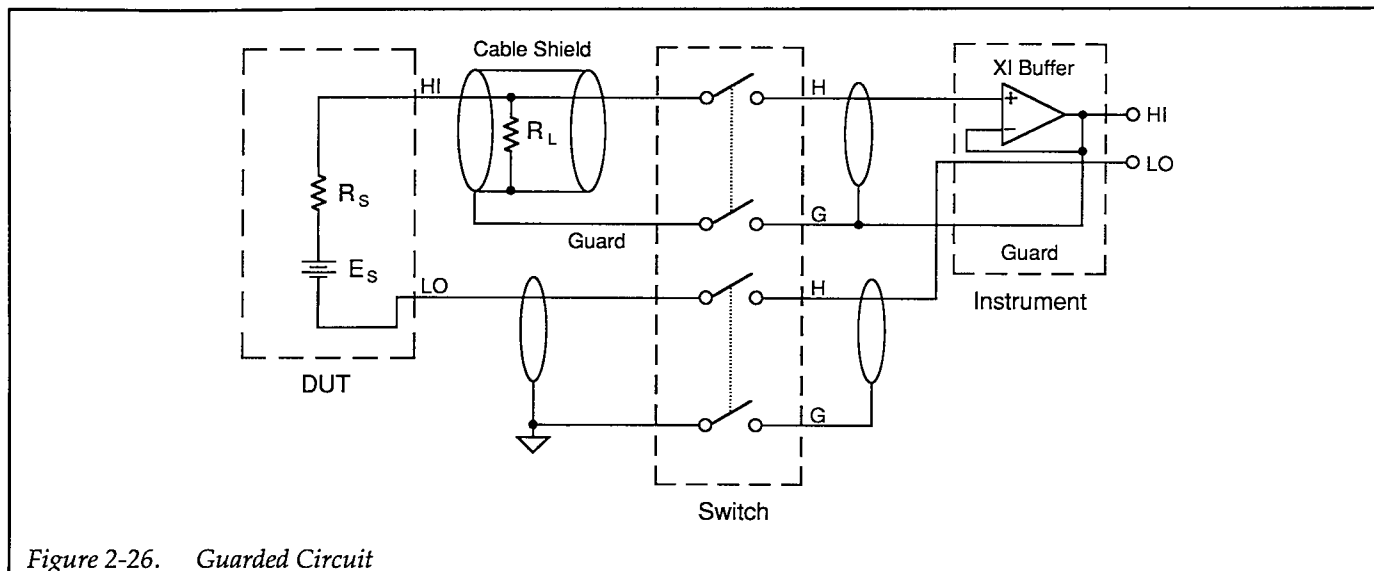


Figure 2-26. Guarded Circuit

WARNING

Be sure that all cable shields carrying guard are properly insulated to avoid possible personal contact with hazardous guard voltages. If a guard shield around the DUT is used, an earth-grounded safety shield, surrounding guard, must be provided to avoid a possible shock hazard.

2.9.8 Multiple Card Considerations

Several cards installed in one mainframe can be connected together to expand the multiplexer or to add multiplexing capability to matrix cards. When properly configured with the backplane jumpers, the banks of these cards are routed through the 3-pole general purpose backplane of the mainframe.

Since connecting two or more cards together effectively parallels the pathways, some degradation in card specifications can be expected when connecting two or more cards together to expand a multiplexer or matrix, as the case may be. For that reason, the specifications for the Model 7075 given at the front of this manual are applicable only with one card that uses the same backplane pathways installed in the mainframe.

2.9.9 Bandwidth and Crosstalk

Figure 2-27 through Figure 2-34 show typical AC response curves for the 3dB bandwidth and crosstalk.

Measurements for the eight plots were performed using the HP 8752A Network Analyzer under the following conditions:

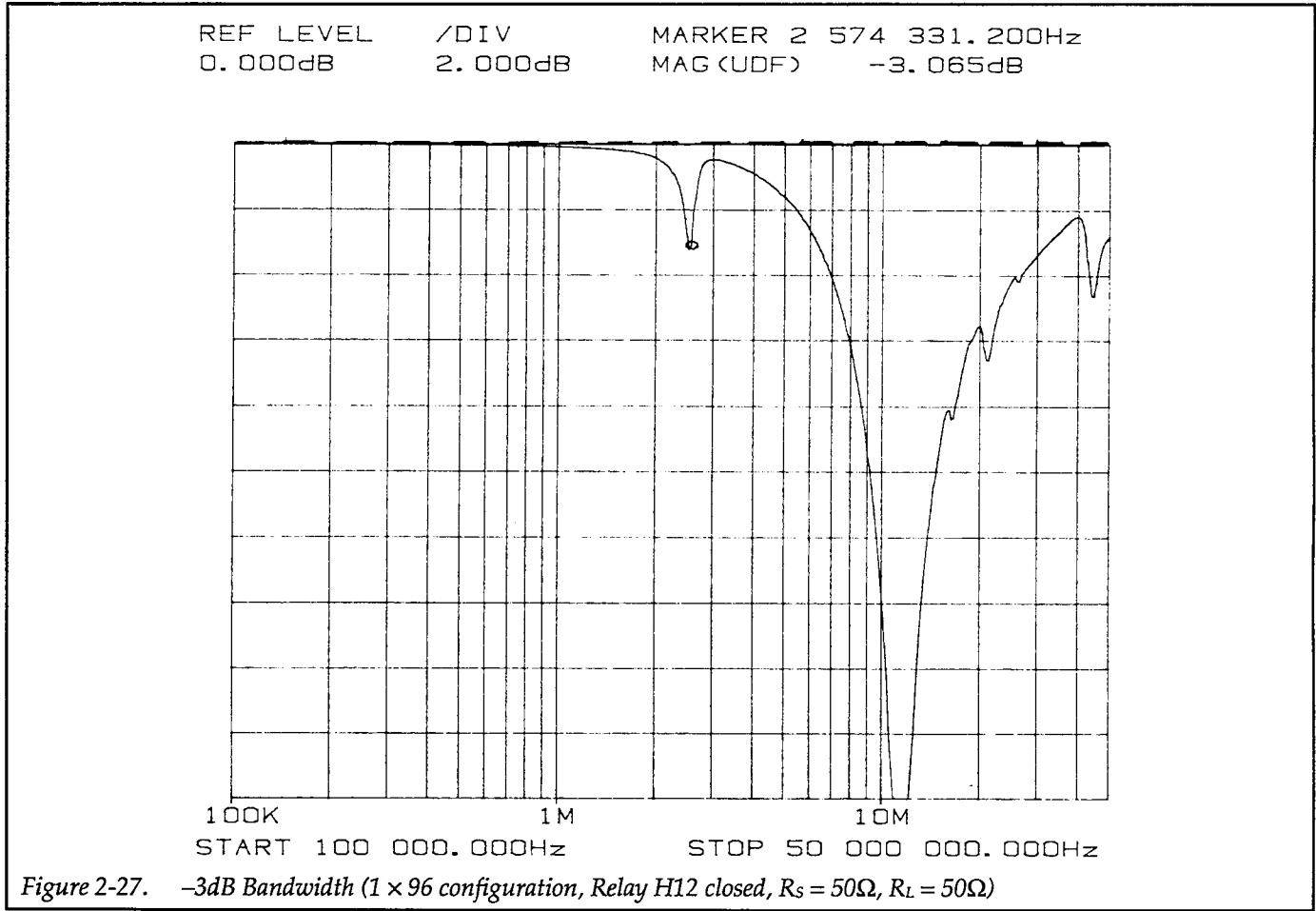
1. The Model 7075 backplane jumpers are installed and configured per factory default.
2. The Model 7075 is installed in slot #1 of the Model 707 mainframe. The other mainframe slots are empty.
3. 50Ω source (R_s).
4. 50Ω and 1MΩ loads (R_L).
5. Only the indicated relay for each test is closed. All others are open.
6. All test results are exclusive of cable capacitance effects. If you are connecting long cables to the card, the effects of distributed capacitance of the cables could reduce the bandwidth considerably.

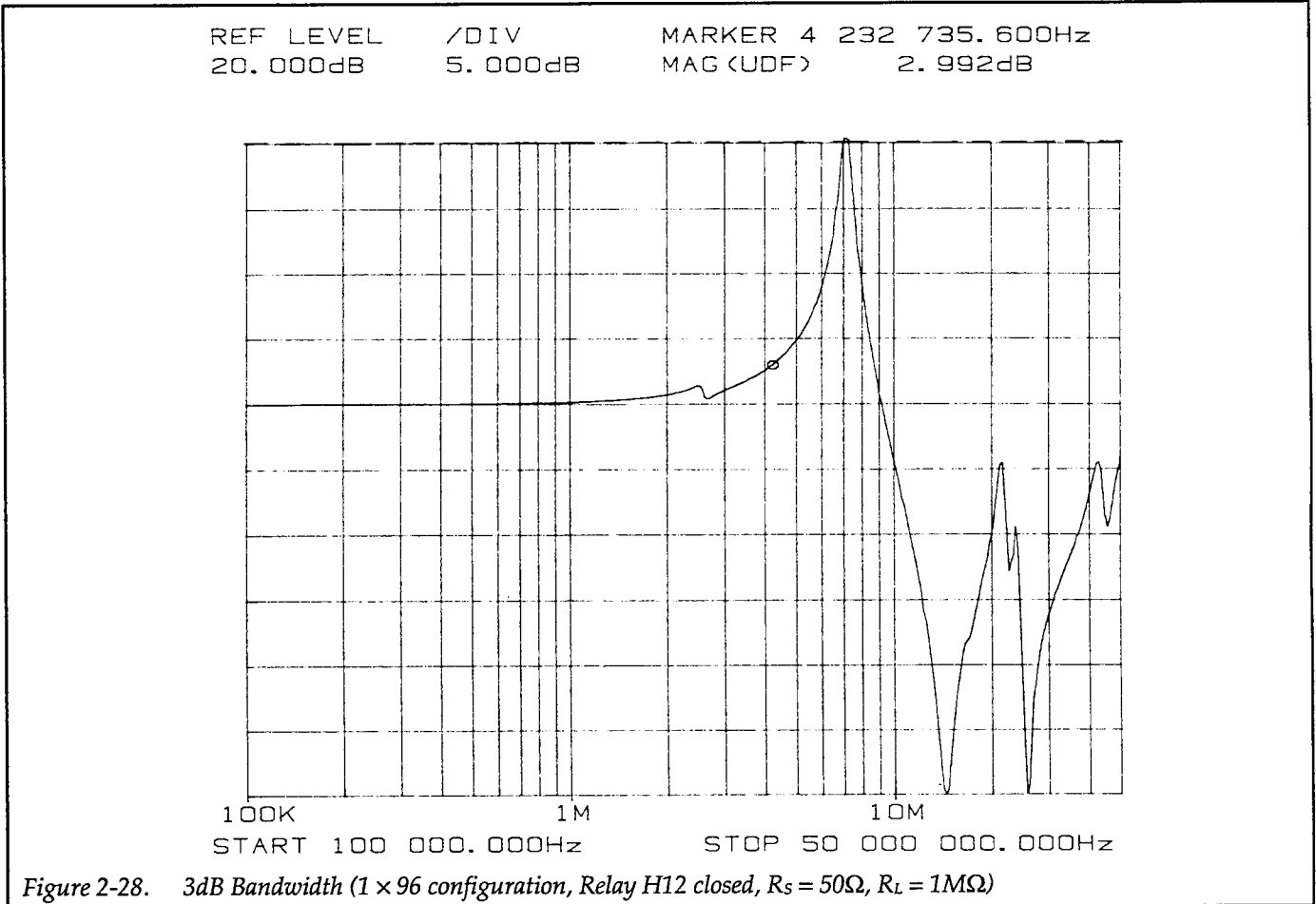
1 × 96 Configuration Response Curves

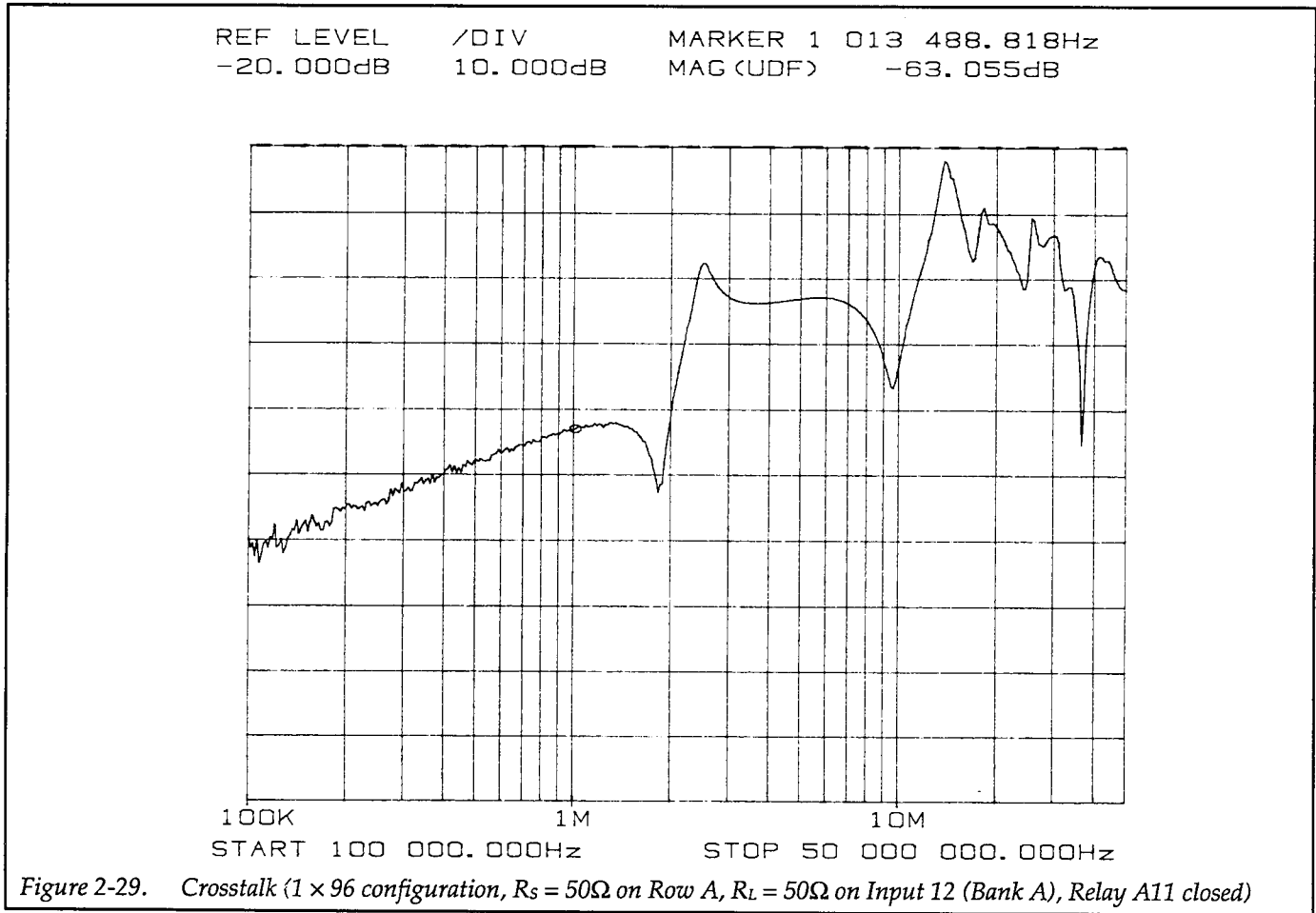
Bandwidth — The bandwidth response curves for the 1 × 96 configuration are shown in Figure 2-27 and Figure 2-28. For both curves, the 50Ω source (R_s) is connected to Row H, the load (R_L) is connected to Input 12 of Bank H, and relay H12 is closed. For Figure 2-27, R_L is a 50Ω load and for Figure 2-28, R_L is a 1MΩ load.

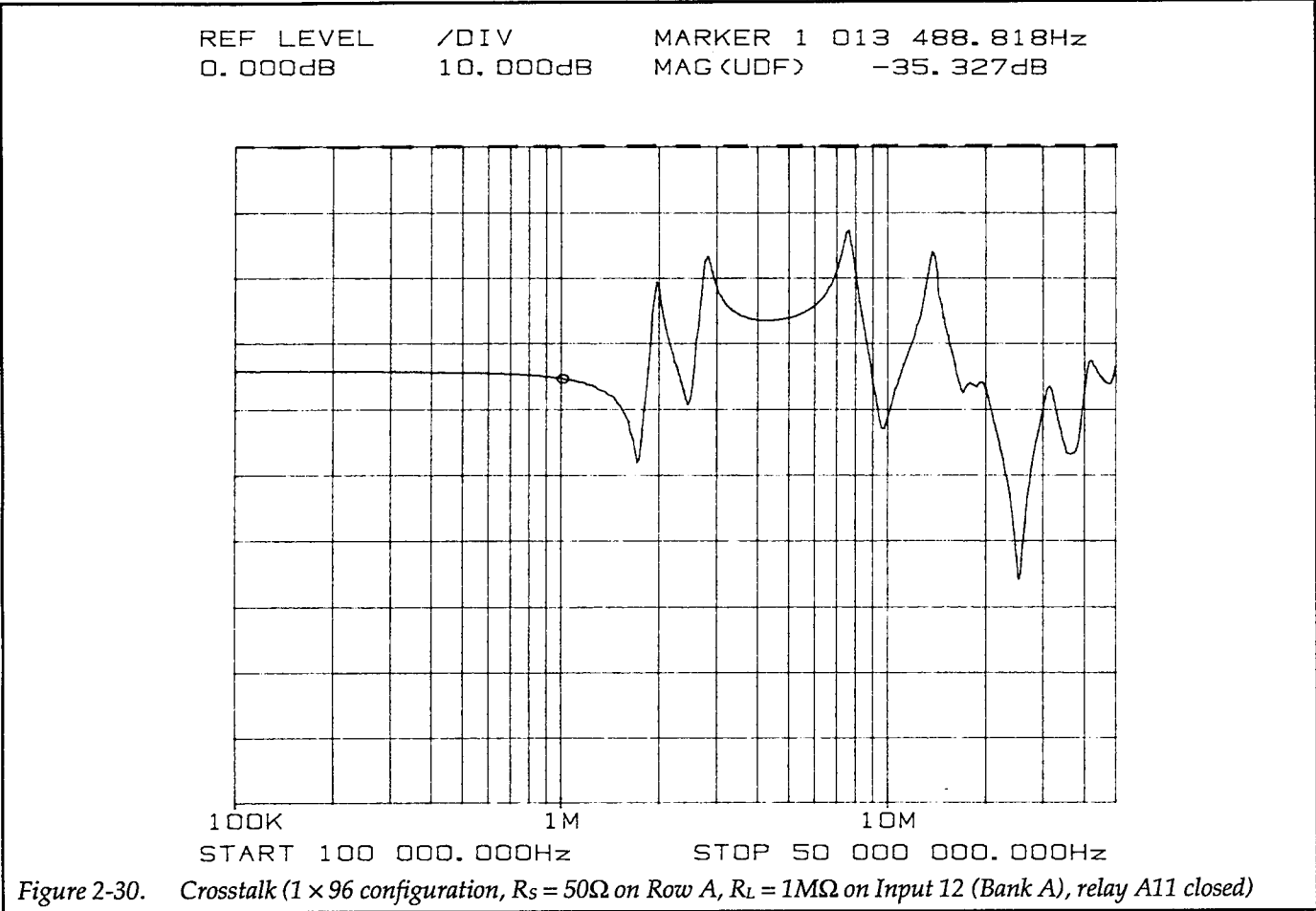
Crosstalk — The crosstalk response curves for the 1 × 96 configuration are shown in Figure 2-29 and Figure 2-30. For both curves, the 50Ω source (R_s) is connected to Row A, the load (R_L) is connected to Input 12 of Bank A, and relay A11 is closed. For Figure 2-29, R_L is a 50Ω load and for Figure 2-30, R_L is a 1MΩ load.

