KEITHLEY

Model 7070 Universal Adapter Card

Instruction Manual

A GREATER MEASURE OF CONFIDENCE

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

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

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

LIMITATION OF WARRANTY

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

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Universal Adapter Card
Instruction Manual

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Manual Print History

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

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Safety Precautions

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

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

The types of product users are:

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

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

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

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

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.

SAFETY PRECAUTIONS

The following safety precautions should be observed before using the Model 7070 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 adapter card.

Exercise extreme caution when a shock hazard is present at the test circuit. User-supplied lethal voltages may be present on the card or the card 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 exceed 200V between any two pins or any pin and earth ground.

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

For maximum safety, do not touch the card, test cables or any instruments while power is applied to the circuit under test. Turn off the power and discharge any capacitors before connecting or disconnecting cables from the adapter card.

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. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

Do not exceed the maximum input signal levels of the adapter card, as defined in the specifications and operation section of this manual.

Observe IEC-348 recommended voltage spacing with high-voltage circuits (>200V) mounted on the unplated prototyping area (see paragraph 2.5.10).

SPECIFICATIONS

DESCRIPTION: Backplane extender card for 707 matrix cards or breadboard card, jumper selectable. Access to analog and digital backplanes, relay drivers, and power supplies.

MAXIMUM SIGNAL LEVEL (BACKPLANE): 200V, 1A.

COMMON MODE VOLTAGE (BACKPLANE): 200V maximum between any two pins or chassis.

SUPPLY SPECIFICATIONS: 6V, 2.9A* maximum; 5V, 500mA maximum, digital supply. *Assuming no other cards are installed. See individual card specifications for their relay drive requirements.

RELAY DRIVE LINES: 96 open collector sink drivers, 140mA each. Coded in 8 row × 12 column format for front panel display. User may provide external coil voltage supply up to 35V or use mainframe 6V supply.

BREADBOARD SPACE: Approximately 330mm × 228mm (13 in. × 9 in.).

RIBBON CABLE: Extends analog and digital backplanes 10 feet for benchtop servicing of cards.

CONNECTOR TYPE: 20 quick disconnect with 3 screw terminals. 2 strain relief clamps.

ACCESSORY SUPPLIED: Instruction manual.

Specifications subject to change without notice.

Contains information on Model 7070 features, specifications, and accessories.

SECTION 1
General Information

Details installation of the Model 7070 Universal Adapter Card within the Model 707 Switching Matrix, covers card signal paths, describes use as an extender card, and presents information for mounting relays and other components on the breadboard portion of the Model 7070.

SECTION 2
Operation

Gives typical applications for the Model 7070.

SECTION 3
Applications

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

SECTION 4
Service Information

Lists replacement parts, and also includes component layout and schematic drawings for the Model 7070.

SECTION 5
Replaceable Parts

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SECTION 1
General Information

1.1 INTRODUCTION

This section contains general information about the Model 7070.

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

1.2 FEATURES

The Model 7070 Universal Adapter Card provides two functions. As an extender card, the unit is designed for backplane extension using a 10-foot ribbon cable assembly. The second function is as prototyping or breadboarding card, allowing for user-installed relays or other circuits for custom matrix designs.

There are now two versions of the Model 7070. The standard Model 7070 Universal Adapter Card includes ribbon cables for extender card operation. All sections of this manual apply to this version of the card. The Model 7070-PCA Prototype Circuit Assembly is intended for use only as a prototyping card and does not include extender cables. Those with a Model 7070-PCA should disregard all references in this manual to extender card operation. Major sections that do not apply to the Model 7070-PCA include: paragraph 2.4, Table 5-2, and the extender board component layout and schematic located at the end of Section 5.

Other key features of the Model 7070 Universal Adapter Card include:

- Detachable 10-foot ribbon cable assembly for extender card operation.
- Prototyping area consisting of a grid of holes on 0.1 in. centers for relay and component mounting.
- 96 relay drivers, each with 140mA current sink capability.
- On-card decoding circuity to allow mainframe front panel and IEEE-488 control of user-installed relays and circuits.
- Plated-through holes and pads for easy access to backplane pathways and relay drivers.
- Screw-terminal connections using quick-disconnect connectors for row and column connections.
- 8 × 12 (eight row by 12 column) matrix implementation with user-supplied relays or circuity.
- Guarding pathways are maintained on the card.

1.3 WARRANTY INFORMATION

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7070 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 adapter card or manual will be explained in an addendum included with the unit. Be sure to note these changes and incorporate them into the manual before using or servicing the unit.

1.5 SAFETY SYMBOLS AND TERMS

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

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

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

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

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

1.6 SPECIFICATIONS

Model 7070 specifications may be found at the front of this manual. 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 7070, 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 7070 order:

- Model 7070 Universal Adapter Card.
- Ribbon cable/extender board assembly.
- Ribbon cable clips (5).
- Model 7070 Instruction Manual.
- Additional Accessories as ordered.

1.7.3 Instruction Manual

The Model 7070 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 adapter card instruction manual.

If an additional instruction manual is required, order the manual package, Keithley part number 7070-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 REPACKING FOR SHIPMENT

Should it become necessary to return the Model 7070 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

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

SECTION 2
Operation

2.1 INTRODUCTION

This section contains information on card and matrix configuration, extender and prototyping functions, as well as measurement considerations, and is arranged as follows:

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

2.3 Card Configuration: Covers the various connectors and pads on the card.

2.4 Extender Card Operation: Details using the Model 7070 as an extender card for such applications as troubleshooting other matrix cards.

2.5 Prototype Card Operation: Discusses breadboarding relays and other circuits to construct a custom matrix card.

2.6 Measurement Considerations: Covers some important aspects to keep in mind when using the Model 7070.

2.2 HANDLING PRECAUTIONS

To maintain isolation, care should be taken when handling the adapter 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, edge connectors, or components after prototyping and cleaning.

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

Contamination from solder flux can also degrade performance. After soldering wires to the card, carefully clean it using the procedure discussed in paragraph 2.6.3.

2.3 CARD CONFIGURATION

The overall configuration of the Model 7070 is shown in Figure 2-1. The following paragraphs discuss the main aspects of the card.

WARNING
User-supplied lethal voltages may be present on the PC board or connectors.