SECTION 2
Operation





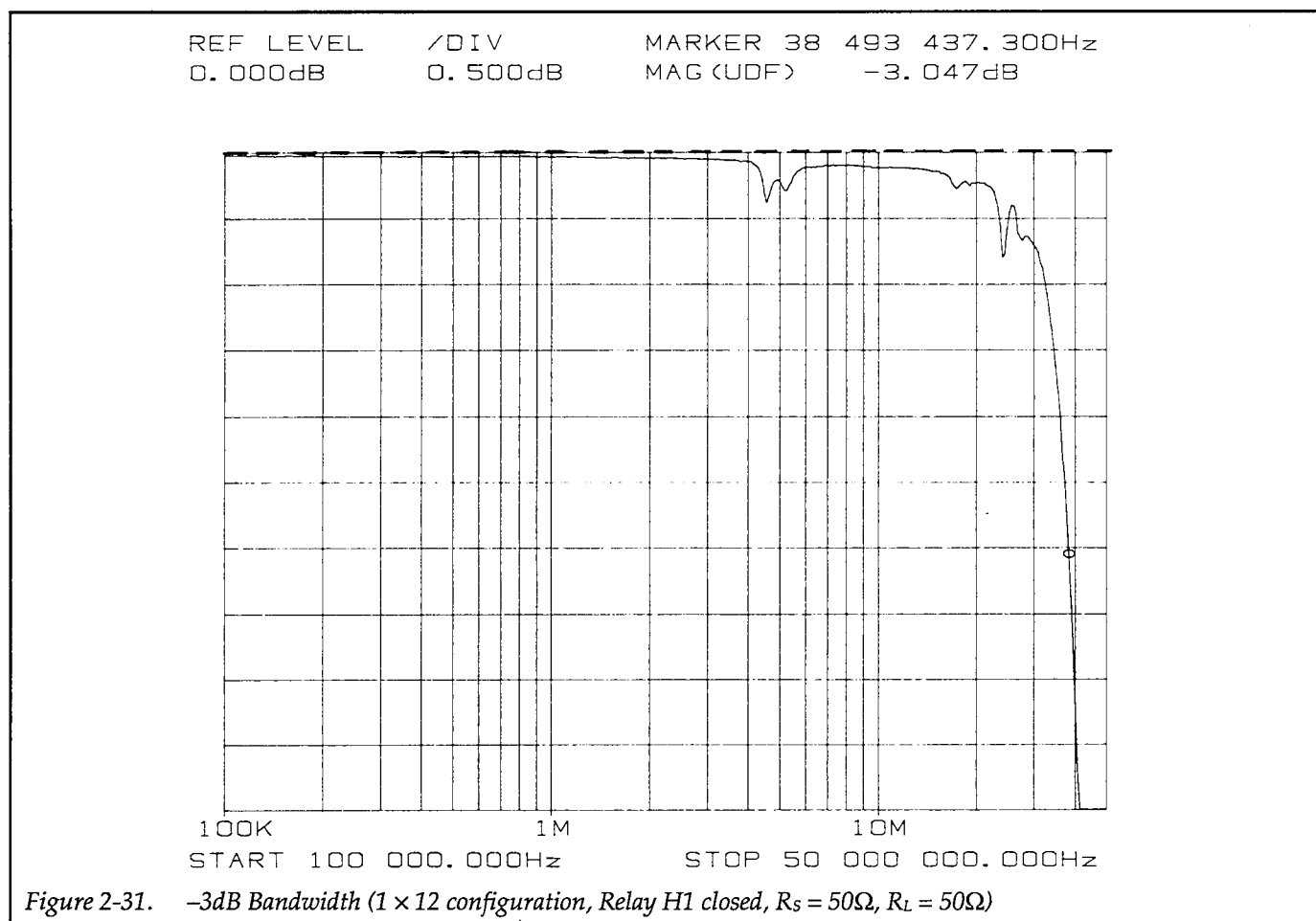


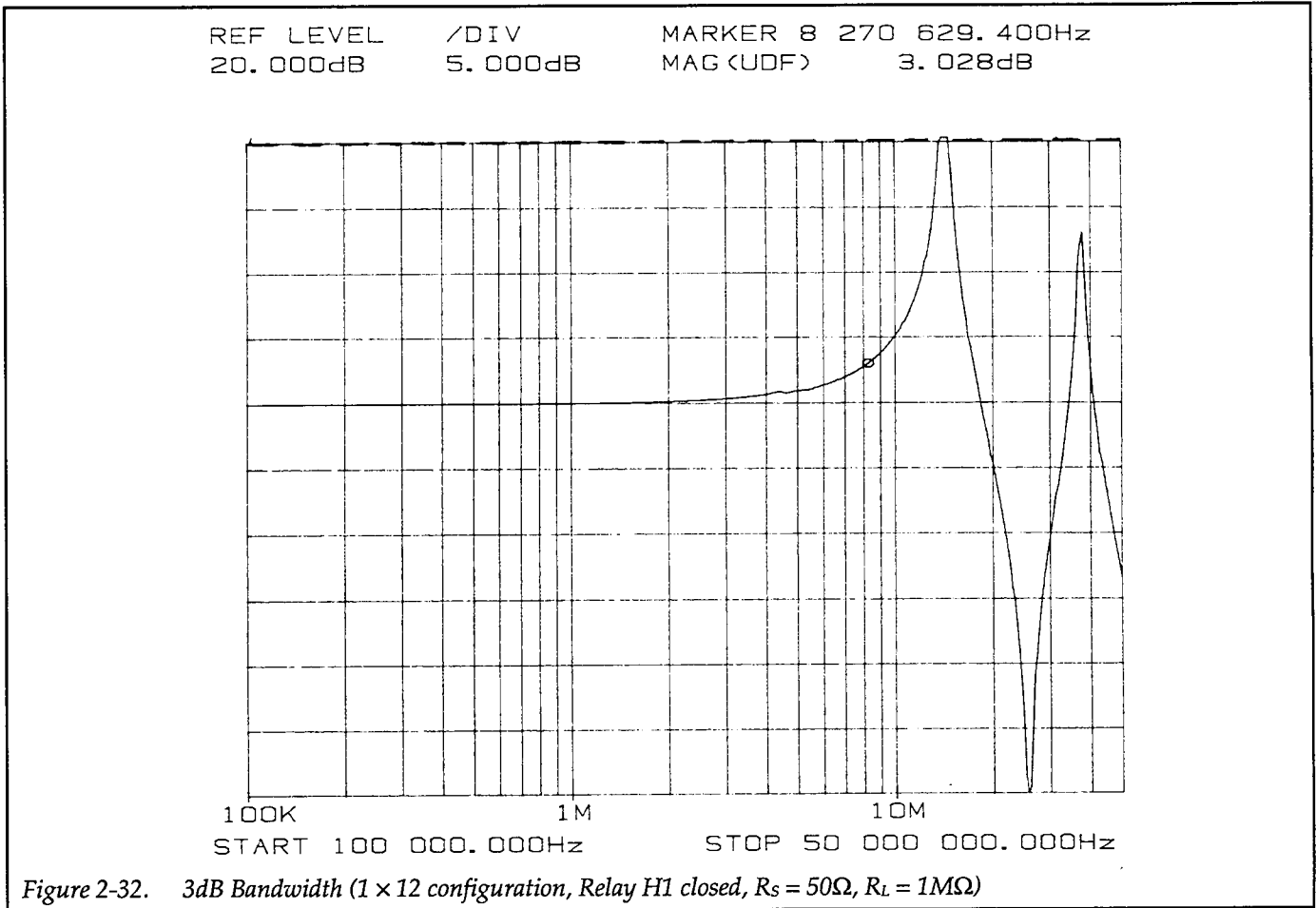


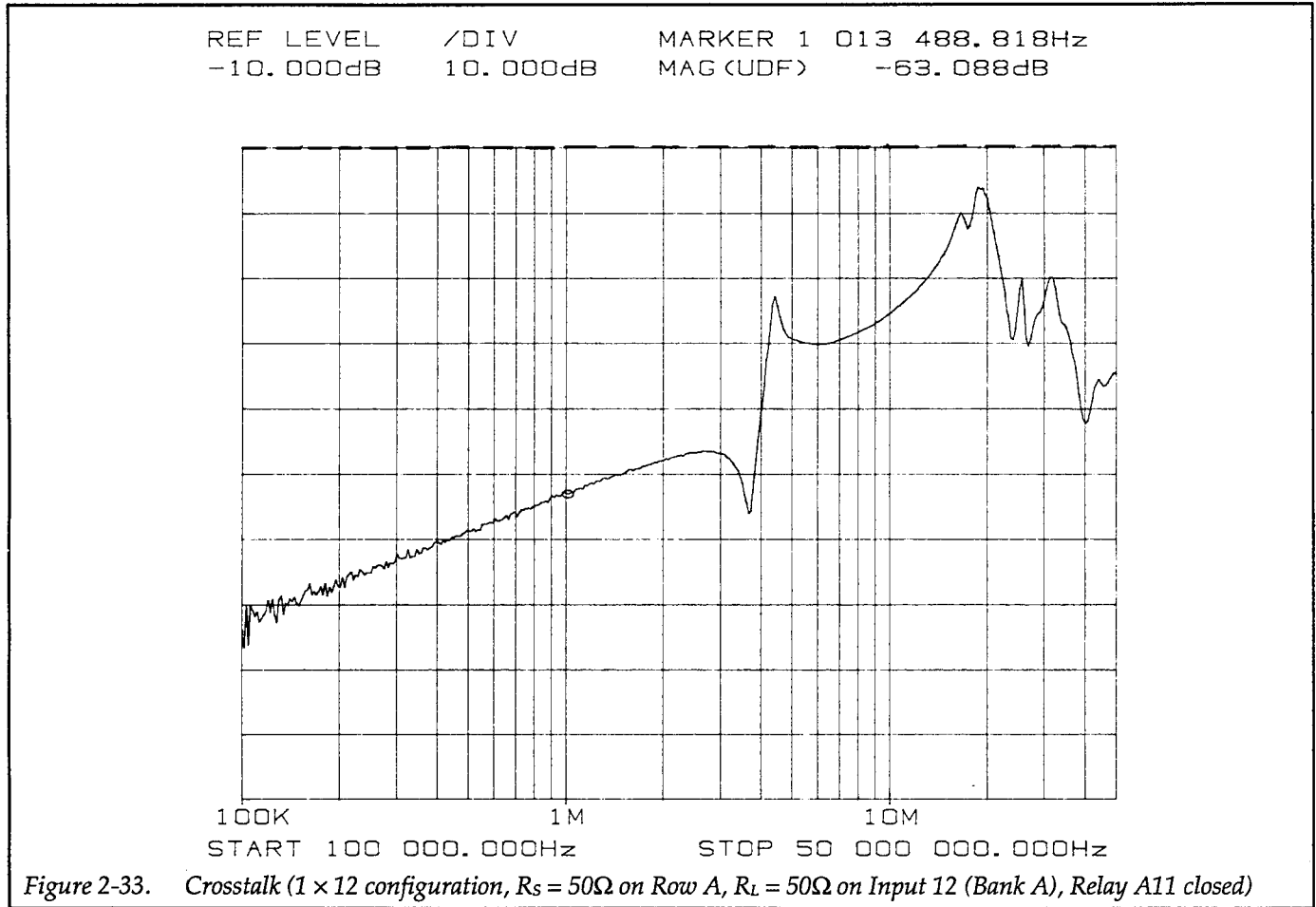
1 × 12 Configuration Response Curves

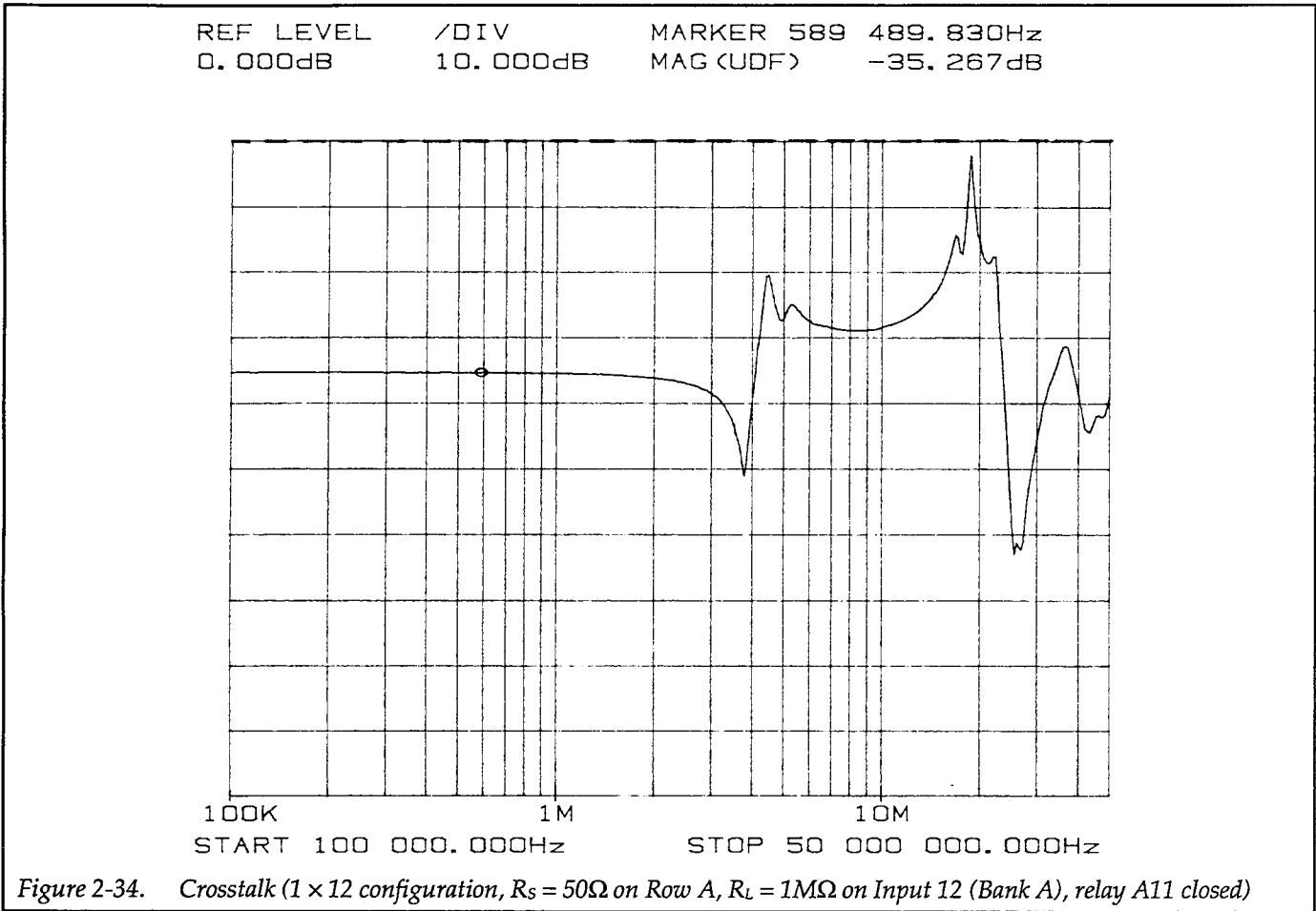
Bandwidth — The bandwidth response curves for the 1 × 12 configuration are shown in Figure 2-31 and Figure 2-32. For both curves, the 50Ω source (R_s) is connected to Row H, the load (R_L) is connected to Input 1 of Bank H, and relay H1 is closed. For Figure 2-31, R_L is a 50Ω load and for Figure 2-32, R_L is a 1MΩ load.

Crosstalk — The crosstalk response curves for the 1 × 12 configuration are shown in Figure 2-33 and Figure 2-34. For both curves, the 50Ω source (R_s) is connected to Row A, the load (R_L) is connected to Input 12 of Bank A, and relay A11 is closed. For Figure 2-33, R_L is a 50Ω load and for Figure 2-34, R_L is a 1MΩ load.









SECTION 3

Applications

3.1 INTRODUCTION

Applications for the Model 7075 Multiplexer Card will depend on your particular needs. This section presents some typical applications for the Model 7075, and it is arranged as follows:

3.2 Resistor Testing: Outlines three types of resistor tests, including 2-wire and 4-wire DMM tests, and low-resistance tests using a separate current source and nanovoltmeter.

3.3 Transistor Testing: Covers typical transistor tests such as current gain and common-emitter characteristics.

Testing with Matrix Cards: Shows how to use the Model 7075 with matrix cards like the Model 7076 to enhance test system capabilities.

Several example application programs, which are written in Hewlett-Packard BASIC 4.0, are included in this section. These programs are included only as examples to demonstrate fundamental programming techniques, and are not intended to suit specific needs.

3.2 Resistor Testing

The Model 7075 can be used to test a large number of resistors using only one test instrument or group of instruments. Such tests include 2-wire and 4-wire resistance measurements using a DMM, and low-resistance measurements using a current source and nanovoltmeter, as discussed in the following paragraphs.

3.2.1 2-Wire Resistance Tests

Figure 3-1 shows a typical test setup for making 2-wire resistance measurements. The Model 7075 card provides the switching function, while the resistance measurements are made by a Model 199 DMM. Since only 2-pole

switching is required for this application, one Model 7075 card can be used to switch up to 96 resistors (additional multiplexer banks can be added, if desired, by connecting cards together).

Short runs of #18 AWG or larger wire are recommended to minimize errors due to connecting wires. Various other techniques such as shorting one multiplexer input with heavy wire can be used to correct for nominal path resistance. With the shorted channel closed, enable the DMM zero feature, and leave zero enabled while making measurements.

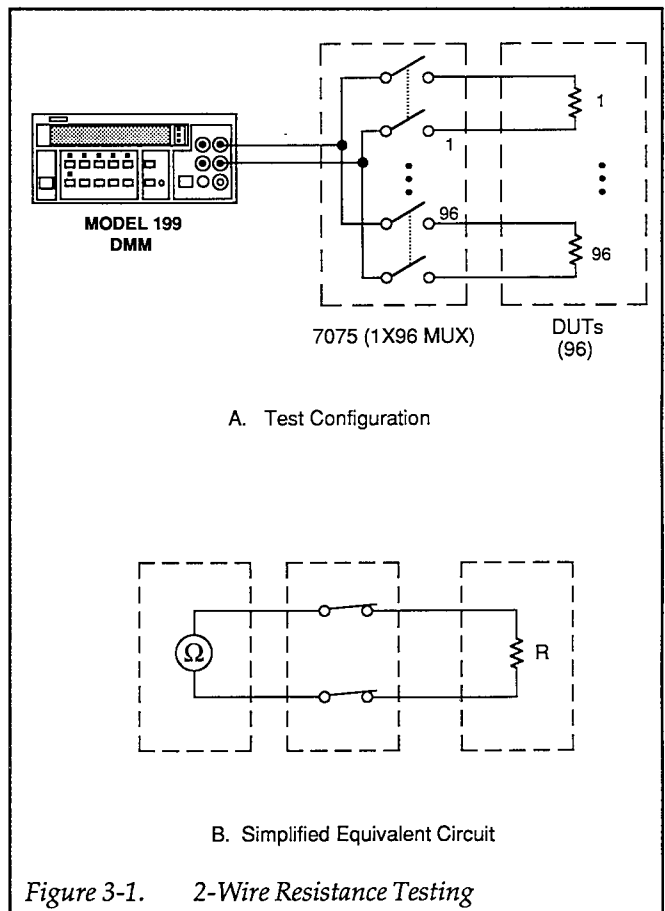


Figure 3-1. 2-Wire Resistance Testing

3.2.2 4-Wire Resistance Tests

More precise measurements over a wider range of system and DUT conditions can be obtained by using the 4-wire measurement scheme shown in Figure 3-2. Here, separate sense leads from the Model 196 DMM are routed through the multiplexer to the resistor under test. The extra set of sense leads minimizes the effects of voltage drops across the test leads. Note, however, that an extra two poles of switching are required for each resistor to be tested. For that reason, only 48 resistors per card can be tested using this configuration.

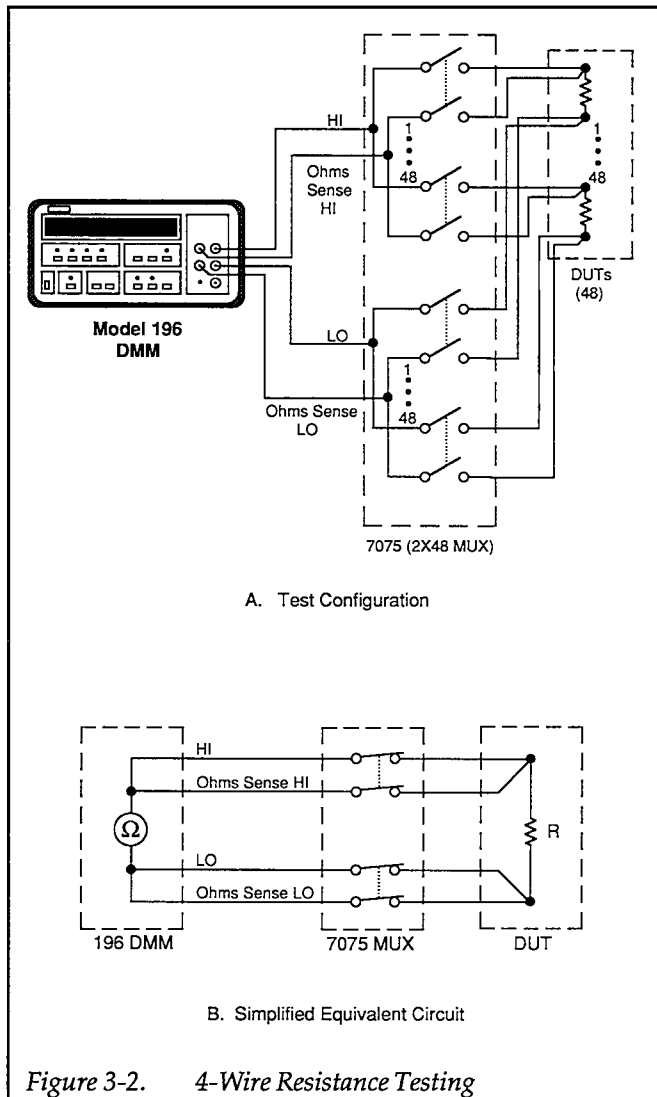


Figure 3-2. 4-Wire Resistance Testing

Although the 4-wire connection scheme does minimize problems caused by voltage drops, there is one other potentially troublesome area associated with low resistance measurements: thermal EMFs caused by the relay contacts. In order to compensate for thermal EMFs, the offset-compensated ohms feature of the Model 196 DMM should be used. To use this feature, short the HI and Guard terminals of one of the bank inputs, (at the card BANK connector) then close the relay. Enable zero on the Model 196, then select offset-compensated ohms.

3.2.3 Low-Level Resistance Measurements

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

Figure 3-3 shows a typical test configuration for a switching system capable of testing a number of low-resistance devices. The Model 220 Current Source forces current through the device under test, while the Model 181 Nanovoltmeter measures the resulting voltage across the device.

Since low voltage levels are being measured, thermal EMF offsets generated by relay and connector contacts will have a detrimental effect on measurement accuracy unless steps are taken to avoid them. Thermal EMF effects can be virtually eliminated by taking two voltage measurements, E1 and E2, the first with the current, I, flowing in one direction, and the second with a current, I, of the same magnitude flowing in the opposite direction. The resistance can then be calculated as follows:

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

Note that simply reversing the current source polarity will result in a 2X accuracy specification change. To avoid this problem, matrix switching could be added to the test system to reverse the current. See paragraph 3.4.

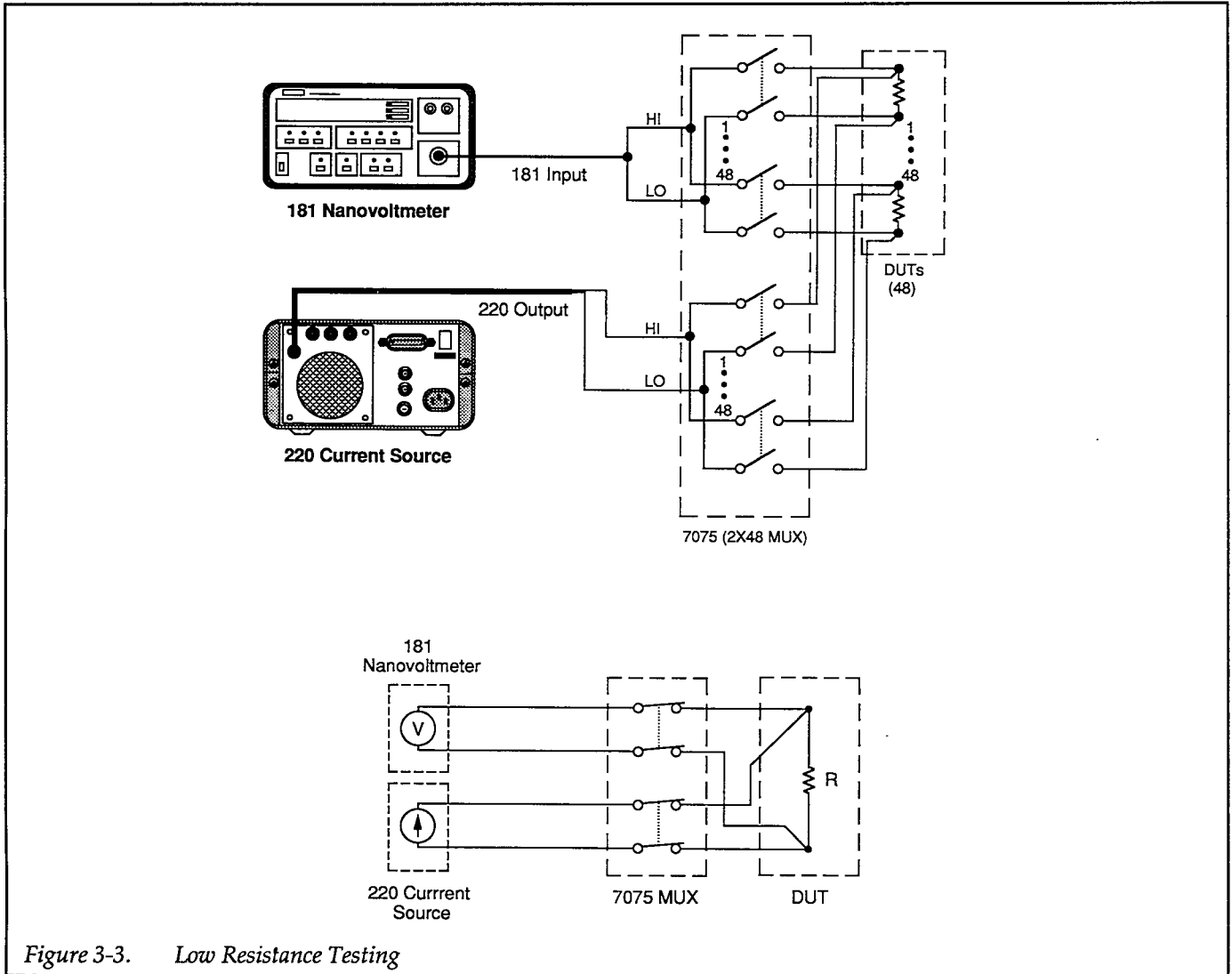


Figure 3-3. Low Resistance Testing

3.2.4 Example Resistor Test Program

The example program below demonstrates programming techniques for testing resistors using the 2-wire test configuration shown in Figure 3-1. The program assumes that the Model 7075 is located in slot 1 of the mainframe, and that all 96 inputs are to be used for testing. The program sequences through all 96 inputs, taking a resistance reading on each channel and displaying the results. A one-second delay is incorporated into the program for settling.

PROGRAM	COMMENTS
10 REMOTE 718	Put 707 in remote.
20 REMOTE 726	Put 199 in remote.
30 OUTPUT 718;"R0X"	Reset 707.
40 OUTPUT 726;"F2R0G1T3X"	199 ohms, autorange, one-shot trigger.
50 FOR I=65 TO 72	Loop for A-H ASCII values.
60 FOR J=1 TO 12	Loop for all 12 inputs.
70 OUTPUT 718;"C";CHR\$(I);J;"X"	Close row CHR\$(I), input J.
80 WAIT 1	Wait one second settling time.
90 TRIGGER 726	Trigger 199 reading.
100 ENTER 726;A\$	Get 199 resistance reading.
110 PRINT "BANK";CHR\$(I); "CHANNEL";J;"READING:";A\$	Display row, input reading
120 OUTPUT 718;"N";CHR\$(I);J;"X"	Open bank CHR\$(I), input J.
130 NEXT J	Loop back for next input.
140 NEXT I	Loop back for next row.
150 END	

3.3 TRANSISTOR TESTING

Typical transistor tests that can be performed with the aid of the Model 7075 include current gain tests, leakage tests, as well as tests to determine the common-emitter characteristics of the device. The following paragraphs discuss these tests and give typical equipment configurations for the tests.