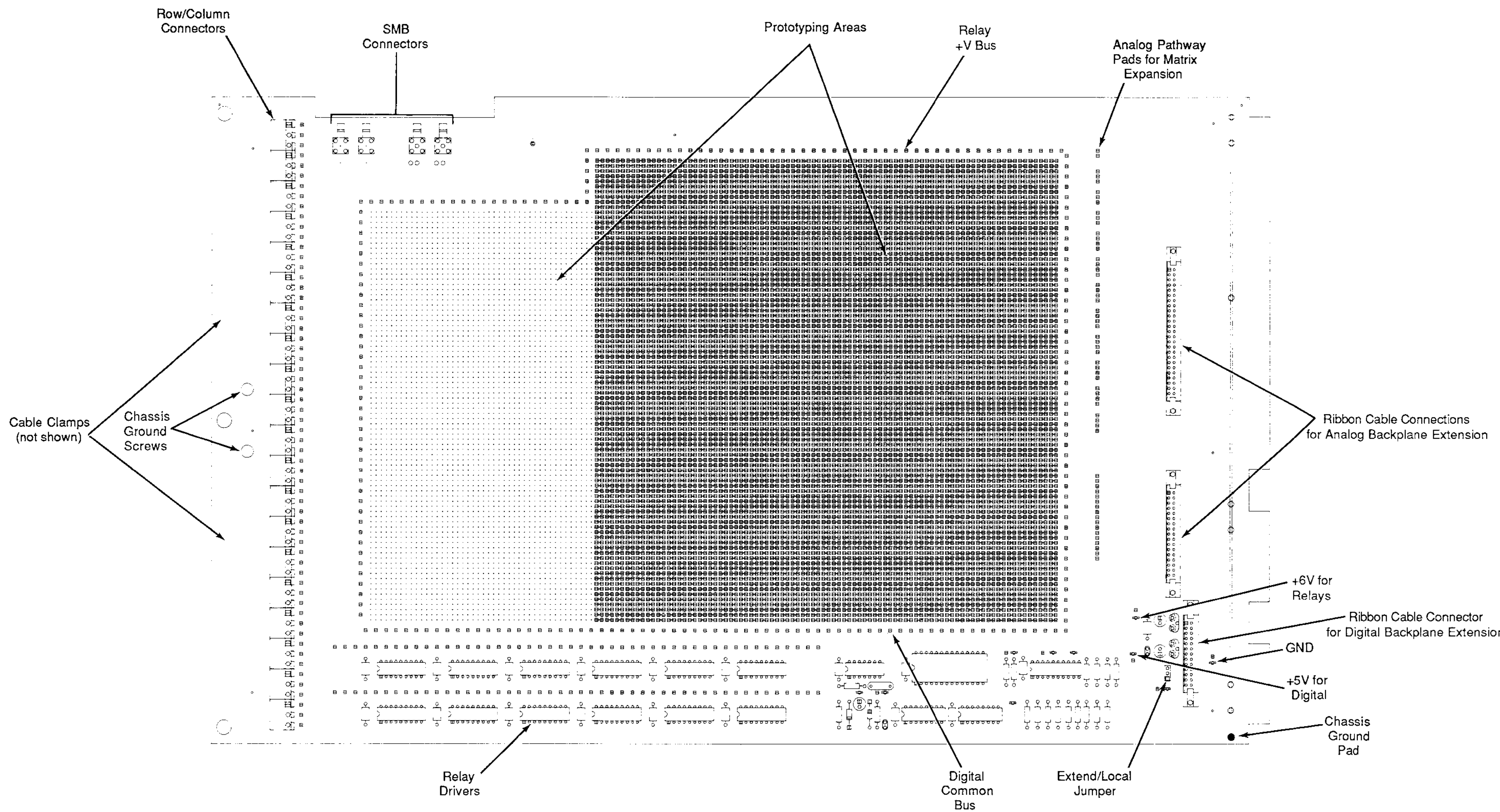


Figure 2-1. Card Configuration

2.3.1 Row/Column Connectors

A 3-terminal removable connector block is available for each row and column connection of the switching matrix. These blocks are labelled rows A through H, and columns 1 through 12. The three terminals available are H (HI), L (LO), and G (guard). The connectors are equipped with screw terminals, and they accept wires as large as #16AWG. Plated through holes with pads adjacent to the connectors allow input/output connections to circuits and relays mounted on the protoptyping areas.

2.3.2 SMB Connectors

The four SMB connectors are intended for expanding the matrix of rows A, B, G, and H to a Model 7072 Semiconductor Matrix Card. These jumpers are supplied with the Model 7072, and they can be installed as discussed in the Model 7072 Instruction Manual.

2.3.3 Prototyping Areas

There are two prototyping areas located on the card. The larger of the two is approximately 9in. × 9in. and has plated-through hole pairs (0.04in. in diameter) on 0.1in. centers. The unplated area is about 4.5in × 8in. and is intended for such applications as switching higher voltages than 200V using suitable relays and wiring. Again, the holes are 0.04in. in diameter and are located on 0.1in. centers.

WARNING
The maximum voltage between any two backplane connections or between any backplane connector and chassis ground is 200V. The maximum voltage between any two pads in the plated area is 200V. IEC-348 recommended spacing must be maintained for high-voltage circuits mounted on the unplated prototyping area. See paragraph 2.6.10 for high-voltage considerations.

2.3.4 Analog Pathway Connections

Three groups of pads are intended for matrix expansion to other cards available for the matrix system: the Model 7071 General Purpose Matrix Card, the Model 7072 Semiconductor Matrix Card, and the Model 7073 Coaxial Matrix Card. As summarized in Table 1, ANALOG #1 accesses rows C through F of the Model 7072 expansion pathways, ANALOG #2 accesses rows A through H of the Model 7071 expansion pathways, and ANALOG #3 access rows A through H of the Model 7073 expansion pathways. Note that Model 7072 expansion of rows A, B, G, and H is available through the SMB connectors.