3.3.1 Current Gain Tests

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

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

Figure 3-4 shows the test configuration and equivalent circuit for the current gain test. The Model 224 Current Source is used to source the base current, I_B . The Model 230 Voltage Source supplies the collector-emitter voltage, V_{CE} , and the collector current, I_C , is measured by the Model 196 DMM. Switching among the transistors being tested is, of course, performed by the Model 7075 multiplexer card.

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

In order to reduce errors caused by voltage burden, use a higher current range on the Model 196 DMM. Doing so will result in the loss of one or two decades of resolution,

but 3-1/2 or 4-1/2 digit resolution will probably be adequate for most situations.

3.3.2 Common-Emitter Characteristic Tests

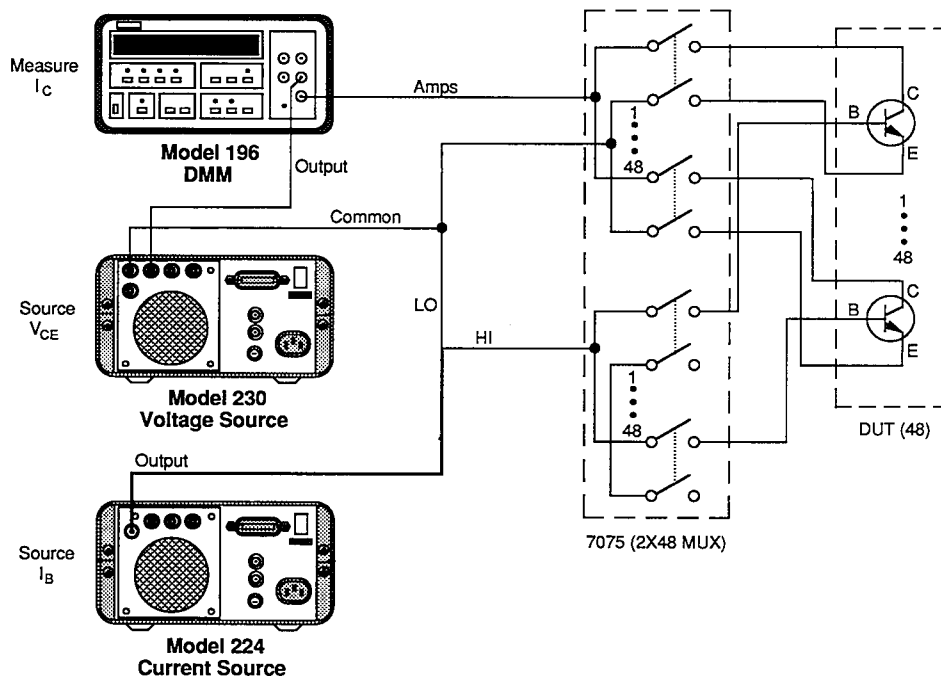
Common-emitter characteristics are determined by setting the base current, I_B , to specific values. At each I_B value, the collector-emitter voltage, V_{CE} , is swept across the desired range at specific intervals, and the collector current, I_C , is then measured. When the data are plotted, the result is the familiar family of common-emitter curves (Figure 3-5).

The same test configuration that is used for current gain tests can be used for measuring common-emitter characteristics (Figure 3-4). The Model 224 is used to set the base current, I_B , to the desired values. The Model 230 Voltage Source provides the collector-emitter voltage, V_{CE} , and the Model 196 DMM measures the collector current, I_C .

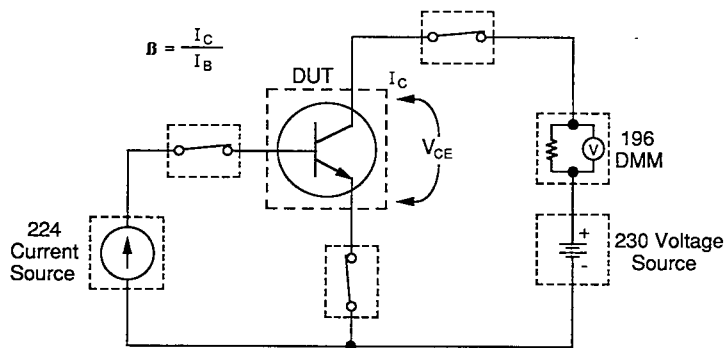
3.3.3 Example Transistor Test Program

The example program below shows general techniques for performing current gain tests using the test setup shown in Figure 3-4 (note that the Model 224 Current Source must be equipped with the optional Model 2243 IEEE-488 interface). The program will allow the operator to type in the desired voltage source (V_{CE}) and current source (I_B) values.

Note that the program assumes that the Model 7075 is located in slot 1 of the mainframe, and that 48 transistors are to be tested for current gain. Because of the switching configuration used, two bank-input combinations must be closed simultaneously. For example, Row A, Input 1, and Row E, Input 1 will be closed at the same time.



A. Test Configuration



B. Simplified Equivalent Circuit

Figure 3-4. Configuration for Current Gain and Common Emitter Test

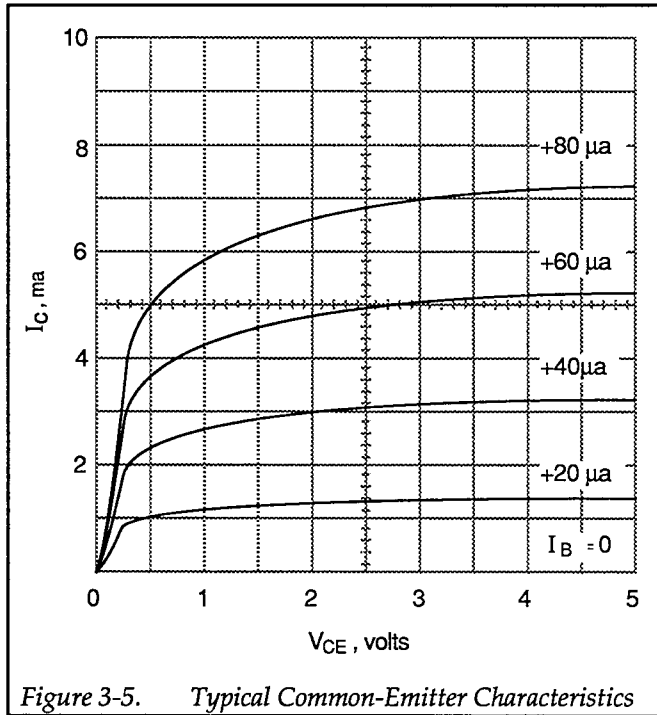


Figure 3-5. Typical Common-Emitter Characteristics

PROGRAM	COMMENTS
10 REMOTE 718	Put 707 in remote.
20 REMOTE 713	Put 230 in remote.
30 REMOTE 719	Put 224 in remote.
40 REMOTE 707	Put 196 in remote.
50 CLEAR 7	Clear instruments.
60 OUTPUT 718;"R0X"	Reset 707.
70 OUTPUT 713;"I2X"	230 20mA current limit.
80 OUTPUT 719L;"V10X"	224 10V compliance limit.
90 OUTPUT 707;"F3R0G1T3X"	196 DCA, autorange, one-shot trigger.
100 INPUT "VCE VALUE (0-101V)", Vce	Input V_{CE} value.
110 IF ABS(Vce) > 101 THEN GOTO	Check voltage limits.
120 OUTPUT 713;"V";Vce;"X"	Program 230 voltage.
120 INPUT "Ib VALUE (0-101MA)", Ib	Input I_B value.
130 IF ABS(Ib) > 101E-3 THEN GOTO	Check current limits.
120	
140 OUTPUT 719;"I";Ib;"X"	Program 224 current.
150 IF ABS(Vce)>30 THEN PRINT	Display hazard warning.
"WARNING: HAZARDOUS	
VOLTAGE WILL BE APPLIED TO	
DEVICE DURING TEST"	
160 INPUT "PRESS ENTER TO BE-	Pause for start signal from op-
GIN",A\$	erator.
170 OUTPUT 719;"F1X"	Turn on 224 output.
180 OUTPUT 713;"F1X"	Turn on 230 output.
190 FOR I=65 TO 68	Loop for ASCII A-D values.
200 C1\$=CHR\$(I)	Define row A-D command let-
	ter.
210 C2\$=CHR\$(I+4)	Define row F-H command let-
	ter.
220 FOR J=1 TO 12	Loop for all 12 inputs in bank.
230 OUTPUT 718;"C";C1\$;J;"X"	Close row A-D input J.
240 OUTPUT 718;"C";C2\$;J;"X"	Close row E-H, input J.
250 WAIT 1	Wait one second for settling.
260 TRIGGER 707	Trigger 196 reading.
270 ENTER 707; Ic	Get 196 current reading (I_c).
280 PRINT "BANK";C1\$;	Display row A-D, input read-
"CHANNEL"; J;"DEVICE	ing.
CURRENT GAIN";:Ic/Ib	
290 OUTPUT 718;"N";C1\$;J;"X"	Open row A-D, input J.
300 OUTPUT 718;"N";C2\$;J;"X"	Open row E-H, input J.
310 NEXT J	Loop back for next input.
320 NEXT I	Loop back for next row.
330 OUTPUT 713;"F0X"	Turn off 230 output.
340 OUTPUT 719;"F0X"	Turn off 224 output.
350 END	

3.4 TESTING WITH MATRIX CARDS

The Model 7075 can be added to a matrix switching system to enhance the test capabilities of that system. The following paragraphs discuss an overall multiplexer/matrix switching system and also briefly outline a typical test that can be made with such a system.

3.4.1 Multiplexer and Matrix Card Connections

Figure 3-6 shows a typical system using Model 7076 and 7075 cards together. In this instance, the multiplexer card is configured as eight 1×12 multiplexers. Note that rows A through H of the card are connected to rows A through H of the matrix through the backplane of the mainframe; no external wiring is necessary to connect the two cards together.

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

3.4.2 Resistivity Tests

The general test configuration shown in Figure 3-7 can be used to perform resistivity tests on semiconductors. Such tests can yield important information such as doping concentration.

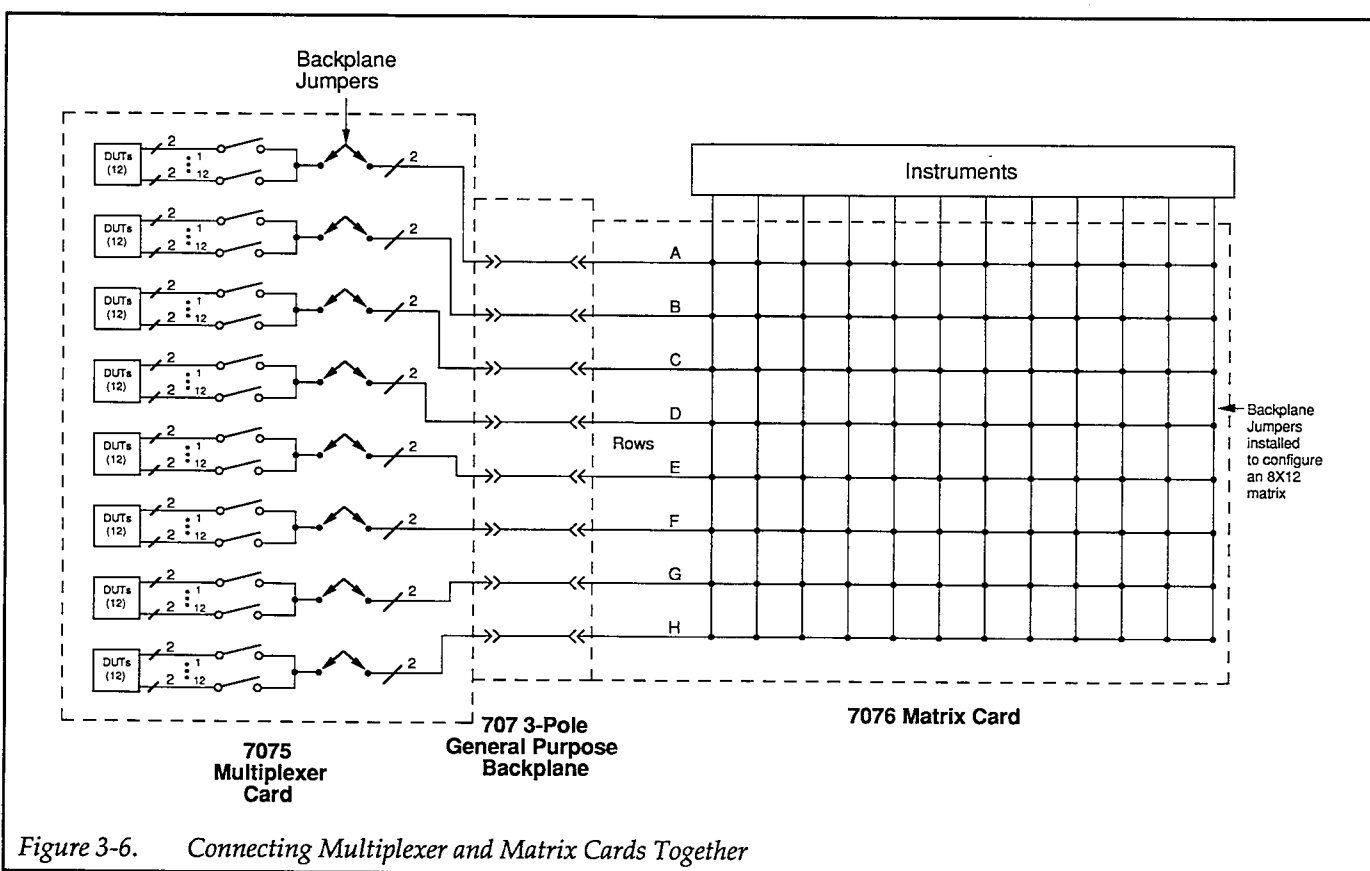


Figure 3-6. Connecting Multiplexer and Matrix Cards Together

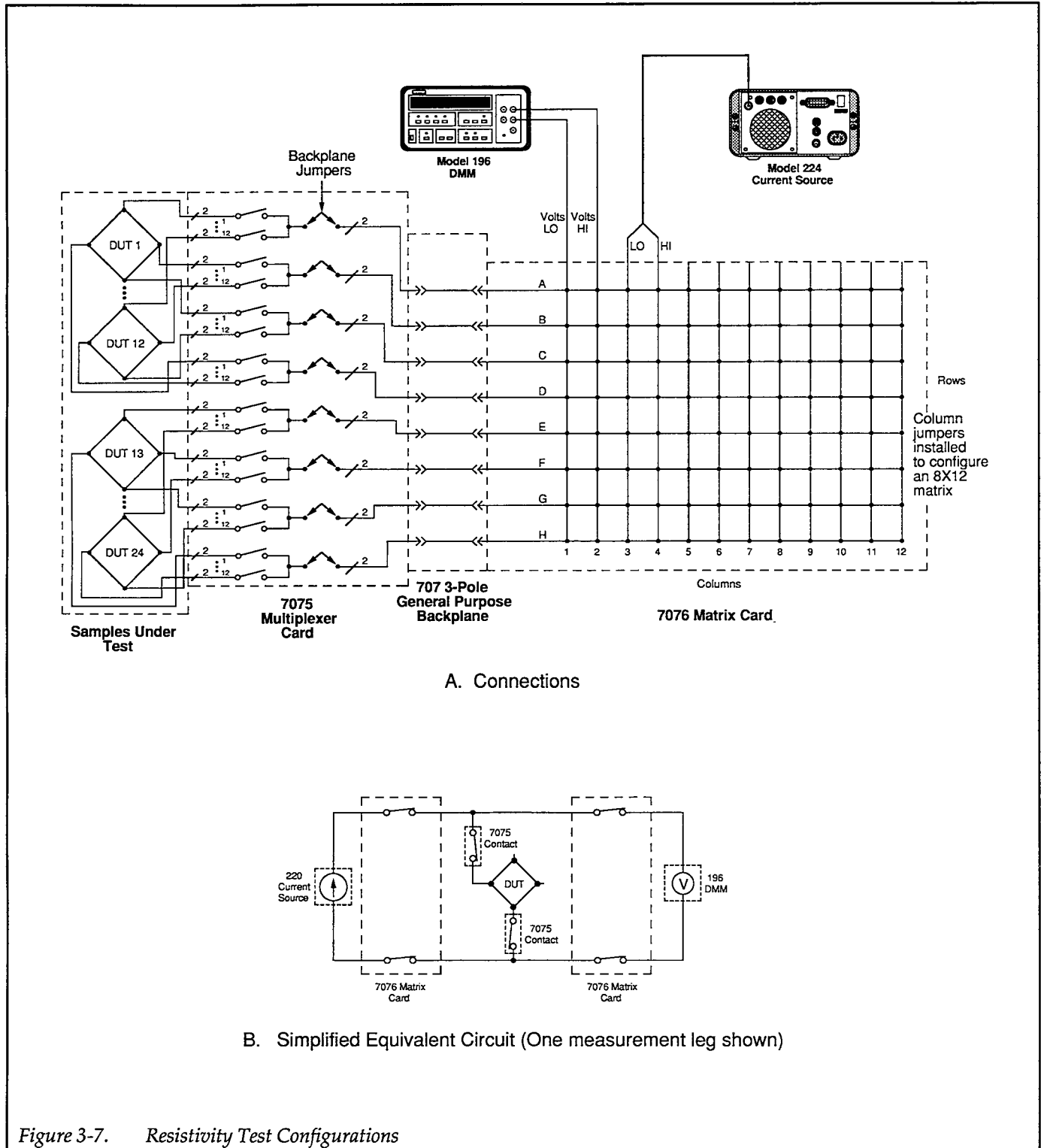


Figure 3-7. Resistivity Test Configurations

As shown in Figure 3-7, the Model 7075 switches a large number of samples for the test. The Model 7076 Matrix Card allows any device test node to be connected to any instrument terminal. The Model 220 Current Source forces a current through the DUT, and the Model 196 DMM measures the voltage across the device. In order to minimize errors caused by sample loading, the Model 196 should be used on the 300mV or 3V ranges. Also, resistance values should be 1M Ω or less.

In order to perform the tests, a current (from the the Model 220) is applied to two terminals, and the voltage is measured (by the Model 196) across the two opposite terminals. A total of eight such measurements are required, as shown in Figure 3-8.

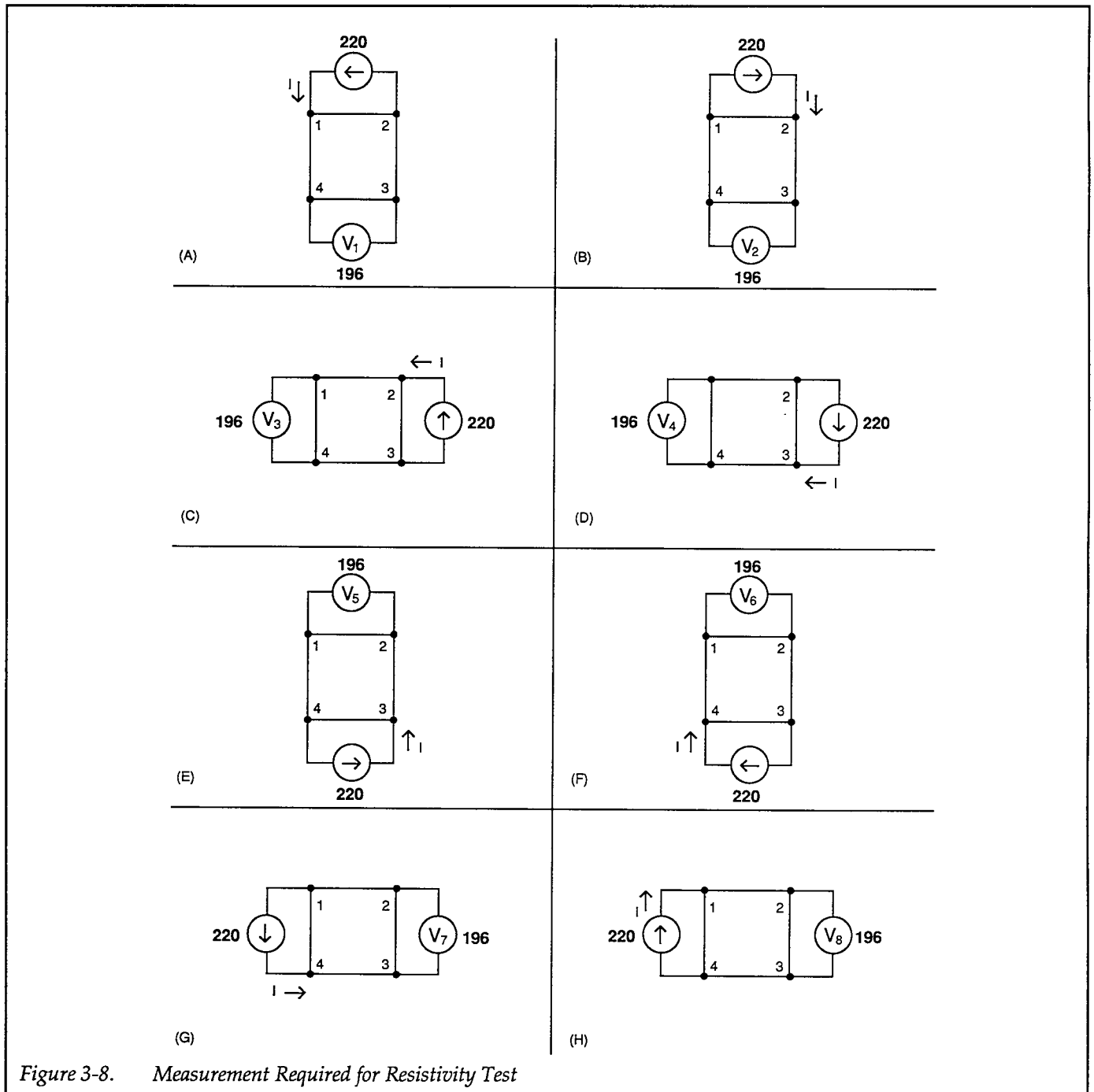


Figure 3-8. Measurement Required for Resistivity Test

Once the measurements have been taken, the resistivity can be calculated. Two values of resistivity, A and B, are initially computed as follows:

$$\sigma_A = \frac{1.1331f_A T_8 (V_2 + V_4 - V_1 - V_3)}{I}$$

$$\sigma_B = \frac{1.1331f_B T_8 (V_6 + V_8 - V_5 - V_7)}{I}$$

Where:

σ_A and σ_B are the resistivities in Ω -cm,

t_s is the sample thickness in cm,

V_1 through V_8 are the voltages measured by the Model 196,

I is the current through the sample in amperes,

f_A and f_B are geometrical factors based on sample symmetry ($f_A = f_B = 1$) for perfect symmetry).

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

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

3.4.3 Example Resistivity Test Program

The program shown below demonstrates programming fundamentals for making resistivity tests using the test setup shown in Figure 3-7. The program assumes that the Model 7075 is located in slot 1, and the Model 7076 is located in slot 2 of the mainframe. Also note that the Model 196 is connected to columns 1 and 2, while the Model 220 is connected to columns 3 and 4. The test is restricted to the first 12 4-terminal samples (DUT 1 to DUT 12) for the sake of simplicity.