Table 2-1. Analog Pathway Summary

Pathway	Card	Signal Lines
ANALOG #1	7072, rows C-F	HI, Guard
ANALOG #2	7071, rows A-H	HI, LO, Guard
ANALOG #3	7073, rows A-H	HI, Guard

2.3.5 Ribbon Cable Connections

The three ribbon cable connectors mate with the ribbon cable headers when the Model 7070 is being used as an extender card. In addition to the three analog pathways, the digital circuits are extended through the ribbon cable so that any card connected to the extender can function normally.

2.3.6 CARD FUNCTION Jumper

The CARD FUNCTION jumper selects the operating mode of the adapter card. In the EXTEND position, the Model 7070 is set up for extender card operation. In the LOCAL position, relays or circuits on the card can be controlled by the relay drivers.

2.3.7 Relay Drivers

There are 96 relay drivers located in 12 ICs on the circuit boards. The connecting pads for the drivers are labelled in row-column format. The output of each driver is active LO, with a 140mA sink capability. Note, however, that the maximum number of relays that can be energized is limited by the power available; see paragraph 2.5.4 for more information.

2.3.8 +V Relay and Digital Common Buses

The +V RELAY BUS is intended for connection of the supply voltage to the on-card relays. If using the +6V mainframe supply, a jumper must be connected between the +V RELAY BUS and the +6V supply pad on the card. If an external supply is used, it should be connected to the +V RELAY BUS, and the +6V supply must be disconnected from +V RELAY BUS.

The DIGITAL COMMON BUS provides a common connection for on-card active circuits using the mainframe's +5V supply.

2.3.9 +5V and +6V Supplies

The +5V supply can be used to power user-installed digital circuits mounted on the Model 7070 breadboard. Note that the maximum +5V supply current for the card is 500mA. The +6V supply can be used to power user-installed relays. The maximum current available from the +6V supply 2.9A; this value assumes that no other cards are installed in the mainframe. See paragraph 2.5.4 for a detailed discussion of power supply limitations.

2.3.10 Chassis and GND Connections

The two screw terminals adjacent to the input/output connectors are at chassis ground potential and can be used to connect cable shields to chassis ground. An additional chassis ground pad is located on the lower rear corner of the card. The GND pad located at the lower rear terminal is connected to digital common.

2.4 EXTENDER CARD OPERATION

NOTE

This section does not apply to the Model 7070-PCA.

One of the two functions of the Model 7070 is used as an extender card for troubleshooting or bench-top testing of other matrix cards. The following paragraphs discuss setting up the unit as an extender card, connecting the ribbon cables, and connecting other cards to the extender board.

2.4.1 Selecting the Extend Function

In order to use the Model 7070 as an extender card, the CARD FUNCTION switch must be in the EXTEND position, as shown in Figure 2-2.

NOTE

If relays are mounted on the card, disconnect the +V relay bus from the relay supply voltage before using the Model 7070 as an extender card. Otherwise, any on-card relays will be energized when accessing the card slot.

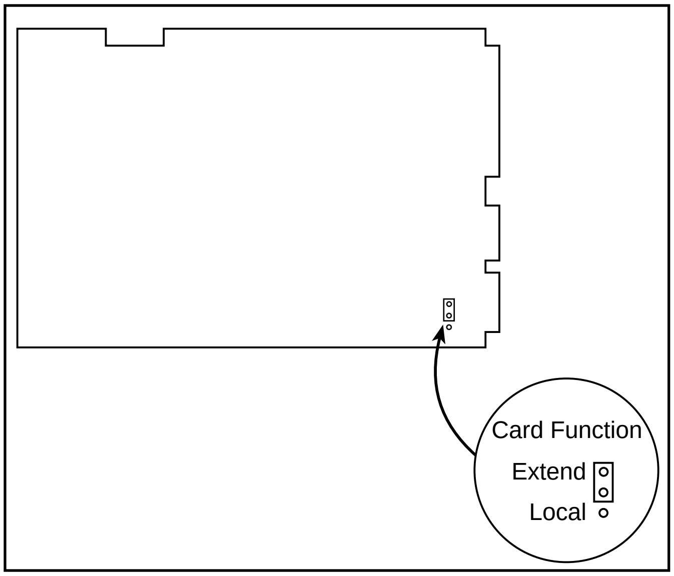


Figure 2-2. Extend Function Jumper Selection

2.4.2 Ribbon Cable Connections

Three 10-foot ribbon cables attached to an extender board are supplied with the Model 7070. In order to use the Model 7070 as an extender card, these cables must be connected to the on-card connectors, as shown in Figure 2-3. The widest cable should be routed through the upper cable clamp, while the two narrower cables should be routed through the lower cable clamp (remove upper half of clamp first). After making connections, secure the ribbon cables with the clamps. Also dress the cables with the supplied cable clips where convenient.

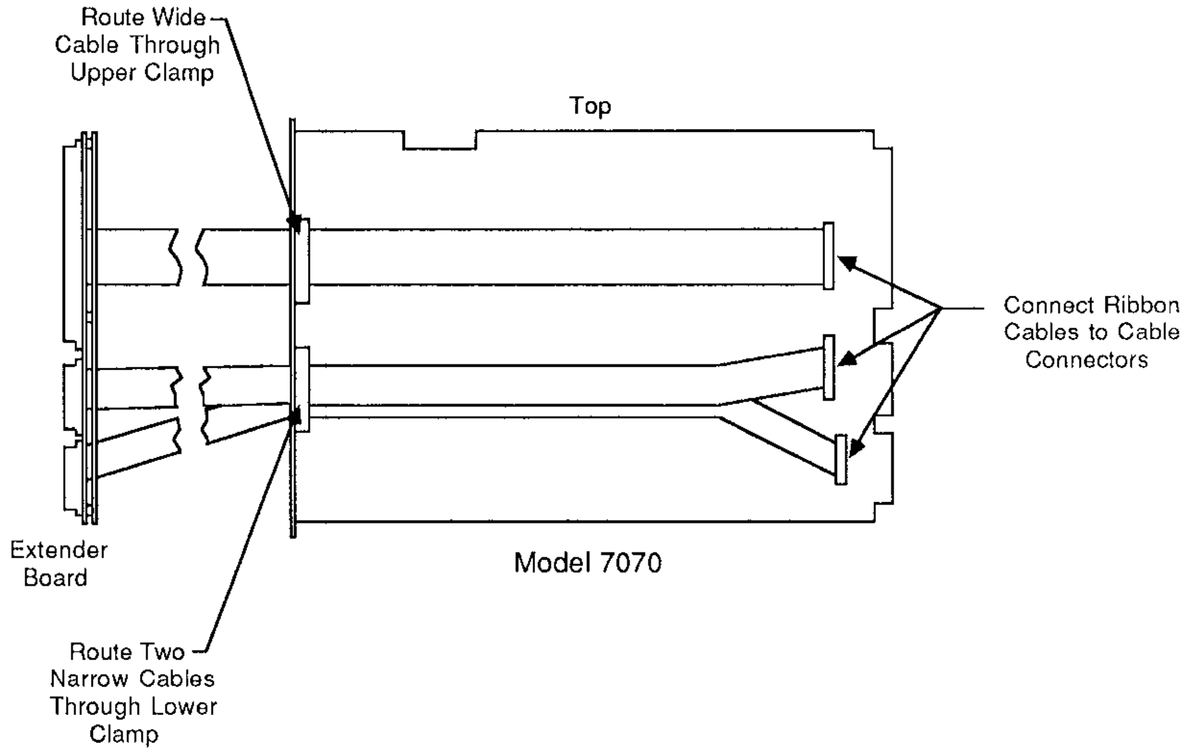


Figure 2-3. Ribbon Cable Connections

2.4.3 Connecting Cards to the Extender Card

To connect other cards to the Model 7070, simply plug in the card in question to the extender board, as shown in Figure 2-4. Make certain the card is properly seated in the edge connectors.

WARNING
User-supplied lethal voltages may be present on the extender board. Place the matrix card that has been set outside the mainframe on a non-conductive surface. Do not place the matrix card on a conductive surface such as a rack. Voltages present on the card could short, causing a shock hazard or possible damage to the matrix card or mainframe.

CAUTION
Do not touch any card edge connectors to avoid contaminating them; such contamination may degrade card performance.