PROGRAM	COMMENTS
10 DIM A(12,8)	Dimension reading array.
20 REMOTE 718	Put 707 in remote.
30 REMOTE 707	Put 196 in remote.
40 REMOTE 712	Put 220 in remote.
50 CLEAR 7	Clear instruments.
60 OUPUT 707;"F0R0G1X"	196 DCV, auto range, data format.
70 OUTPUT 712;"V30X"	220 30V compliance.
80 OUTPUT 718;"R0X"	Reset 707
90 INPUT "220 CURRENT (<=101mA)",I1	Input 220 current.
100 I1 = ABS(I1)	Use positive current only.
110 IF I1 > 101E-3 THEN GOTO 90	Check current limits.
120 OUTPUT 712;"I";I1;"X"	Program 220 current.
130 INPUT "PRESS ENTER TO START" AS	Pause for operator signal.
140 FOR I=1 TO 12	Loop for all 12 DUTs.
150 OUTPUT 718;"CA";I;"B";I;"C";I;"D";I;"X"	Close 7074 inputs.
160 RESTORE	Restore data pointer.
170 FOR J=1 TO 8	Loop for all eight readings.
180 READ C\$	Read 7071 command string.
190 OUTPUT 718;"C";C\$;"X"	Close 7071 crosspoints.
200 WAIT 1	Wait one second for settling.
210 OUTPUT 707;"Z1X"	Zero the 196.
220 WAIT 1	One second settling time.
230 OUTPUT 712;"F1X"	Turn on 220 output.
240 WAIT 1	One second settling time.
250 ENTER 707; A(I,J)	Get 196 reading, store in array.
260 OUTPUT 712;"F0X"	Turn off 220 output.
270 OUTPUT 707;"Z0X"	Turn off 196 zero.
280 OUTPUT 718;"N";C\$;"X"	Open 7071 crosspoints.
290 NEXT J	Loop back and make measurement.
300 OUTPUT 718;"NA";I;"B";I;"C";I;"D";I;"X"	Open 7074 inputs.
310 NEXT I	Loop back and measure next DUT.
320 INPUT "ENTER SAMPLE THICKNESS (CM)", T	Input sample thickness.
330 FOR I=1 TO 12	Loop for all 12 devices.
340 Pa=1.1331*T/I1*(A(I,2)+A(I,4)-A(I,1)-A(I,3))	Compute A.
350 Pb=1.1331*T/I1*(A(I,6)+A(I,8)-A(I,5)-A(I,7))	Compute B.
360 Pavg=(Pa+Pb)/2	Compute average resistivity.
370 PRINT"DEVICE";I;"RESISTIVITY=";PAVG;"OHM-CM"	Display average resistivity.
380 NEXT I	Loop back for next device.
390 DATA "A16,B15,C13D14"	7071 command strings.
400 DATA "A15,B16,C13,D14"	
410 DATA "A14,B16,C15,D13"	
420 DATA "A14,B15,C16,D13"	
430 DATA "A13,B14,C16,D15"	
440 DATA "A13,B14,C15,D16"	
450 DATA "A15,B13,C14,D16"	
460 DATA "A16, B13, C14, D15"	
470 END	

SECTION 4

Service Information

4.1 INTRODUCTION

This section contains information necessary to service the Model 7075 Multiplexer Card and is arranged as follows:

4.2 Handling and Cleaning Precautions: Discusses handling precautions and methods to clean the card should it become contaminated.

4.3 Relay Test Program Setup: Explains how to connect the multiplexer card to the mainframe for the relay test program.

4.4 Performance Verification: Covers the procedures necessary to determine if the card meets stated specifications.

4.5 Special Handling of Static-Sensitive Devices: Reviews precautions necessary when handling static-sensitive devices.

4.6 Disassembly: Details disassembly of the Model 7075 and also outlines important reassembly points.

4.7 Troubleshooting: Presents some troubleshooting tips for the Model 7075 including relay replacement precautions.

4.8 Principles of Operation: Briefly discusses circuit operation.

WARNING

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

4.2 HANDLING AND CLEANING PRECAUTIONS

Because of the high-impedance areas on the Model 7075, 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. Do not touch areas adjacent to electrical contacts. When servicing the card, wear clean, cotton gloves.
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.

4.3 RELAY TEST PROGRAM SETUP

The relays on Model 7075 can be tested using the test software supplied with the Model 707 Switching Matrix. The following paragraphs discuss the test equipment and connections. For detailed information on using the test software, consult Section 6 of the Model 707 Instruction Manual.

If your copy of the test software does not support the Model 7075, contact the Sales Department for a free upgrade. Model numbers are:

for IBM PC/XT/AT: 7078-RTS-1
for HP Series 200/300: 7078-RTS-2

4.3.1 Recommended Equipment

- Model 707 Switching Matrix
- Model 7076-CMTC High Isolation Cable
- CS-400 D-sub Plug
- Relay test software (supplied with Model 707)
- IBM PC compatible or Hewlett-Packard Series 200 or 300 computer
- Relay test terminal block (supplied with Model 707)

4.3.2 Connections

The test cable should be prepared using the information shown in Figure 4-1. The relay connector should be connected to the ROW A-H plug using 2-foot lengths of stranded hook-up wire.

Figure 4-2 shows how to connect the prepared test cable to the Model 7075. Connect the D-sub plug the ROW A-H connector, and be sure to connect the test connector to the RELAY TEST jack on the rear panel of the Model 707.

Using four Model 7076-CMTC cables, connect banks A to B, C to D, E to F, and G to H as shown in Figure 4-2.

4.3.3 Running the Test

Follow the instructions given in the Model 707 Instruction Manual to perform the relay test. The computer will advise you as to which relay, if any, fails to pass the test.

4.4 PERFORMANCE VERIFICATION

The following paragraphs discuss performance verification procedures for the Model 7075, including path resistance, offset current, contact potential, and isolation.

The procedures in this section are rather lengthy due to the large number of bank and channel combinations that are checked. As an alternative to this extensive testing, it may be desirable to check only those paths that are going to be used, or those that are suspected of being below standards.

The procedures in this section make external equipment connections to the multiplexer at the receptacles. De-

tailed connection techniques to D-sub receptacles are covered in paragraph 2.6.

The performance verification procedures must be performed with only one multiplexer card (the one being checked) installed in the Model 707 mainframe. Also, the Model 707 must not be daisy-chained to another Model 707.

CAUTION

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

NOTE

Failure of any performance verification test may indicate that the multiplexer card is contaminated. See paragraph 4.2 to clean the card. If the test still fails after cleaning, try cleaning the backplane (see the Model 707 Instruction Manual).

4.4.1 Environmental Conditions

All verification measurements should be made at an ambient temperature between 0°C and 35°C and at a relative humidity of less than 70%. If the multiplexer card has been subjected to temperature or humidity extremes, allow the card to environmentally stabilize for at least one hour before performing any tests.

4.4.2 Recommended Test Equipment

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

NOTE

Do not connect the Model 7075 to the mainframe using a Model 7070 extender card; the Model 7075 must be installed within the mainframe for the performance verification tests. Also, no other cards can be installed in the mainframe during testing.

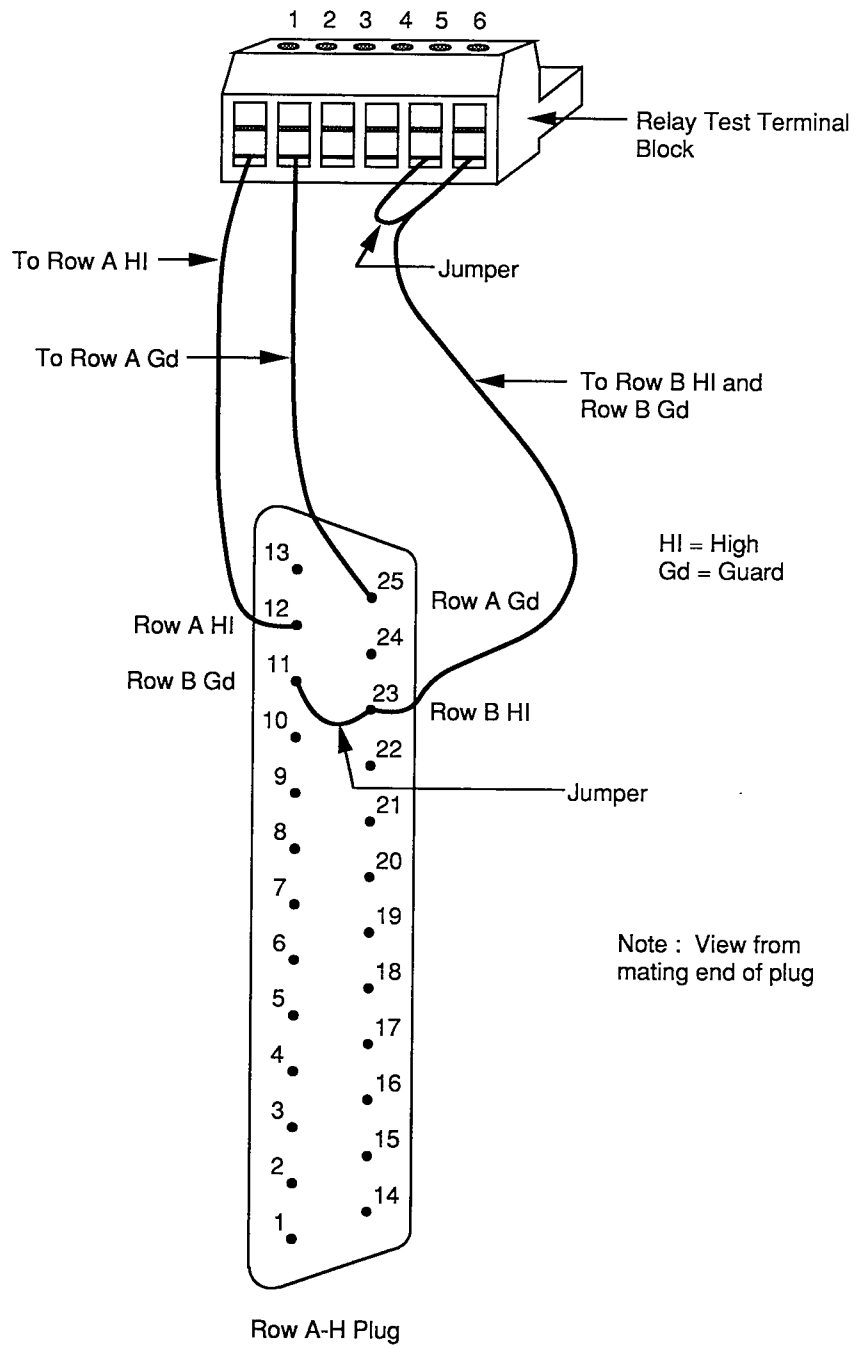


Figure 4-1. Test Cable Preparation

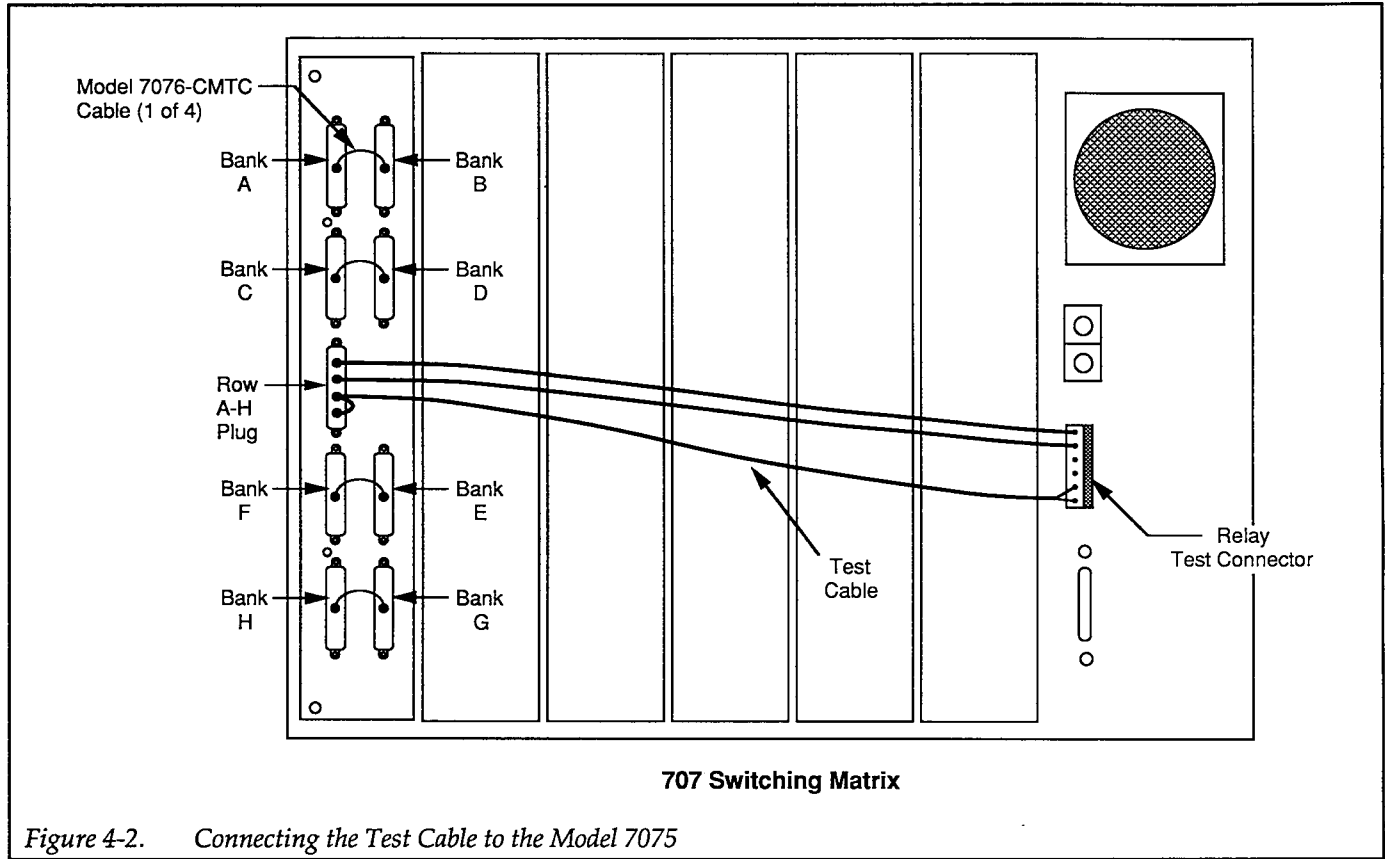


Figure 4-2. Connecting the Test Cable to the Model 7075

Table 4-1. Recommended Verification Equipment

Description	Model or Part #	Specifications	Application
DMM Electrometer with voltage source	Keithley 196 Keithley 617	300; 0.01% 10pA, 100pA; 1.6% 100V source; 0.2%	Path resistance Offset current isolation
Nanovoltmeter	Keithley 181	2mV; 0.015%	Contact potential
Triax cable (unterminated)	Keithley 7025	—	Offset current isolation
Low thermal cable (unterminated)	Keithley 1484	—	Contact potential
D-sub Plug	Keithley CS-400	—	All

Table 4-2. Performance Record

Date: _____ Performed By: _____
Time: _____ Serial Number: _____

Pathway(s)	Path Resistance	Offset Current	Contact Potential	Path Isolation	Differential Isolation	Common-mode Isolation

4.4.3 Performance Record

The results of the various performance verification tests can be recorded in Table 4-2 for future reference. Space has been provided for additional information such as date and operator's name.

BANK and ROW A-H receptacles on the rear panel of the card. A convenient way to do so is to hard-wire 25-pin D-sub plugs and then mate them to the appropriate receptacles. Some of the tests require that channel or bank terminals be jumpered together. These jumpers can also be done at D-sub plugs. Each jumper should be kept as short as possible to minimize path resistance.

4.4.4 Initial Preparation

Bank and Backplane Jumpers

All of the performance verification tests require that the internal bank and backplane jumpers be removed. See paragraph 2.4 for complete details.

The Keithley part number for the D-sub plug is CS-400. Pin identification for the plug is provided by Figure 4-3.

Test Connections

In order to complete the verification tests, it will be necessary for you to connect the equipment test leads to the

CAUTION

After making solder connections to D-sub plugs, remove solder flux as explained in paragraph 4.2. Failure to clean the plugs could result in degraded performance preventing the card from passing verification tests.

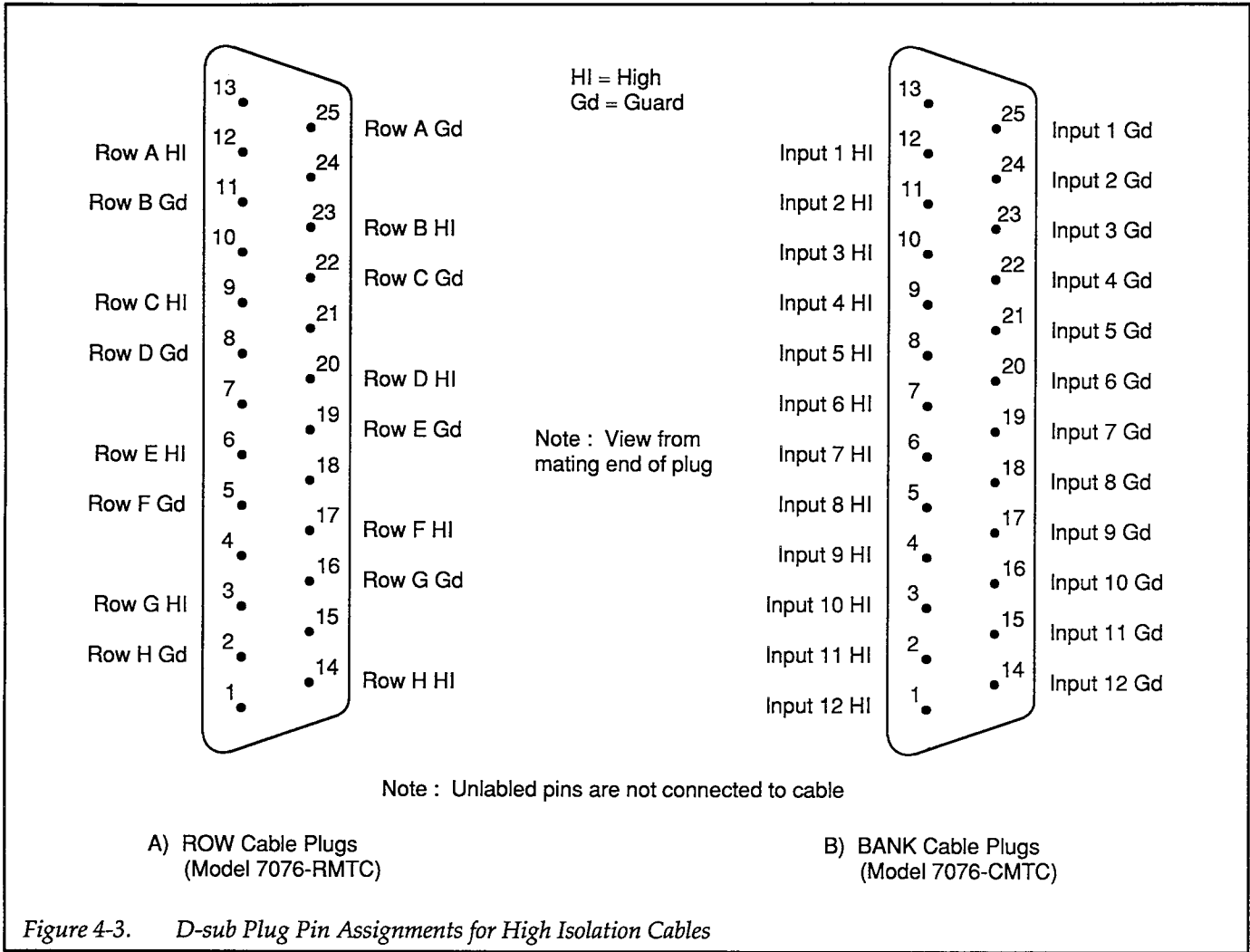


Figure 4-3. D-sub Plug Pin Assignments for High Isolation Cables

Before pre-wiring any D-sub plugs, study the following test procedures to determine the connection requirements.

4.4.5 Path Resistance Tests

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

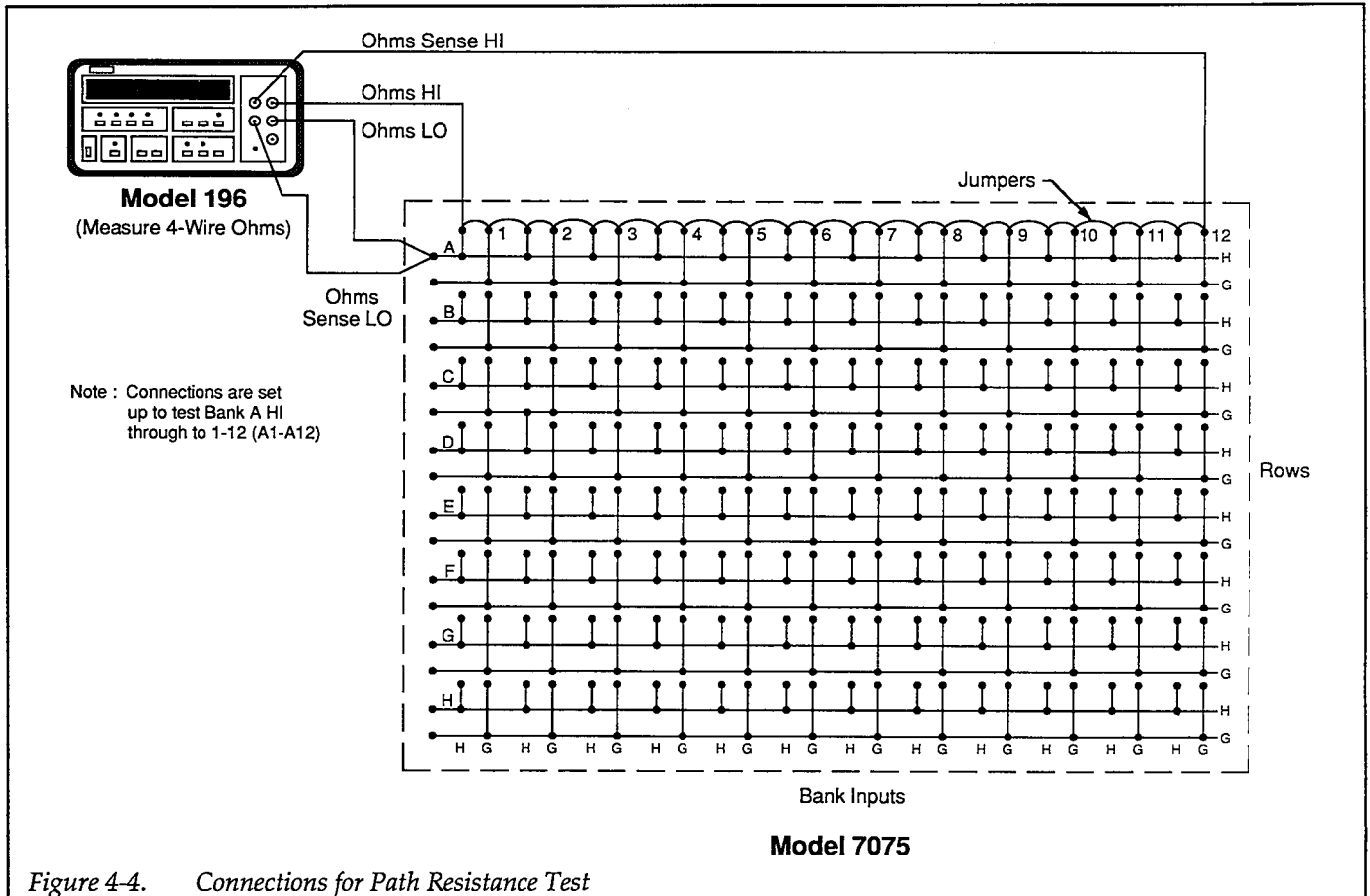
NOTE

Refer to Figure 4-4 for the following procedure.

1. Turn the Model 707 off if it is on.
2. Turn on the Model 196, and allow it to warm up for one hour before making measurements.

3. Install the Model 7075 in the mainframe, and secure it with the mounting screws. Turn on the Model 707 power after installation.
4. Connect all terminals of the Bank A multiplexer inputs together to form one common terminal, as shown in Figure 4-4.
5. Set the Model 196 to the 300Ω range, and connect four test leads to the OHMS and OHMS SENSE input jacks.
6. Short the four test leads together, and zero the Model 196. Leave zero enabled for the entire test.
7. Connect OHMS HI and OHMS SENSE HI of the Model 196 to the common terminal (jumper on the BANK A receptacle). It is recommended that the physical connections be made at inputs 1 and 12 of Row A, as shown in Figure 4-4.
8. Connect OHMS LO and OHMS SENSE LO to the HI (H) terminal of Input 1, on the BANK A receptacle.

9. From the front panel of the Model 707, close the Bank A, Channel 1 relay. Verify that the resistance of this path is $<1.5\Omega$.
10. Open Row A, Input 1, and close Row A, Input 2. Verify that the resistance of this path is within the limits given in step 9.
11. Using the basic procedure of steps 9 and 10, check the resistance of Row A HI (H) terminal paths for Inputs 3 through 12 of Row A.
12. Move the OHMS LO and OHMS SENSE LO test leads to the Guard (G) terminal of Row A, Input 1.
13. Repeat steps 9 through 11 to check the Guard (G) terminal paths of Row A.
14. Repeat the basic procedure in steps 1 through 13 for Rows B through H.



4.4.6 Offset Current Tests

These tests check leakage current between HI (H) and Guard (G) (differential offset current) and from HI and Guard (G) to chassis (common mode offset current) of each pathway. In general, these tests are performed by simply measuring the leakage current with an electrometer. In the following procedure, the Model 617 is used to measure the leakage current. Test connections are shown in Figure 4-5.

Perform the following procedure to check offset current:

1. Turn the Model 707 off if it is on, and remove any jumpers or wires attached to the BANK or ROW A-H receptacles.
2. Connect the triax cable to the Model 617, but do not connect it to the multiplexer card at this time.
3. If not already installed, place the multiplexer card in slot 1 of the Model 707, then tighten the mounting screws securely.
4. Turn on the Model 617, and allow the unit to warm up for two hours before testing. After warm up, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for

- the entire procedure. Also, be certain that V-Ω, GUARD is OFF.
5. Connect the triax cable to Row A HI and Guard, as shown in Figure 4-5.
6. Turn on the Model 707, then program the unit to close Row A, Input 1.
7. On the Model 617, disable zero check, and allow the reading to settle. Verify that the reading is <100pA. This specification is the offset (leakage) current of the pathway.
8. Enable zero check on the Model 617, and open Row A, Input 1 from the front panel of the Model 707.
9. Repeat the basic procedure in steps 6 through 8 to check the rest of the pathways (Row A, Inputs 2 through 12) of the row.
10. Change the electrometer connections to Row B, and repeat the basic procedure in steps 6 through 9 to check Row B, Inputs B1 through B12.
11. Repeat the basic procedure in steps 6 through 10 for the remaining rows (Rows C through H).
12. Change the electrometer connections, as shown in Figure 4-6. Note that electrometer HI is connected to HI and Guard of the Row A output, which are jumpered together. Electrometer LO is connected to chassis.
13. Repeat steps 6 through 12 to check that the common mode offset current is typically 100pA.

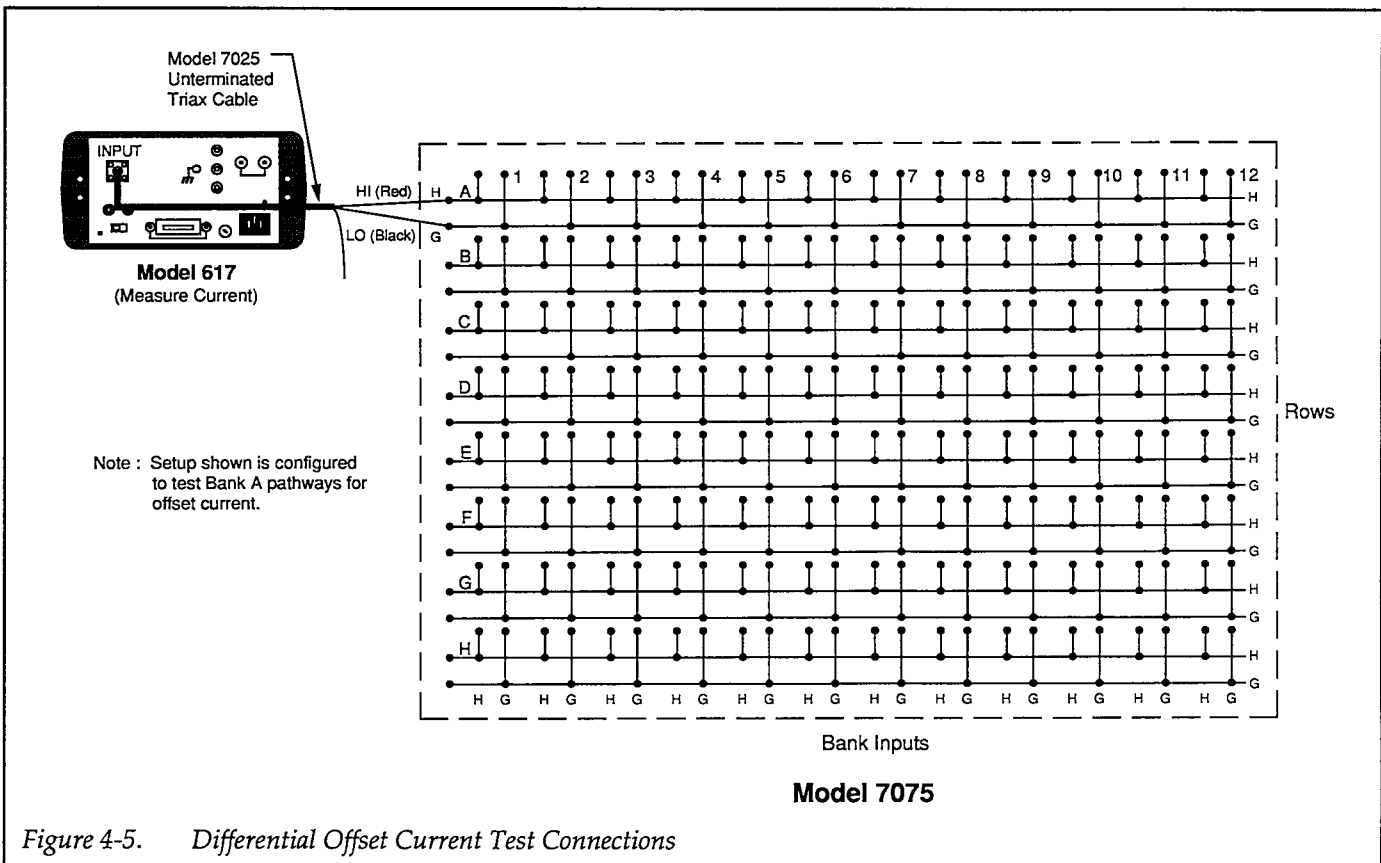
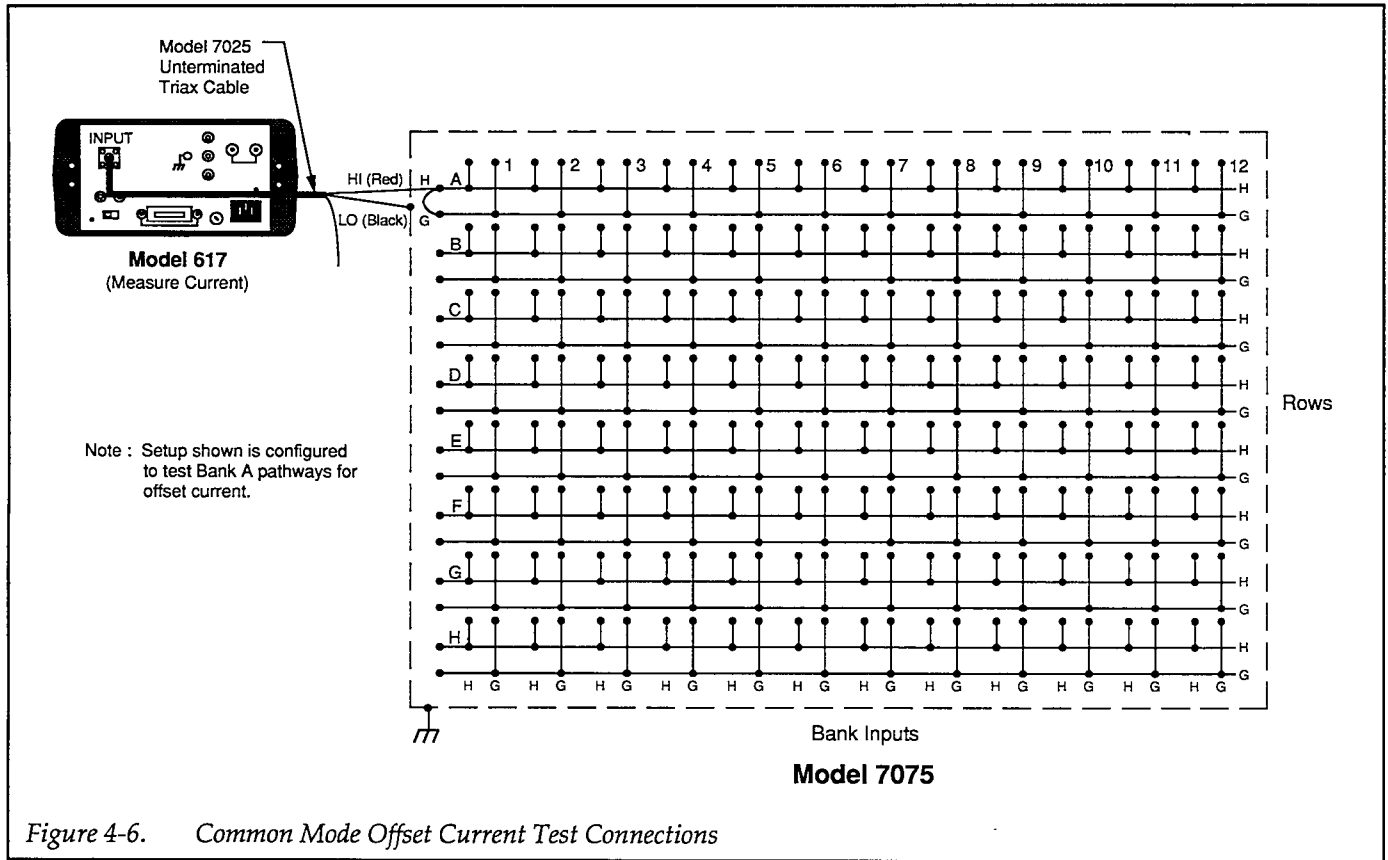


Figure 4-5. Differential Offset Current Test Connections



4.4.7 Contact Potential Tests

These tests check the EMF generated by each relay contact pair (H and G) for each pathway. The tests simply consist of using a nanovoltmeter (Model 181) to measure the contact potential.

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

1. Short HI to Guard of all 12 multiplexer inputs at the BANK A receptacle as shown in Figure 4-7.
2. Turn on the Model 181, and allow the unit to warm up for four hours for rated accuracy.
3. Select the 2mV range on the Model 181, short the input leads, and press ZERO to null out internal offsets. Leave ZERO enabled for the entire procedure.
4. If not already installed, insert the Model 7075 in slot 1 of the mainframe, and secure it with the mounting screws.
5. Connect the Model 181 to Row A as shown in Figure 4-7.
6. Turn on the Model 707.
7. Program the Model 707 to close Row A, Input 1.
8. After settling, verify that the reading on the Model 181 is $<5\mu\text{V}$. This measurement represents the contact potential of the pathway.
9. From the Model 707, open Row A, Input 1.
10. Repeat the basic procedure in steps 7 through 9 to check the rest of the pathways (Row A, Inputs 2 through 12) of the row.
11. Change the nanovoltmeter to Row B, move the thermal shorts to Bank B, and repeat the basic procedure in steps 7 through 9 to check Row B, Inputs 1 through 12.
12. Repeat the basic procedure in steps 7 through 11 for the remaining rows (Rows C through H).

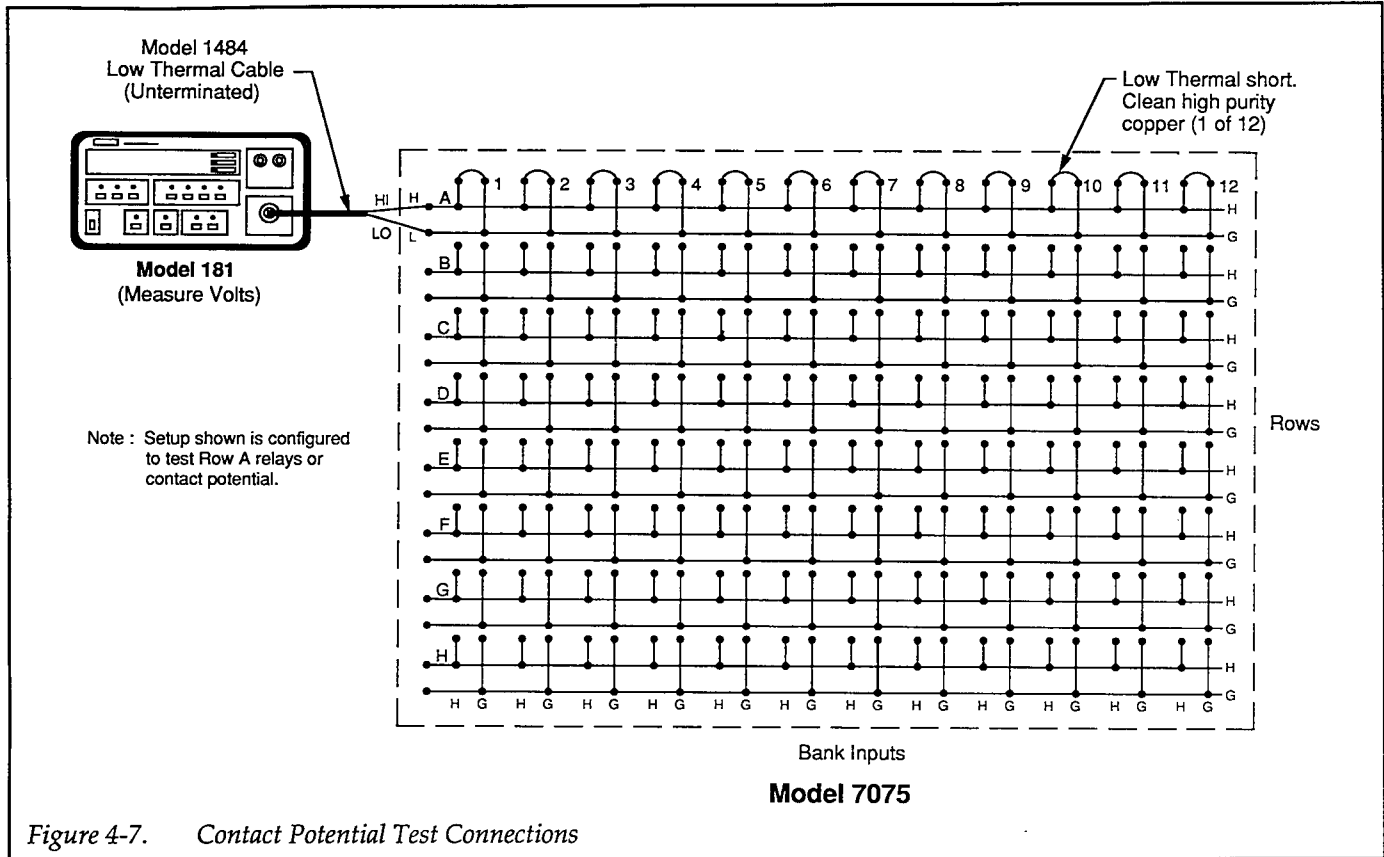


Figure 4-7. Contact Potential Test Connections

4.4.8 Bank and Path Isolation Tests

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

NOTE

Refer to Figure 4-8 for the following procedure.

1. Turn the Model 707 off if it is on, and remove any jumpers or test leads installed on the receptacles.
2. Turn on the Model 617, and allow the unit to warm up for two hours before testing.

3. If not already installed, place the multiplexer card in slot 1 of the Model 707, and secure it with the mounting screws.
4. Turn on the Model 707.

WARNING

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

5. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
6. Connect the electrometer to the Model 7075, as shown in Figure 4-8.
7. On the Model 617, select the 20pA range and release zero check.
8. On the Model 617, press SUPPRESS to cancel offset current, then enable zero check.
9. On the Model 617, set the voltage source for +100V, and select the 20nA current range. Make sure the voltage source is in standby.
10. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.

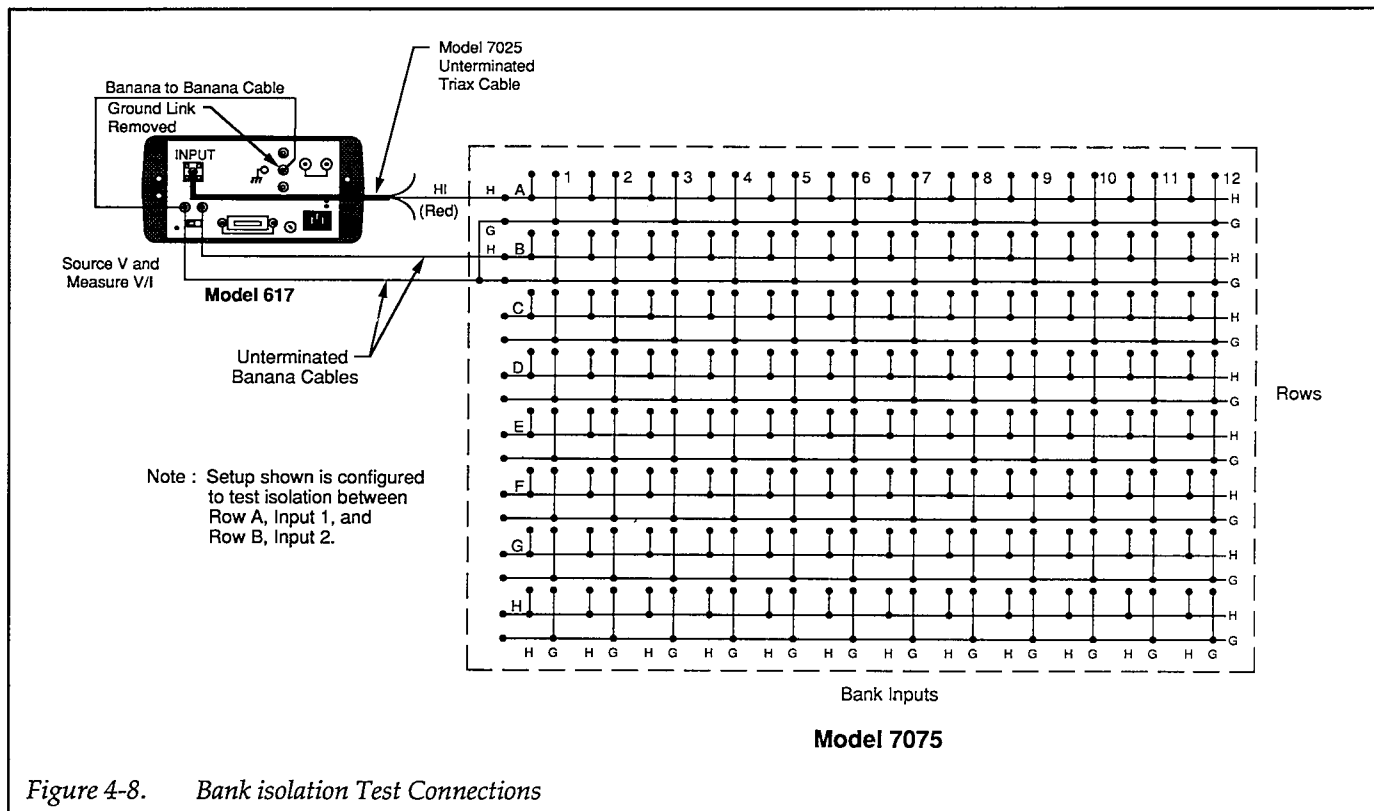


Figure 4-8. Bank isolation Test Connections

11. Program the Model 707 to close Row A, Input 1 and Row B, Input 2.
12. On the Model 617, disable zero check and press OPERATE to source +100V.
13. After allowing the reading on the Model 617 to settle, verify that it is $>10G\Omega$ (10^{10}). This measurement is the leakage resistance (isolation) between Row A, Input 1 and Row B, Input 2.
14. Place the Model 617 voltage source in standby, and enable zero check.
15. Change the electrometer connections so that it is connected to Rows B and C.
16. Program the Model 707 to close Row B, Input 2 and Row C, Input 3.
17. On the Model 617, disable zero check and press OPERATE to source +100V.
18. After allowing the reading on the Model 617 to settle, verify that it is $>10G\Omega$ (10^{10}).
19. Using Table 4-3 as a guide, repeat the basic procedure of steps 15 through 18 for the rest of the bank pairs (test numbers 3 through 11 in the table).
20. Place the Model 617 voltage source in standby, and enable zero check.

NOTE

Refer to Figure 4-9 for the following procedure to check path isolation.

21. Connect the Model 617 to the card as shown in Figure 4-9.
22. Program the Model 707 to close Row A, Input 2 (A2). Make sure all other relays are open.
23. On the Model 617, disable zero check and press OPERATE to source 100V.
24. After allowing the reading on the Model 617 to settle, verify that it is $>10G\Omega$.
25. Place the Model 617 voltage source in standby, and enable zero check.
26. Using Table 4-4 as a guide, perform tests 2 through 11 for the remaining Row A Bank Inputs. Remember to change Bank Input connections as indicated in the table.
27. Use Table 4-4 and the above procedure to test the other rows.

Table 4-3. Bank Isolation Test Summary

Test Number	Bank Isolation	Test Equipment Location	Relays Closed*
1	Row A, Input 1 to Row B, Input 2	Row A and Row B	A1 and B2
2	Row B, Input 2 to Row C, Input 3	Row B and Row C	B2 and C3
3	Bank C, Input 3 to Row D, Input 4	Row C and Row D	C3 and D4
4	Row D, Input 4 to Row E, Input 5	Row D and Row E	D4 and E5
5	Row E, Input 5 to Row F, Input 6	Row E and Row F	E5 and F6
6	Row F, Input 6 to Row G, Input 7	Row F and Row G	F6 and G7
7	Row G, Input 7 to Row H, Input 8	Row G and Row H	G7 and H8
8	Row G, Input 8 to Row H, Input 9	Row G and Row H	G8 and H9
9	Row G, Input 9 to Row H, Input 10	Row G and Row H	G9 and H10
10	Row G, Input 10 to Row H, Input 11	Row G and Row H	G10 and H11
11	Row G, Input 11 to Row H, Input 12	Row G and Row H	G11 and H12

* Row and input, programmed as Row and Column on mainframe.