2.4.4 Card Installation and Removal

After prototyping or extender card selection, the Model 7070 should be installed within the Model 707 Switching Matrix, as summarized below. Figure 2-5 shows the installation procedure.

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

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 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.

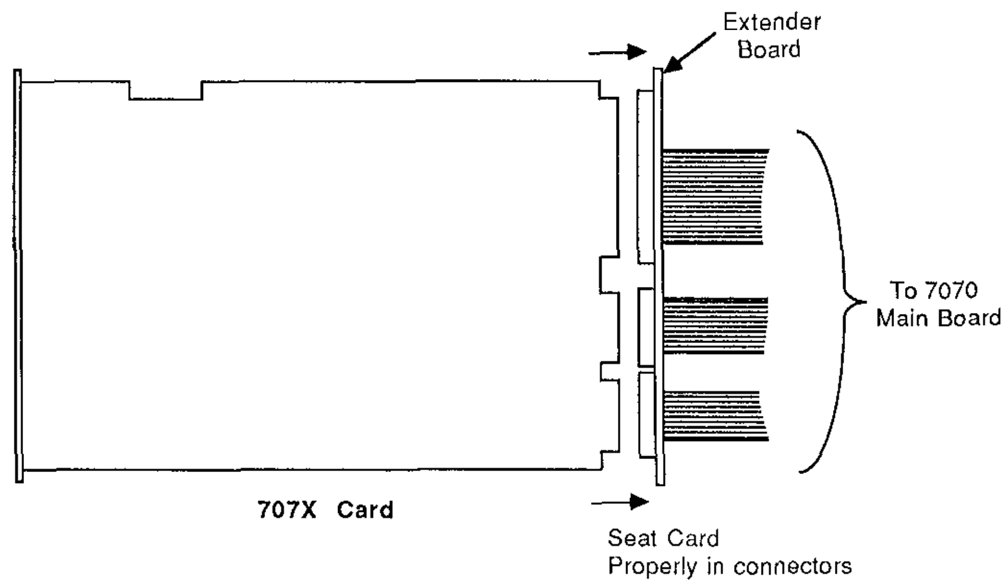


Figure 2-4. Extender Board Connections

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 external and internal cables (internal cables can be reached through the access door). Loosen the mounting screws, then pull the card out of the mainframe by the handle. When the back of the card clears the mainframe, support it by grasping the bottom edge near the rear of the card.