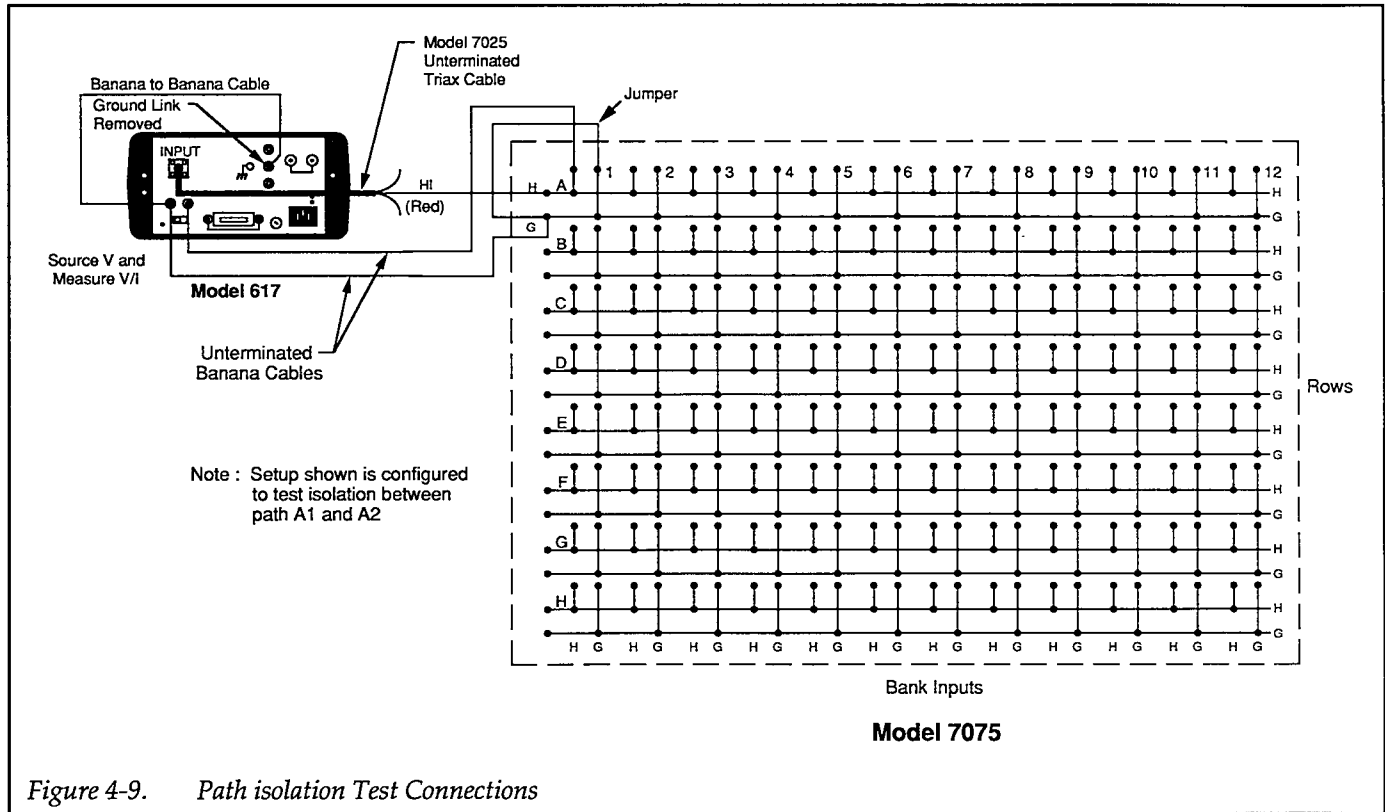


Figure 4-9. Path isolation Test Connections

Table 4-4. Path Isolation Test Summary*

Test Number	Path Isolation	Test Equipment Location	Relay Closed
1	A1 to A2	Row A and Input 1	A2
2	A2 to A3	Row A and Input 2	A3
3	A3 to A4	Row A and Input 3	A4
4	A4 to A5	Row A and Input 4	A5
5	A5 to A6	Row A and Input 5	A6
6	A6 to A7	Row A and Input 6	A7
7	A7 to A8	Row A and Input 7	A8
8	A8 to A9	Row A and Input 8	A9
9	A9 to A10	Row A and Input 9	A10
10	A10 to A11	Row A and Input 10	A11
11	A11 to A12	Row A and Input 11	A12

*This table tests Row A. To use this table to test the other rows, move the electrometer row connections to the appropriate row and change the relay designations in this table accordingly. For example, to test Row B, move the electrometer row connections to Row B and change the relay designations in this table from A2 to B2, A3 to B3, etc.

4.4.9 Differential and Common Mode Isolation Tests

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

1. Turn the Model 707 off if it is on and remove any jumpers and test leads installed on the receptacles.
2. If not already installed, place the multiplexer card in slot 1 of the Model 707, and secure it with the mounting screws.

WARNING

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

3. Turn on the Model 617, and allow the unit to warm up for two hours for rated accuracy.

4. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
5. On the Model 617, set the voltage source for +100V, and select the 200nA current range. Make sure the voltage source is still in standby.
6. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.
7. With the Model 617 in standby, connect the electrometer to Row A of the multiplexer card, as shown in Figure 4-10.
8. Make sure all the relays are open (press RESET on the Model 707).
9. On the Model 617, disable zero check, and press OPERATE to source 100V.
10. After allowing the reading on the Model 617 to settle, verify that it is $>1G\Omega$ (10^9). This measurement is the differential leakage resistance (isolation) of Row A.
11. Place the Model 617 in standby, and enable zero check.
12. Program the Model 707 to close Row A, Input 1.
13. On the Model 617, disable zero check and press OPERATE to source +100V.
14. After allowing the reading on the Model 617 to settle, verify that it is also $>1G\Omega$ (10^9). This measurement checks the differential isolation of Input 1.
15. Using Table 4-5 as a guide, repeat the basic procedure of steps 8 through 14 for the rest of the inputs and rows (test numbers 3 through 13 of the table).
16. Turn off the voltage source, and change the electrometer connections, as shown in Figure 4-11.
17. Repeat steps 4 through 15 to check common mode isolation. Verify that each reading is $>1G\Omega$ (10^9) for the common mode isolation tests only.

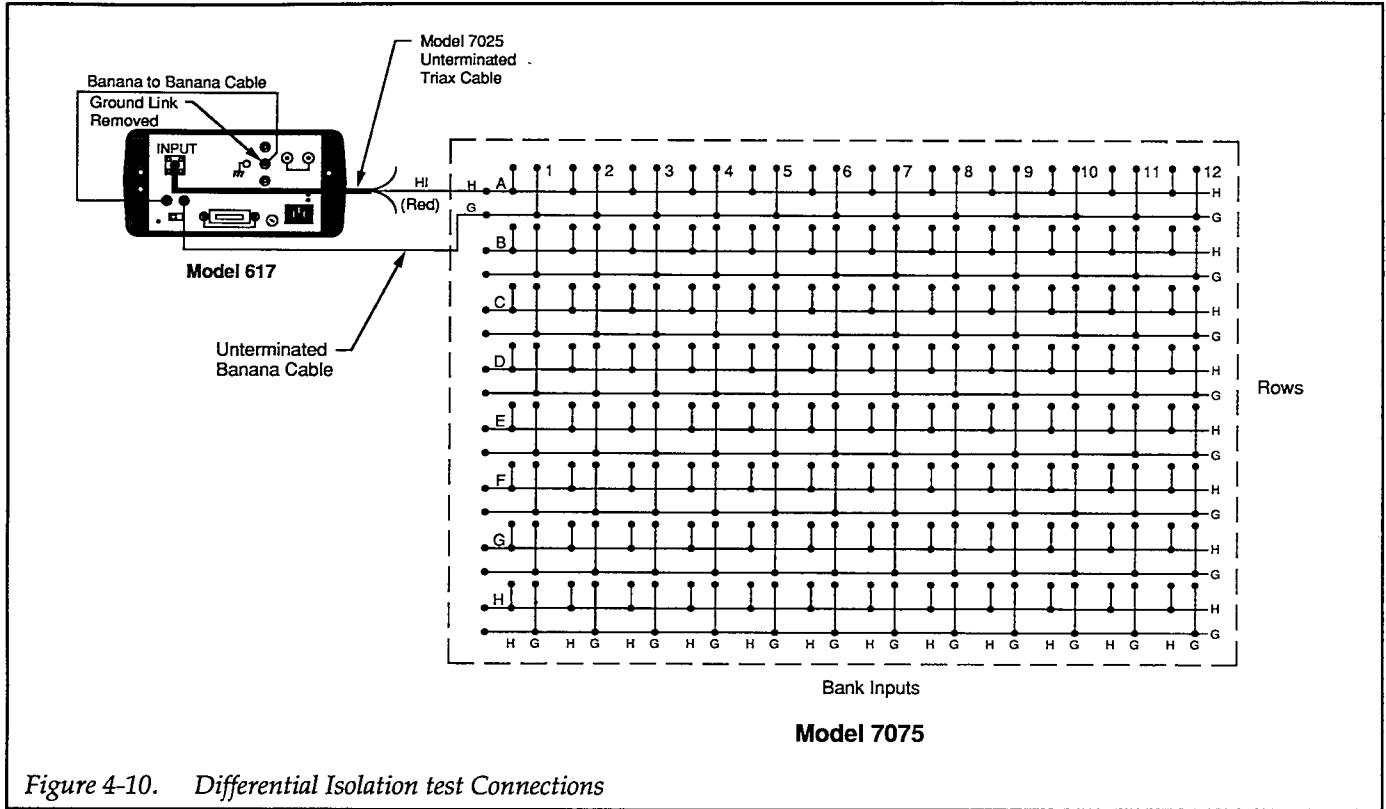


Figure 4-10. Differential Isolation test Connections

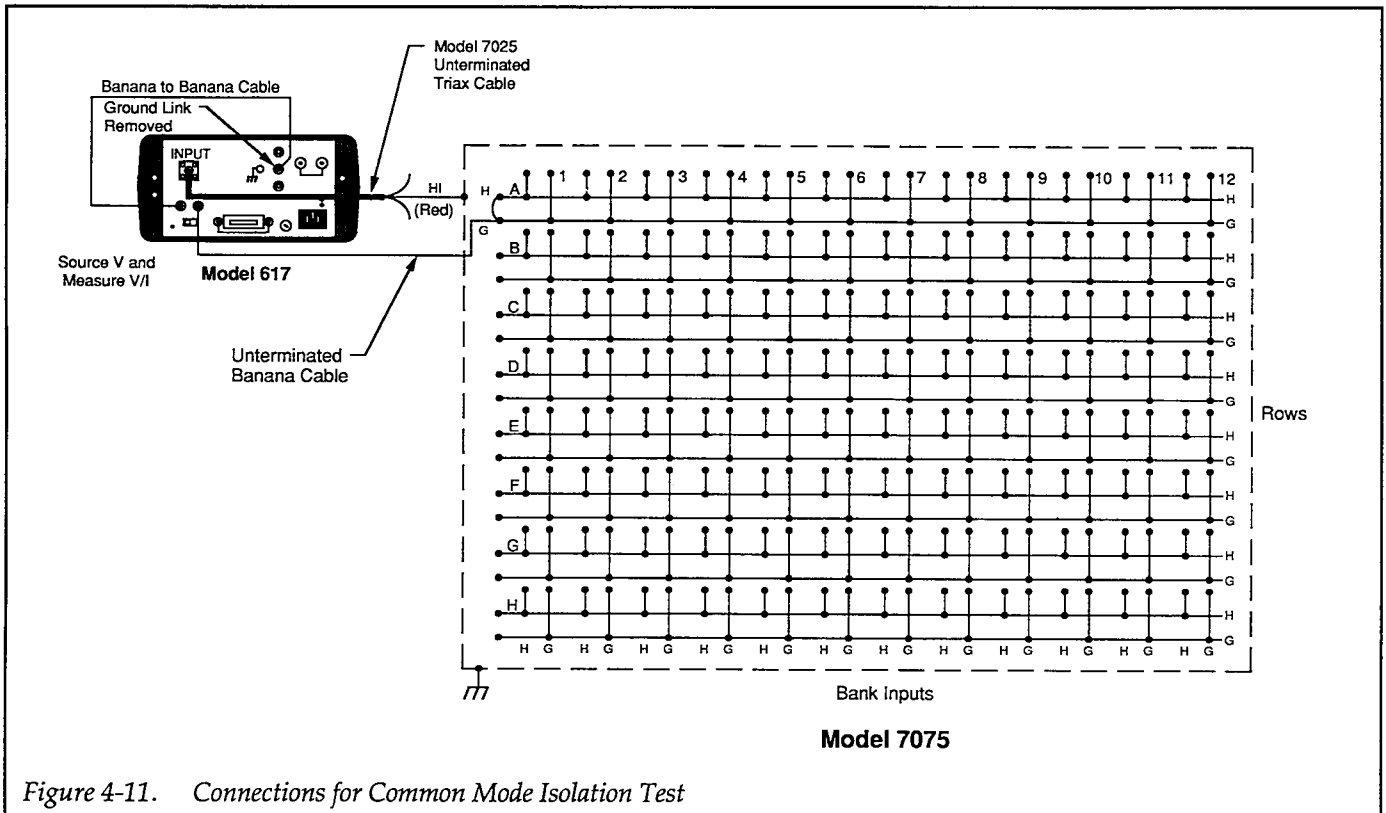


Figure 4-11. Connections for Common Mode Isolation Test

Table 4-5. Differential and Common Mode Isolation Test Summary*

Test No.	Differential or Common Mode Test	Relay Closed
1	Row A	None
2	Row A Input 1	A1
3	Row A Input 2	A2
4	Row A Input 3	A3
5	Row A Input 4	A4
6	Row A Input 5	A5
7	Row A Input 6	A6
8	Row A Input 7	A7
9	Row A Input 8	A8
10	Row A Input 9	A9
11	Row A Input 10	A10
12	Row A Input 11	A11
13	Row A Input 12	A12

*This table tests Row A. To use this table to test the other rows, move the electrometer row connections to the appropriate row and change the relay designations in this table accordingly. For example, to test Row B, move the electrometer row connections to Row B and change the relay designations in this table from A1 to B1, A2 to B2, A3 to B3, etc.

4.5 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

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

NOTE

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

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

- Use only anti-static type de-soldering tools and grounded-tip soldering irons.

4.6 TROUBLESHOOTING

4.6.1 Recommended Equipment

Table 4-6 summarizes the recommended equipment for general troubleshooting.

Table 4-6. Recommended Troubleshooting Equipment

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

4.6.2 Using the Extender Card

In order to gain access to the test points and other circuitry on the Model 7075, the card must be plugged into the Model 7070 Universal Adapter Card used as an extender card, which, in turn, must be plugged into the desired slot of the mainframe. The Model 7070 must be configured as an extender card by placing the configuration jumper in the EXTEND position. See the documentation supplied with the Model 7070 for complete details on using the card.

NOTE

Use the extender card only for troubleshooting; do not use the extender card for performance verification tests.

4.6.3 Input/Output Connections

For some troubleshooting steps, it may be necessary to connect test instruments to the BANK or ROW A-H receptacles on the rear panel. General instructions for making connections, including BANK and ROW A-H plug pin assignments, are located in paragraph 4.4.4.

4.6.4 Troubleshooting Procedure

Table 4-7 summarizes the troubleshooting procedure for the multiplexer card. Some of the troubleshooting steps refer to the ID data timing diagram shown in Figure 4-12.

In addition to the procedure shown, the relay tests outlined in paragraph 4.3.3 can be used to aid in troubleshooting. Also, refer to paragraph 4.7 for an overview of operating principles.

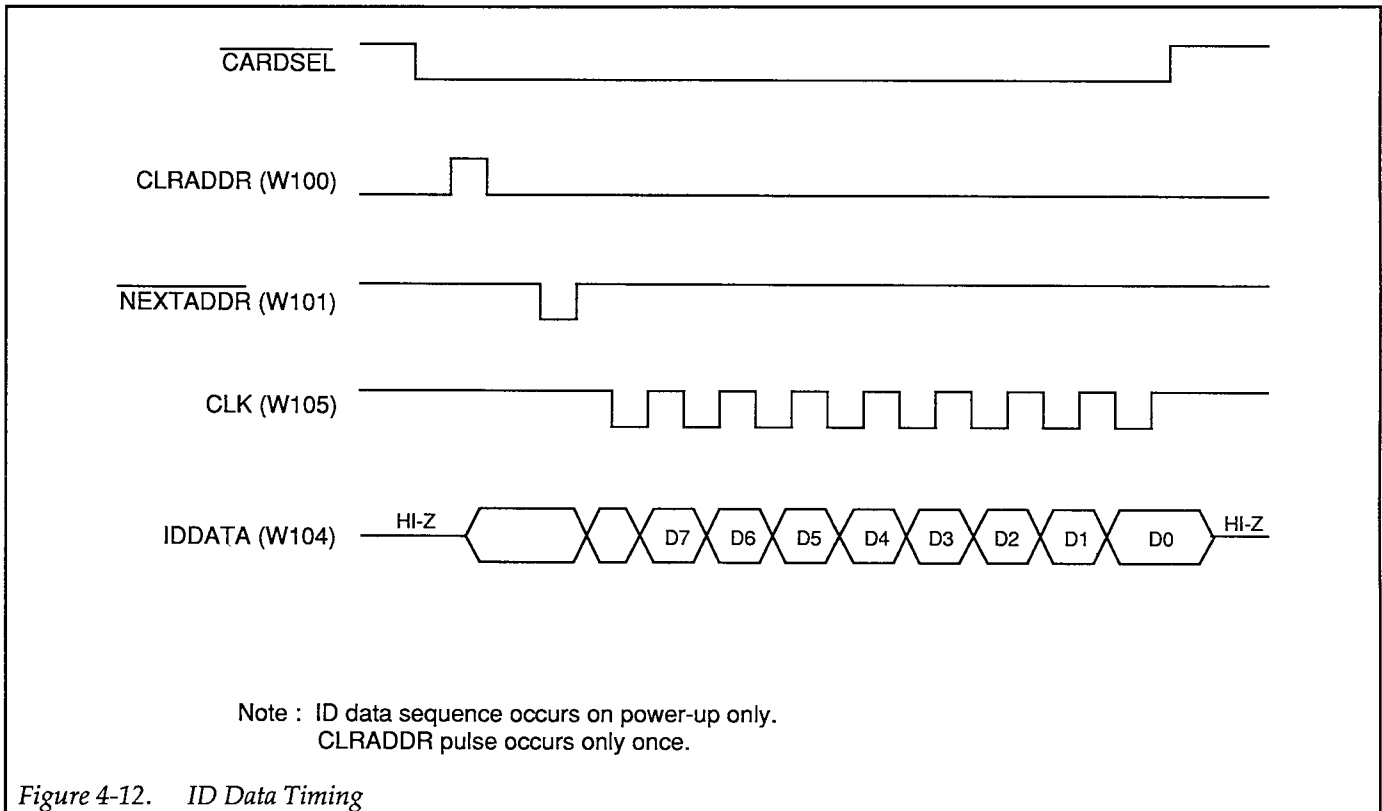
Table 4-7. Troubleshooting Procedure

Step	Item/Component*	Comment	Required Condition*
1	W106	+6V supply	+6V DC
2	W109	+5V supply	+5V DC
3	W100	CLR ADDR line***	High logic pulse at beginning of each card identification byte transfer sequence (upon power up).
4	W101	NEXT ADDR line***	Low logic pulse before each byte transfer.
5	W105	CLK line	1.79MHz clock
6	W104	IDDATA line***	Card identification logic pulse train (on power up).
7	W108	Power up safeguard	Remains low during power up.
8	W102	RELAY DATA line	Logic pulse train to load relay configuration registers.
9	W103	STROBE line	High logic pulse to strobe relay configuration registers.
10	U100 thru U113, pins 10 thru 16	Relay Drivers	+6V for open relays ≈0V for closed relays. Note that pin 10 on U106 and U113 are not connected.

*W100 through W109 are jumpers located on the PC-board. See Component Location drawing (at end of Section 5) for jumper locations.

**All measurements referenced to digital common (W107)

***See Figure 4-12.



4.6.5 Relay Replacement Precautions

A typical failure mode for switching cards is for a number of relay coils to burn out simultaneously. This situation results in the desoldering of a large number of pins, with a good chance of pulling up traces on the PC board. To prevent such damage, use extreme care when replacing relays.

In order to remove relays or other components, first remove all the solder using solder wick or other desoldering aid. Be careful not to apply too much heat, as doing so may result in lifted traces. Once all solder has been removed, carefully remove the relay by hand. **DO NOT** pry up on the relay body with a screwdriver because the resulting force could lift the surrounding trace.

Because of the necessity of these precautions, only skilled technical personnel should attempt to replace relays. If

no qualified technicians are available, it is recommended that you return the card to the Keithley repair department for repair.

4.7 PRINCIPLES OF OPERATION

The following paragraphs discuss the basic operating principles for the Model 7075. A schematic diagram of the multiplexer card may be found in drawing number 7075-106, located at the end of Section 5.

4.7.1 Block Diagram

Figure 4-13 shows a simplified block diagram of the Model 7075. Key elements include the buffer (U129), ID data circuits (U126, U127, and U129), relay drivers (U100-U113) and relays (K100-K195), and power-on safe guard (U130). The major elements are discussed below.

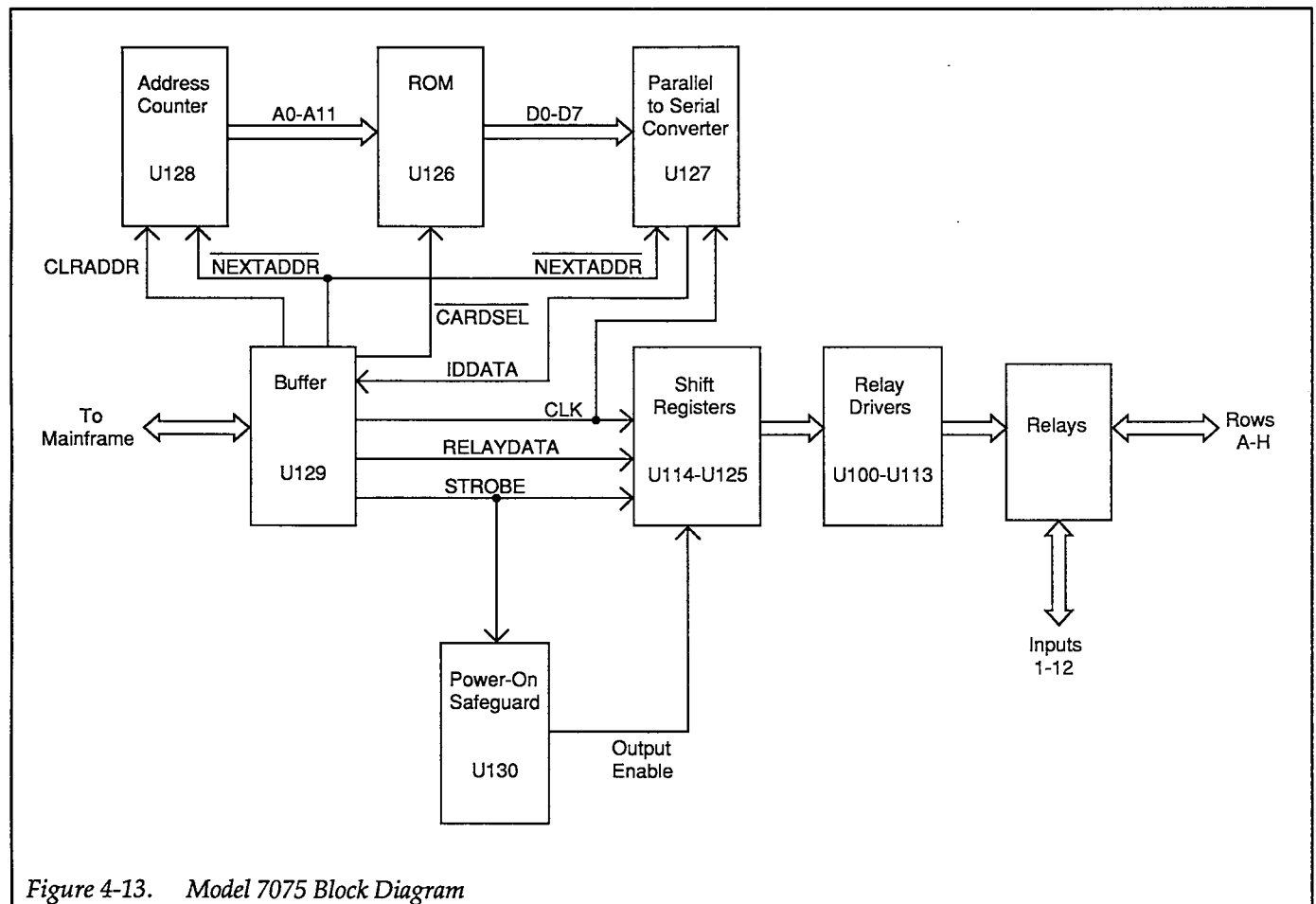


Figure 4-13. Model 7075 Block Diagram

4.7.2 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, and a relay configuration table, which tells the mainframe which relays to close for a specific crosspoint.

ID data is contained within an on-card ROM, U126. In order to read this information, the sequence below is performed upon power up. Figure 4-11 shows the general timing of this sequence.

1. The CARSEL 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. This pulse only occurs once.
3. The NEXTADDR line is set low. NEXTADDR going low increments the counter and enables parallel loading of the parallel-to-serial converter. NEXTADDR is kept low long enough for the counter to increment and for the ROM outputs to stabilize. This sequence functions because the load input of the parallel-to-serial converter is level sensitive rather than edge sensitive. The first ROM address is location 1, not 0.
4. The CLK line clocks the parallel-to-serial converter to shift all eight data bits from the converter to the mainframe via the IDDATA line.

The 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.

4.7.3 Relay Control

The relays are controlled by serial data transmitted via the RELAYDATA line. A total of 16 bytes for each card are shifted in serial fashion into latches located in the 12 shift registers U114-U125. The serial data is fed in through the DATA lines under control of the CLK signal. As data overflows one register, it is fed out the Q'S line of that register to the next IC down the chain.

Once all 16 bytes have been shifted into the card, the STROBE line is set high to latch the relay information into the Q outputs of the shift registers, and the appropriate relays are energized by relay drivers U100-U113. 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.

4.7.4 Power-on Safeguard

A power-on safeguard circuit, made up of U130 and associate components, ensures that relays do not randomly energize upon power-up. The two AND gates, U130, make up an R-S flip-flop. Initially, the Q output of the flip-flop (pin 8 of U130) is set high upon power up. Since the OE terminals of the shift registers U114-U125 are held low, 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 U114-U125 high to enable their outputs. This action allows the relays to be controlled by the transmitted relay data information.

A hold-off period of approximately 470msec is included in the safeguard circuit to guard against premature enabling of the relays. The time constant of the hold-off period is determined by the relative values of R103 and C124.

SECTION 5

Replaceable Parts

5.1 INTRODUCTION

This section contains a list of replaceable parts for the Model 7075, as well as a component layout drawing and schematic diagram of the matrix card.

5.2 PARTS LIST

Replaceable parts are listed in the Model 7075, Parts List. Electrical parts are listed in order of circuit designation.

5.3 ORDERING INFORMATION

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

- Multiplexer card model number (7075)
- Card serial number
- Part description
- Circuit description, if applicable
- Keithley part number

5.4 FACTORY SERVICE

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

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

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

5.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

The component layout and schematic diagram of the Model 7075 follow the parts list.

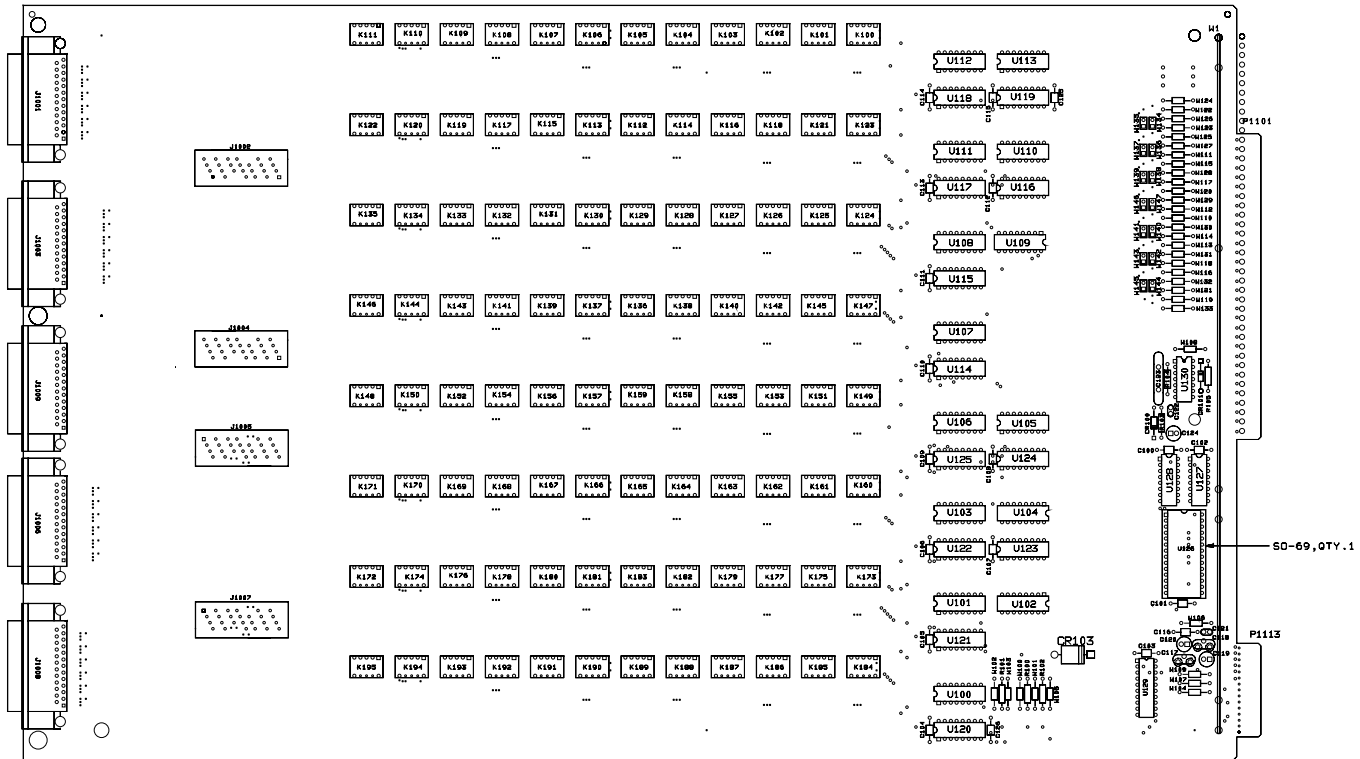
MODEL 7075, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
	CONN,BERG SHIELD, BOTTOM HANDLE PEM NUTS	CS-339 7075-306A HH-33-2 FA-135
C100..116	CAP,.1UF,20%,50V,CERAMIC	C-365-1
C117,118	CAP,270PF,20%,100V,CERAMIC/FERRITE	C-386-270P
C119,120	CAP, 10UF,-20+100%,25V,ALUM ELEC	C-314-10
C121,122	CAP,.01UF,20%,50V,CERAMIC	C-237-.01
C123	CAP,.01UF,10%,1000V,CERAMIC	C-64-.01
C124	CAP, 47UF,10%,16V,ALUM ELEC	C-321-47
CR100	DIODE,SILICON,IN4148 (DO-35)	RF-28
CR101	DIODE,SCHOTTKY, IN5711	RF-69
CR103	DIODE SOCKET,I.C. 28 PIN FOR U126	RF-34 SO-69
J1001,1003,1006 1008,1009 J1002,1004,1005,1007	CONNECTOR, RIGHT ANGLE D-SUB SOCKET	CS-721-1A
	CABLE ASSEMBLY	CA-88-1A
K100..195	RELAY, ULTRA-SMALL POLARIZED TQ2E-5V	RL-136
R100	RES,120K,5%,1/4W,COMPOSITION OR FILM	R-76-120K
R101	RES,11K,5%,1/4W,COMPOSITION OR FILM	R-76-11K
R102	RES,5.1K,5%,1/4W,COMPOSITION OR FILM	R-76-5.1K
R103	RES,47K,5%,1/4W,COMPOSITION OR FILM	R-76-47K
R104	RES,200,5%,1/4W,COMPOSITION OR FILM	R-76-200
R105	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
U100..113	IC,DARLINGTON ARRAY,2003	IC-206
U114..125	IC, 8 BIT SHIFT LAT REG,74HC4094	IC-713
U126	Programmed EPROM	7075-800-*
U127	IC,8-BIT PARALLEL TO SERIAL,74HCT165	IC-548
U128	IC, 12 STAGE BINARY COUNTER,74HCT4040	IC-545
U129	IC, OCTAL BUFFER/LINE DRIVER, 74HC244	IC-489
U130	IC, QUAD 2 INPUT NAND, 74HCT00	IC-399
W1	STIFFENER, BOARD	J-16
W100..125	JUMPER	J-15
W134..147	CONN,BERG,2 PIN	CS-339-2

*ORDER FIRMWARE REVISION LEVEL INDICATED ON IC PACKAGE

00T-SZ02.0N

LTR.	ECO NO.	REVISION	ENG.	DATE
B	970428	RELEASED	MS	4/23/90
C	18232	ADDED C125 & C126	SS	4/8/96
D	21124	ARTWORK HAS REV C		

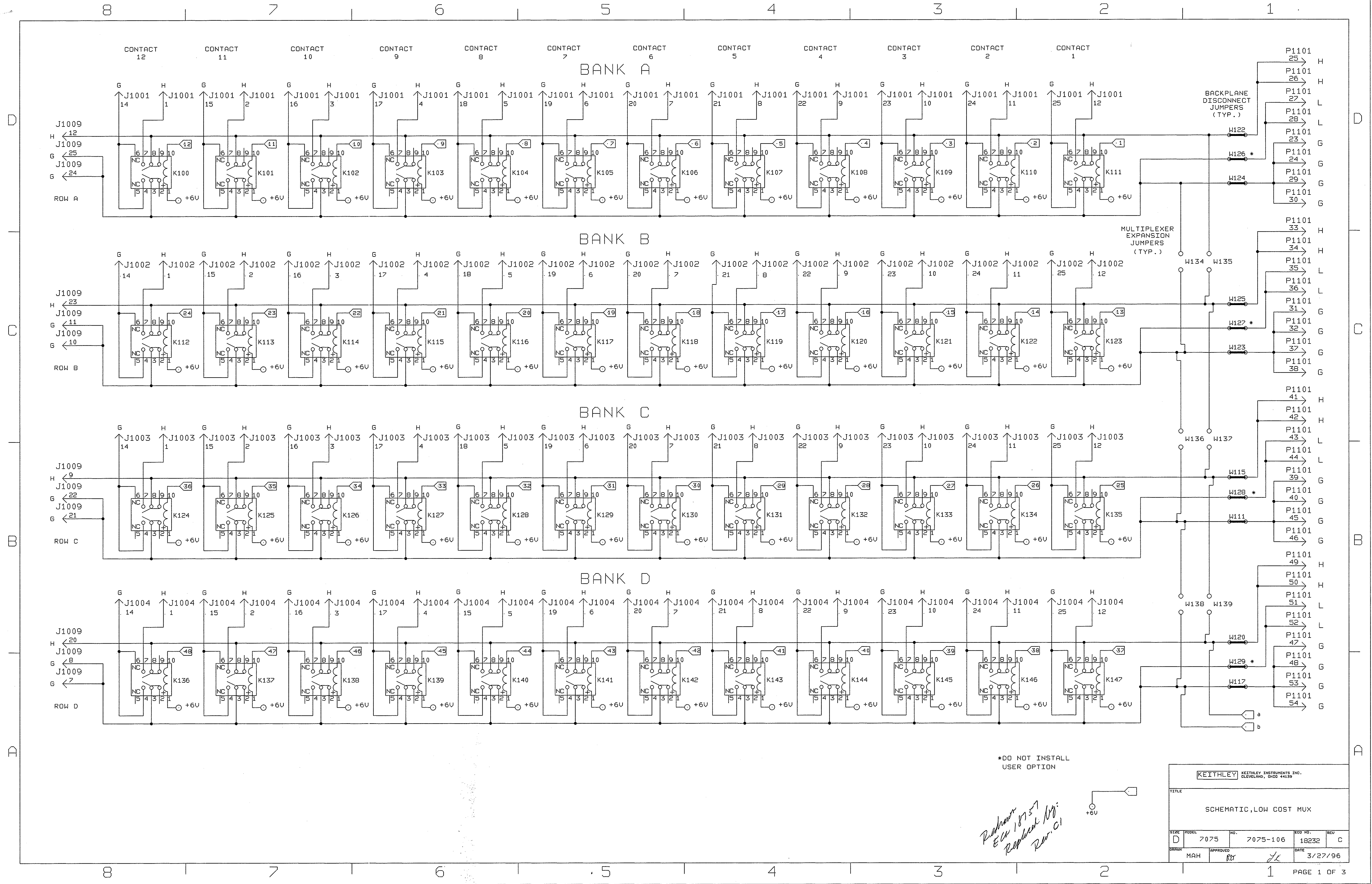


NOTE:
FOR COMPONENT INFORMATION REFER
TO 7075 PRODUCT STRUCTURE.

DO NOT SCALE THIS DRAWING	INTERNATIONAL TELEGRAPHIC UNLESS OTHERWISE SPECIFIED	DATE 4-6-90	SCALE 1:1	TITLE	COMPONENT LAYOUT
KEITHLEY	7075	DRN. MAH	1:1	LOW COST MUX.	
CLEVELAND, OHIO 44139	FRAC. 11/64	MATERIAL			
	SURFACE FIN. 2	FINISH			

MODEL	NEXT ASSEMBLY	QTY.	USED ON
7075			

D NO. 7075-100

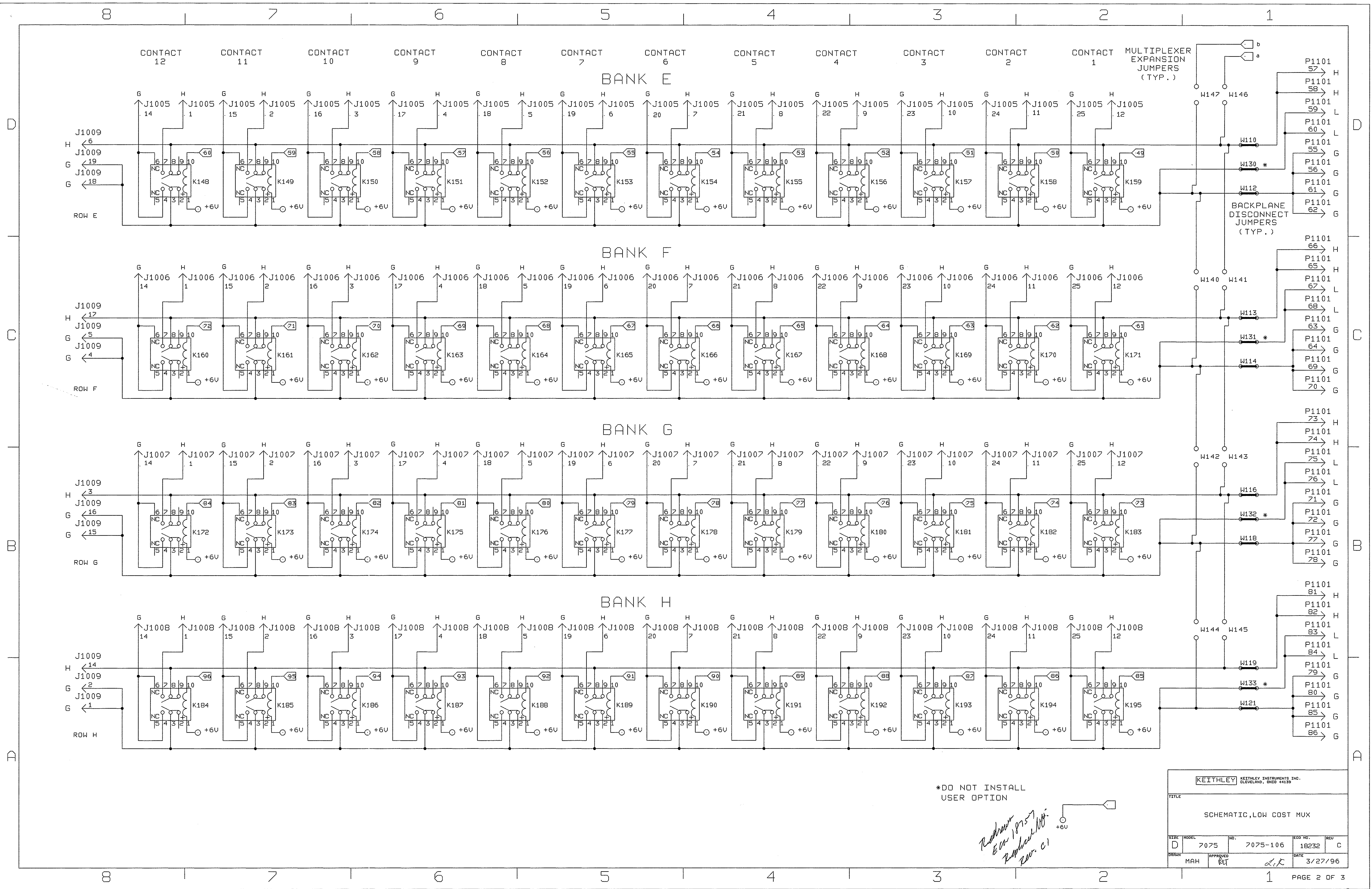


*DO NOT INSTALL
USER OPTION

*Revised
E.C. 1/8/57
Revised N.Y.
Rev. C1*

KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139			
TITLE SCHEMATIC, LOW COST MUX			
SIZE	MODEL	NO.	REV.
D	7075	7075-106	18232 C
DRAWN	APPROVED	DATE	
MAH	RJ	3/27/96	

ORIGINAL IN RED

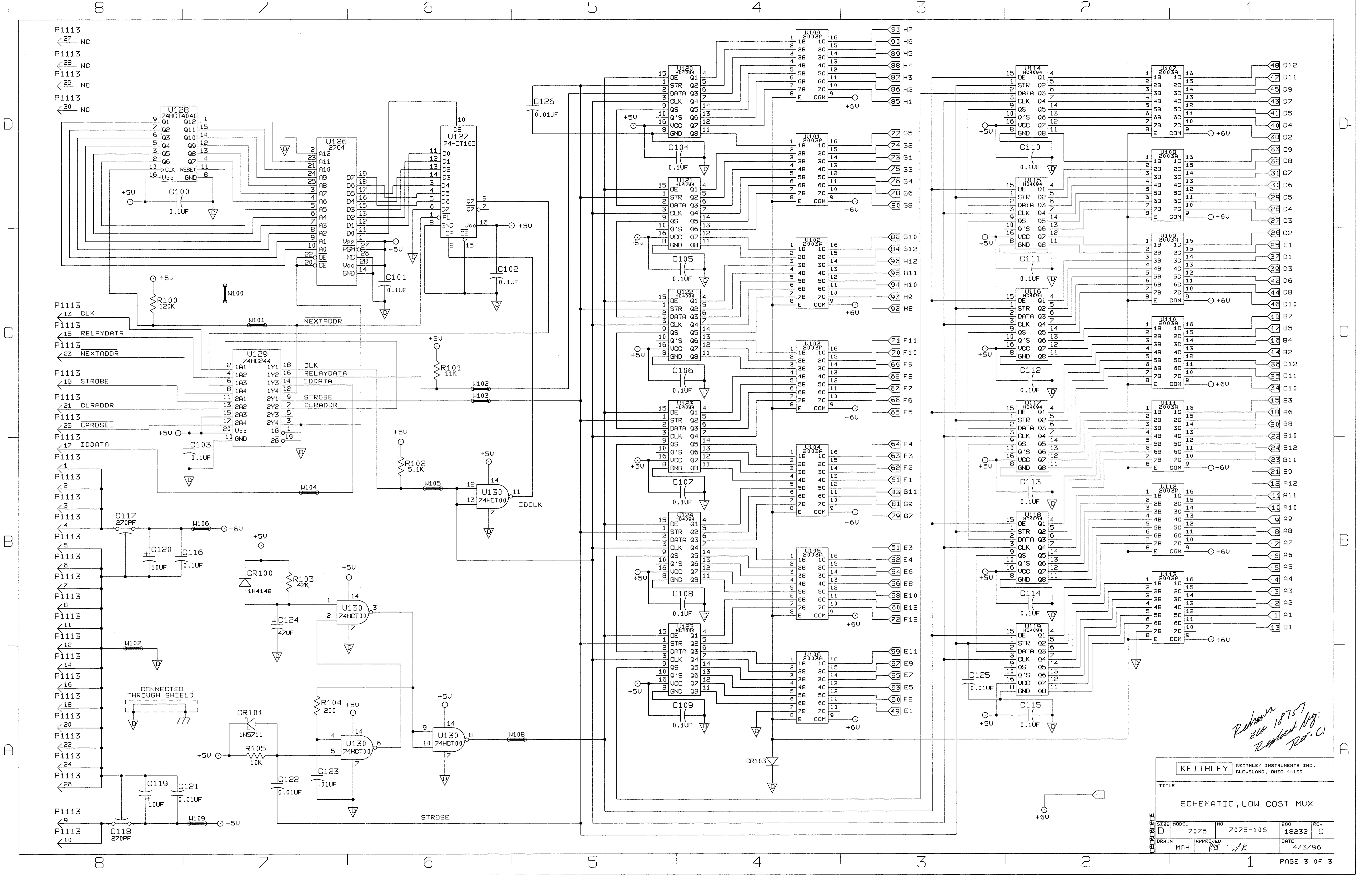


*DO NOT INSTALL
USER OPTION

*Redrawn
E-10 1/8/57
Redrawn
Rev. C1*

KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139				
TITLE SCHEMATIC, LOW COST MUX				
SIZE	MODEL	NO.	ECO NO.	REV.
D	7075	7075-106	18232	C
DESIGN	APPROVED	DATE		
MAH	RET	3/27/96		