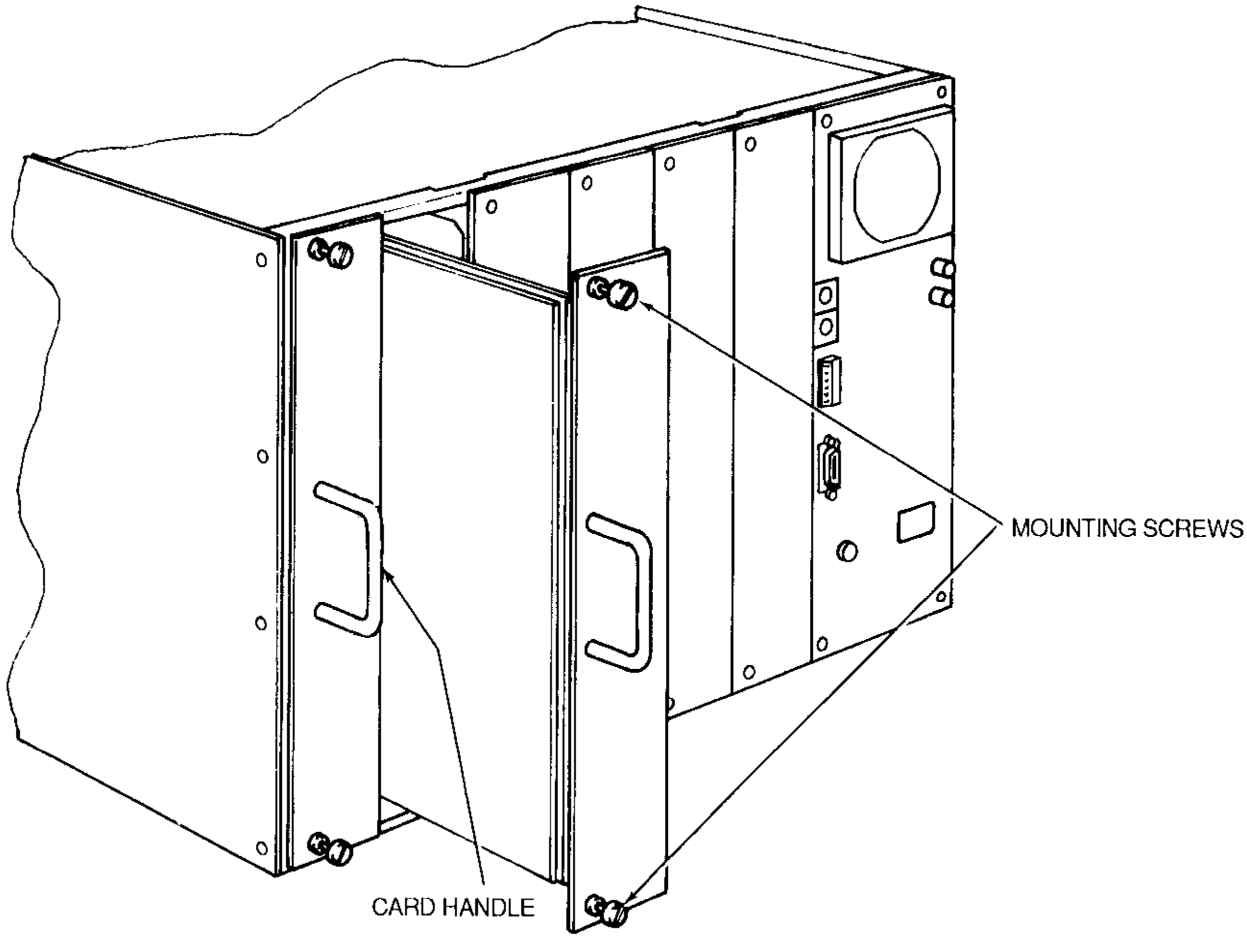


Figure 2-5. Model 7070 Installation

2.4.5 Extender Card Considerations

The following points should be kept in mind when using the extender card.

1. Using the extender card may degrade the specifications of other cards. Card specifications are not applicable when they are used with the extender card.
2. When a matrix card is being operated outside the mainframe, it is no longer shielded from RFI/EMI interference or static discharge by the mainframe. If the card is to be operated in such an enviroment, shield the card as necessary.
3. Because of the long ribbon cables, the digital circuits on the card or in the mainframe may radiate signals that interfere with other equipment. In order to minimize these effects, keep the ribbon cables and external card as far away as possible from sensitive instrumentation.

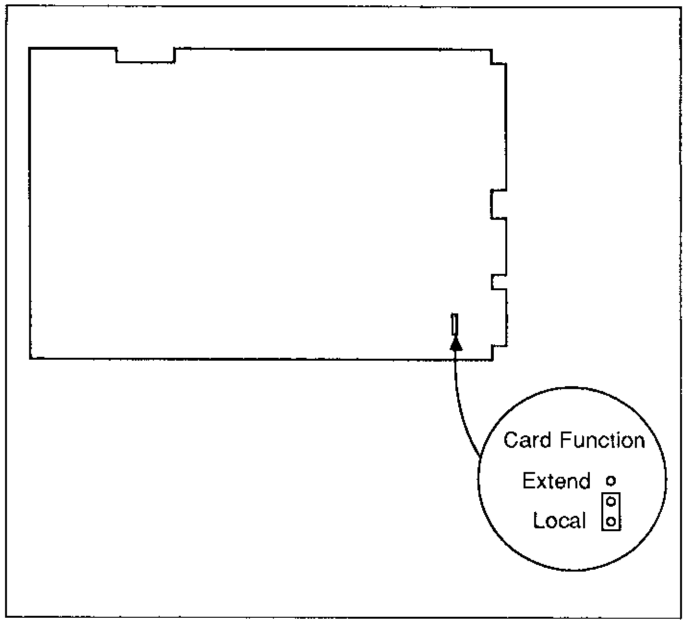


Figure 2-6. LOCAL Function Jumper Position

2.5 PROTOTYPING CARD OPERATION

A primary function of the Model 7070 is as a prototyping card. Two large prototyping areas on the card allow the installation of user-supplied relays or active circuits for custom matrix applications. The following paragraphs describe the major aspects of using the Model 7070 as a prototyping card.