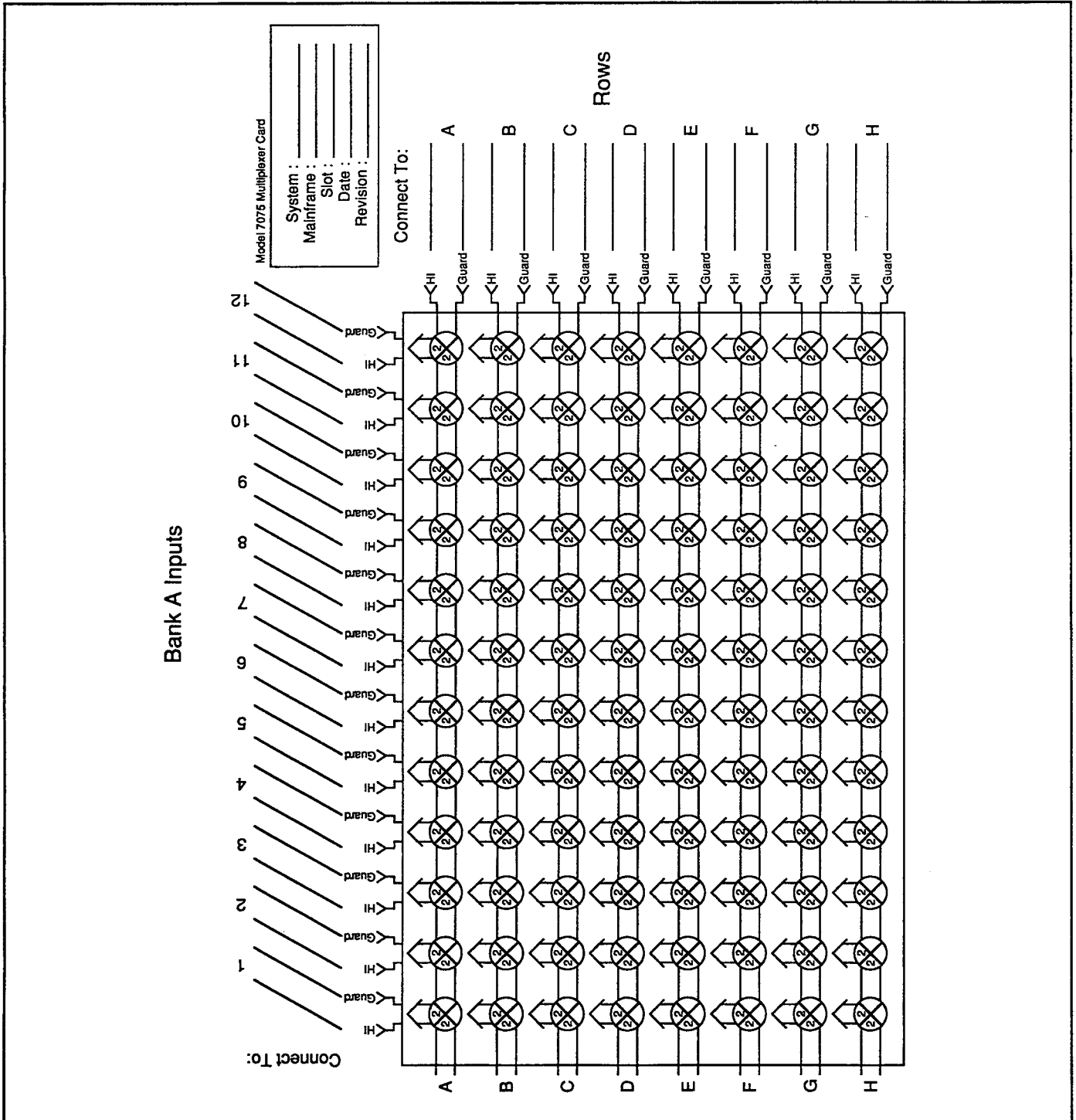
ORIGINAL IF RED

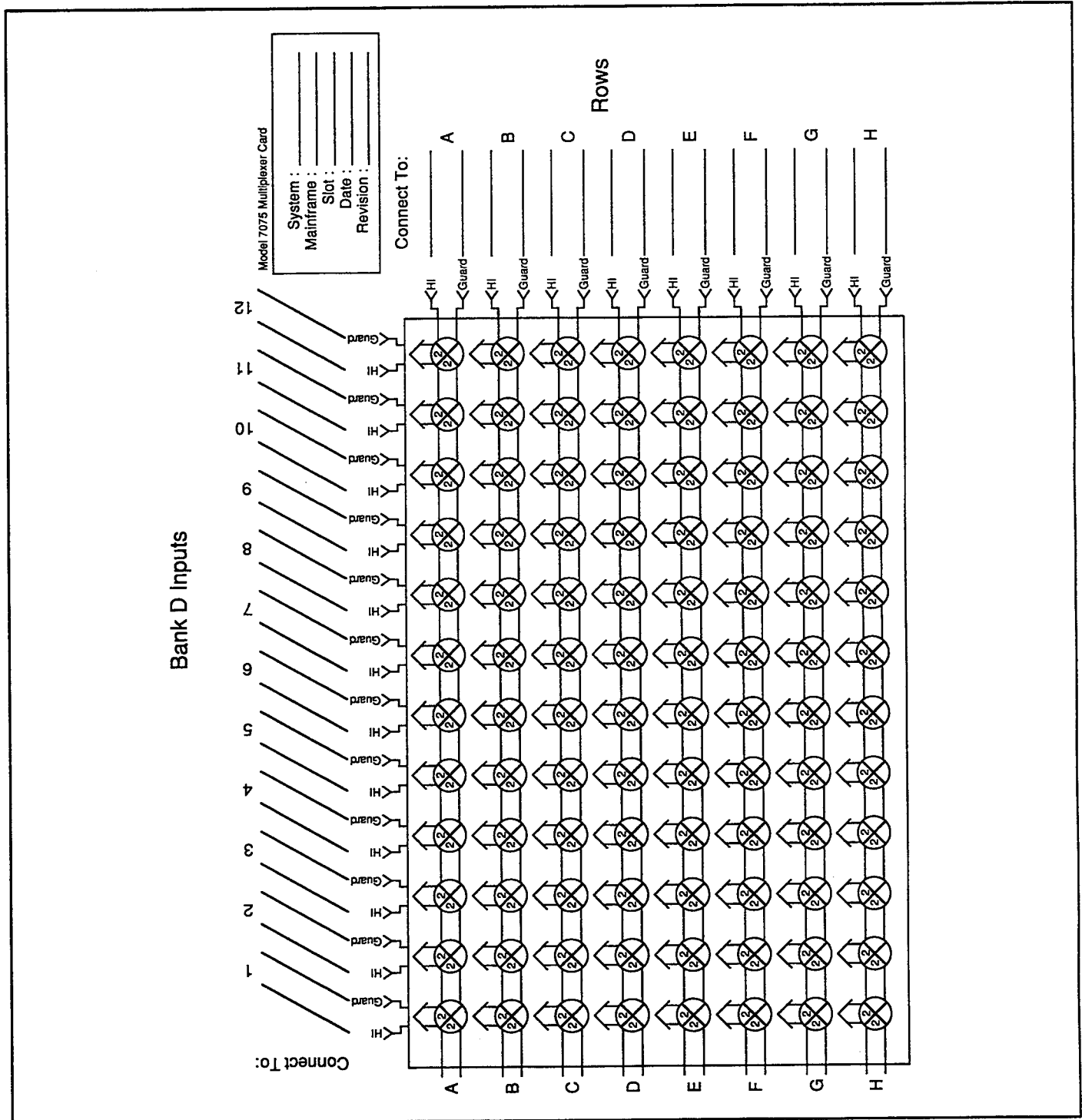


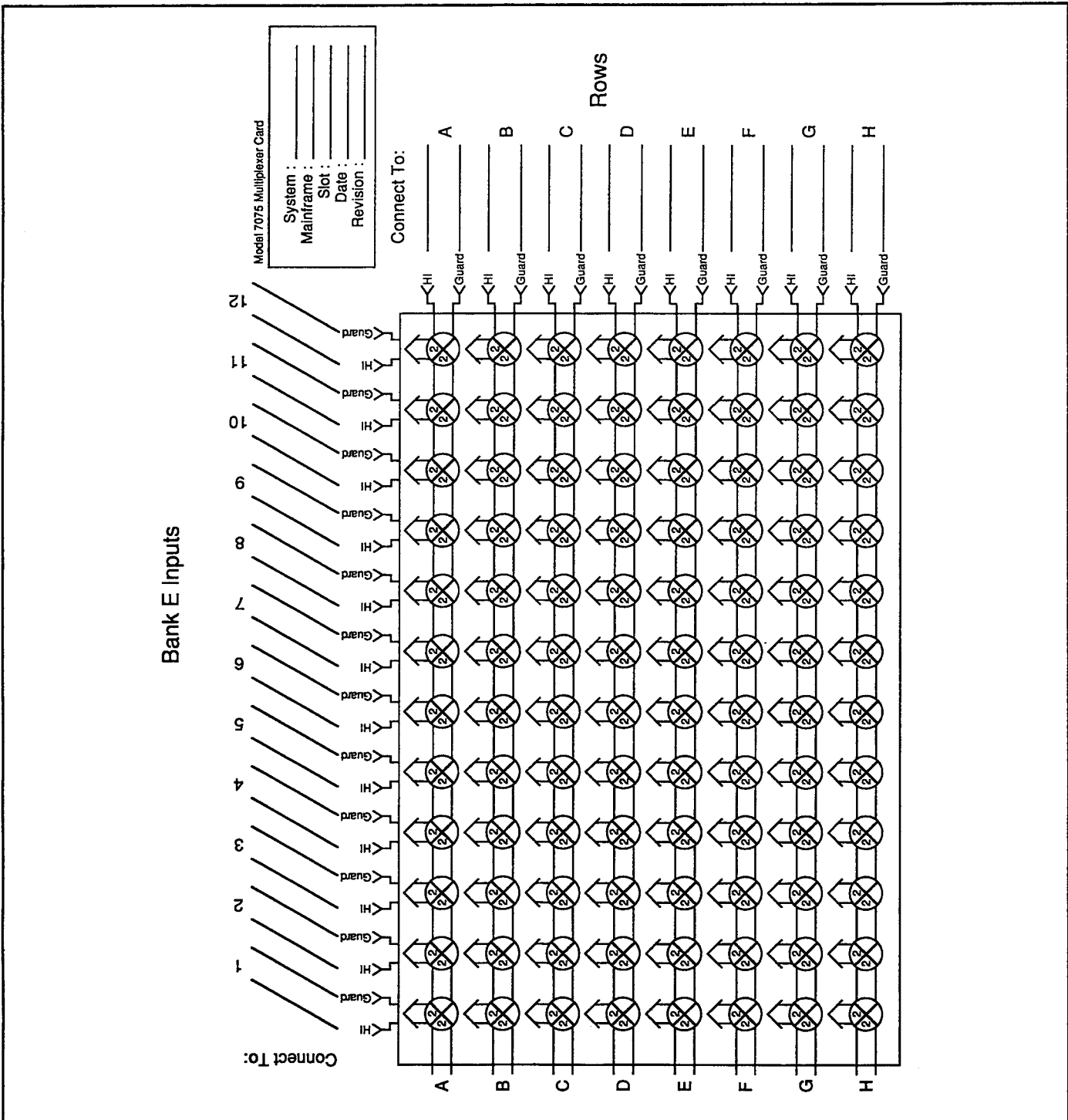
*Revised
EVA 18757
R. J. K.*

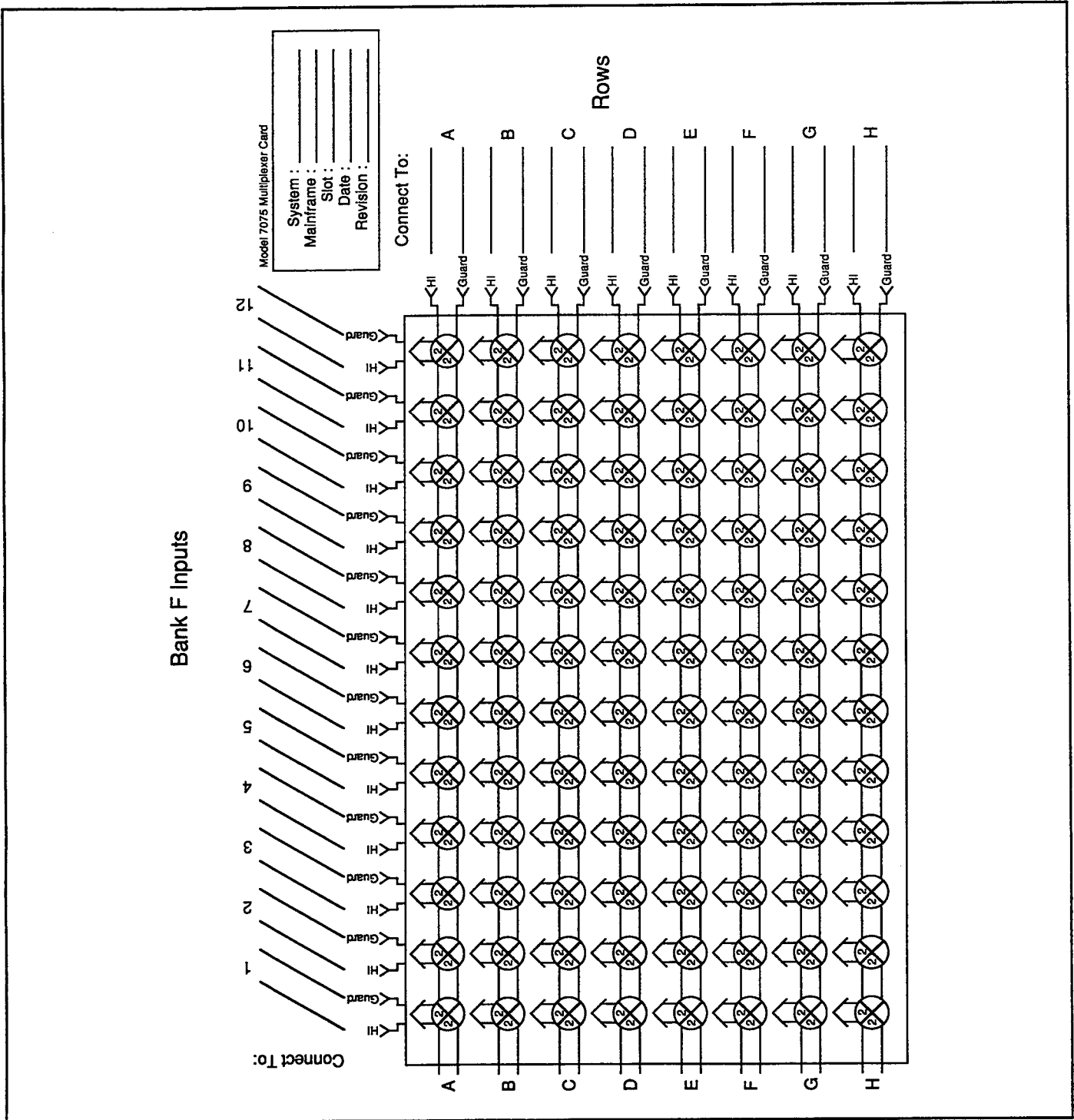
KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
TITLE SCHEMATIC, LOW COST MUX			
NO	MODEL	NO	ECO
D	7075	7075-106	18232
REV			REV
			C
DATE	APPROVED	DATE	
4/3/96	MAH	R. J. K.	

Appendix A Configuration Worksheet

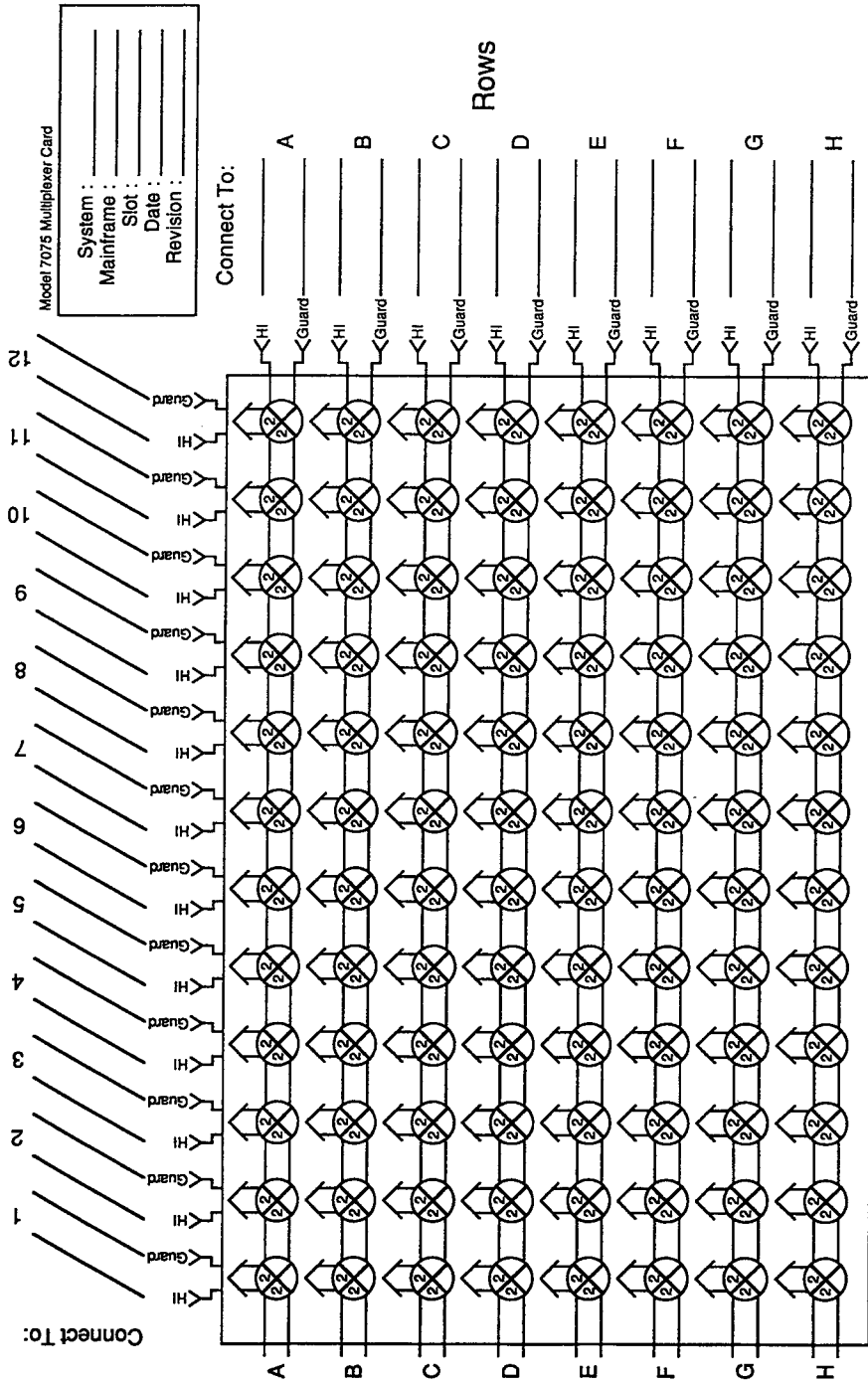


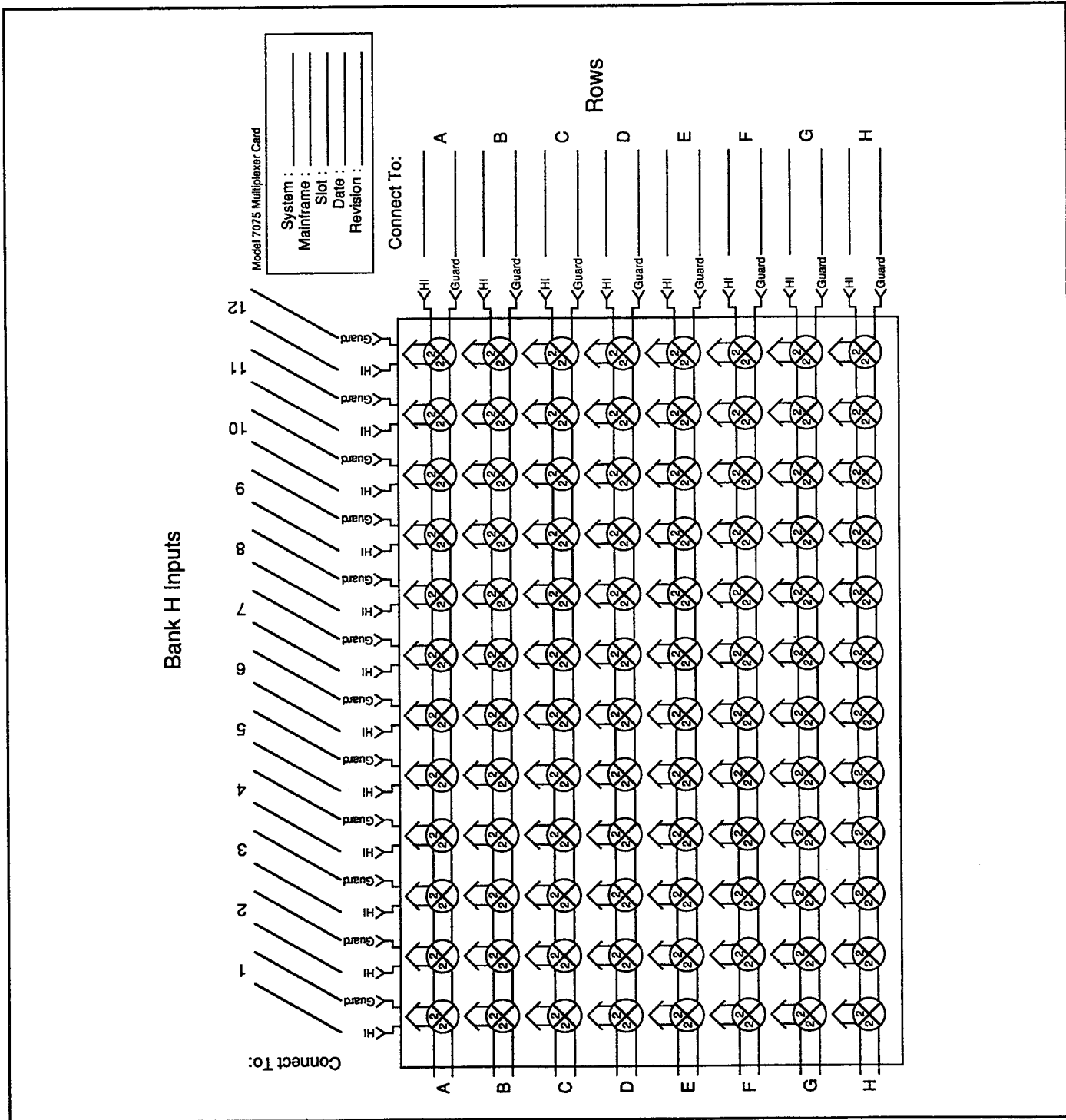






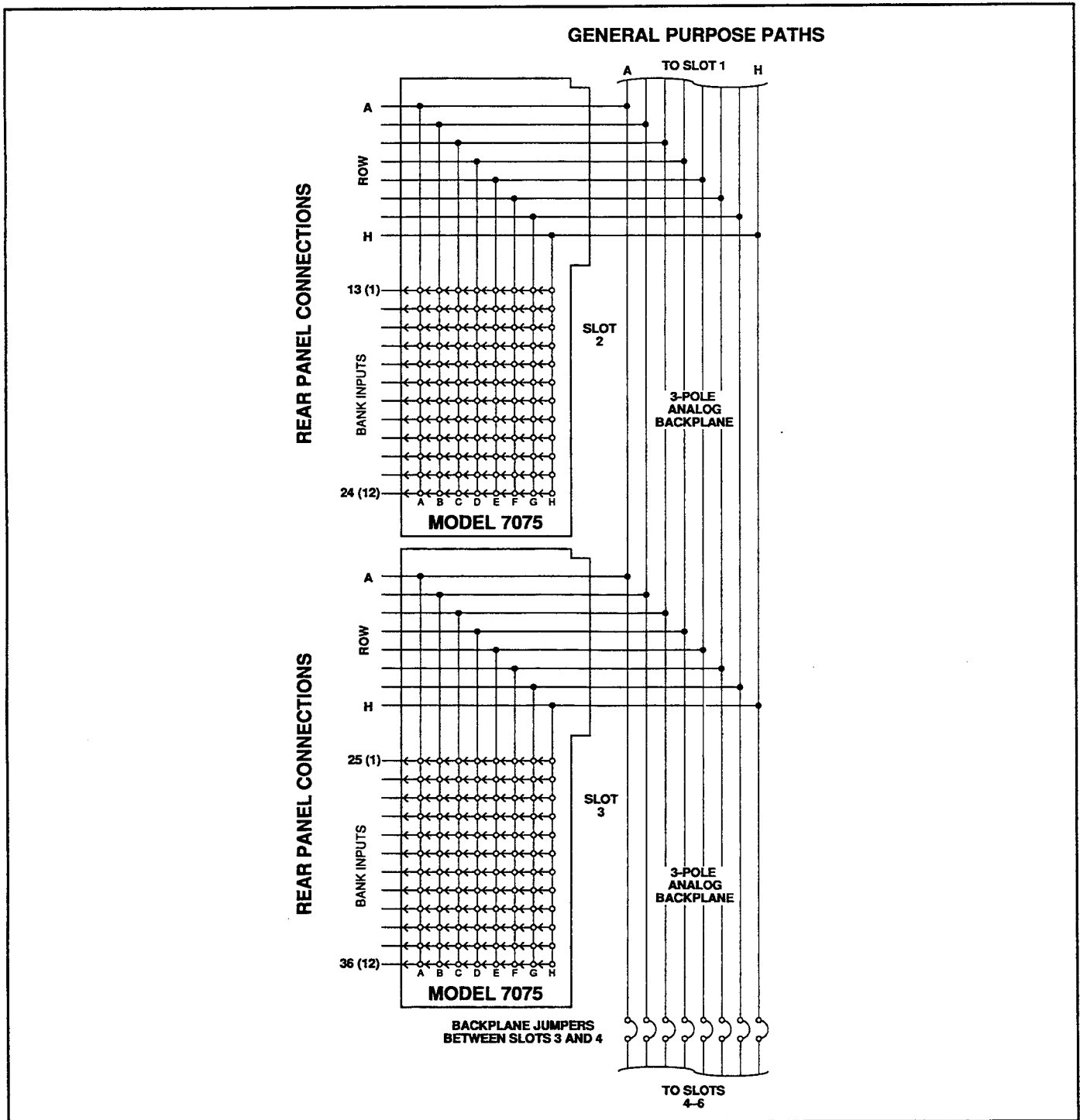
Bank G Inputs





APPENDIX B

Actual Configuration of 7075 Card and Backplane







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.)

Specifications are subject to change without notice.

All Keithley trademarks and trade names are the property of Keithley Instruments, Inc. All other trademarks and trade names are the property of their respective companies.



Keithley Instruments, Inc.

BELGIUM: Keithley Instruments B.V.
CHINA: Keithley Instruments China
FRANCE: Keithley Instruments Sarl
GERMANY: Keithley Instruments GmbH
GREAT BRITAIN: Keithley Instruments Ltd.
INDIA: Keithley Instruments GmbH
ITALY: Keithley Instruments s.r.l.
KOREA: Keithley Instruments Korea
NETHERLANDS: Keithley Instruments B.V.
SWITZERLAND: Keithley Instruments SA
TAIWAN: Keithley Instruments Taiwan

28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168
1-888-KEITHLEY (534-8453) www.keithley.com

Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02/363 00 40 • Fax: 02/363 00 64
Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-6202-2886 • Fax: 8610-6202-2892
3, allée des Garays • 91127 Palaiseau Cédex • 01 64 53 20 20 • Fax: 01 60 11 77 26
Landsberger Strasse 65 • D-82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
The Minster • 58 Portman Road • Reading, Berkshire RG30 1EA • 0118-9 57 56 66 • Fax: 0118-9 59 64 69
Flat 2B, WILLOCRISSE • 14, Rest House Crescent • Bangalore 560 001 • 91-80-509-1320/21 • Fax: 91-80-509-1322
Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-130 • 82-2-574-7778 • Fax: 82-2-574-7838
Postbus 559 • NL-4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
Kriesbachstrasse 4 • 8600 Dübendorf • 01-821 94 44 • Fax: 01-820 30 81
1FL., 85 Po Ai Street • Hsinchu, Taiwan, R.O.C. • 886-3-572-9077 • Fax: 886-3-572-9031