2.5.1 Local Function Selection

In order to use the Model 7070 as a prototyping card, the CARD FUNCTION jumper must be placed in the LOCAL position. Figure 2-6 shows the LOCAL jumper position. Also, the ribbon cables used for the extension function should be disconnected and removed from the card.

2.5.2 Breadboarding Considerations

The adapter card has two prototyping areas available for user-installed components. The larger 9in. × 9in. area has plated-through hole pairs on 0.1in. centers with a hole diameter of 0.04in. The secondary (4½in. × 8in.) prototyping area has unplated holes for such uses as switching higher voltages than 200V. These holes are also on 0.1in. centers and have a diameter of 0.04in.

The holes will accept conventional IC packages, transistors, relays, resistors, and other similar components. In addition, the holes will accept vector pins and micro klip pins to simplify circuit connections. The plated hole pairs can be cut with a sharp knife or razor blade, if necessary. Note that components must be mounted on the same side of the card as the digital components that are already mounted on the card; soldering should be done on the opposite side. After installing components or connecting pins, make sure that pins or leads do not extend more than 0.25in. above the surface of the solder side. After soldering, the board should be cleaned, as discussed in paragraph 2.5.3.

WARNING
The maximum voltage between any two plated pad pairs, or between any plated pad and chassis ground is 200V. The maximum voltage between any two backplane connectors between any backplane connector and chassis ground is 200V. The maximum card signal level is 200V, 1A. IEC-348 recommended spacing must be maintained for high-voltage circuits mounted on the unplated prototyping area. See paragraph 2.5.10 for details.

CAUTION
Make certain the +5V or +6V supplies are not shorted to chassis or common before installing the card. Failure to observe this precaution may result in card or mainframe damage.

2.5.3 Board Cleaning

Flux left on the circuit board after soldering can degrade measurements, especially those of the high-impedance variety. After soldering to the circuit board, the board should be carefully cleaned as follows:

1. Carefully clean the soldered areas using Freon® TMS or TE, or the equivalent. Clean cotton swabs or a clean, soft brush can be used to help remove the flux. Be careful not to spread the flux around to other areas of the board.
2. After cleaning with Freon® , swab the treated area with clean methanol, then blow dry the board with dry nitrogen gas.
3. After cleaning the board, allow it to dry for several hours in a 50°C, low-humidity environment before use.

2.5.4 Power Supply Considerations

The prototyping section has access to the mainframe's +5V and +6V supplies via the supply pads located on the card. The +5V supply can be used to power digital circuits on the card, and it has a maximum current available of 500mA.

The +6V supply is intended for powering on-card relays, and it has a maximum available current of 2.9A. Note, however, that this value excludes any other cards installed in the mainframe. The available current with a given configuration depends on how many other cards are installed in the mainframe, as well as how many crosspoints on each card are closed at any given time.

As summarized in Table 2-2, the amount of drive current required per crosspoint depends on the card type. To determine how much current is available for use by the Model 7070, simply multiply the maximum number of like crosspoints to be closed at any given time by the current per crosspoint. Sum the card totals and subtract that value from 2.9A. The result is the amount of current available to drive prototyping relays. The total number of prototype relays that can be closed at once can then be found by dividing the available current by the drive current per prototyping relay. See the specifications for your relays for the required drive current per relay.

Table 2-2. Drive Current per Crosspoint

Card	Rows	Relay Drive Current (per crosspoint)
7071	A-H	15mA
7072	A-B	40mA
	C-F	60mA
	G-H	80mA
7073	A-H	20mA

2.5.5 Internal/External Relay Powering

Card relays can be powered either from the +6V mainframe supply, or from an external supply of up to 35V, as described below.

Internal Relay Supply

To power all relays from the +6V supply, you must install a jumper between the +6V pad and the +V RELAY BUS, as shown in Figure 2-7. Be sure to remove this jumper if using an external supply.

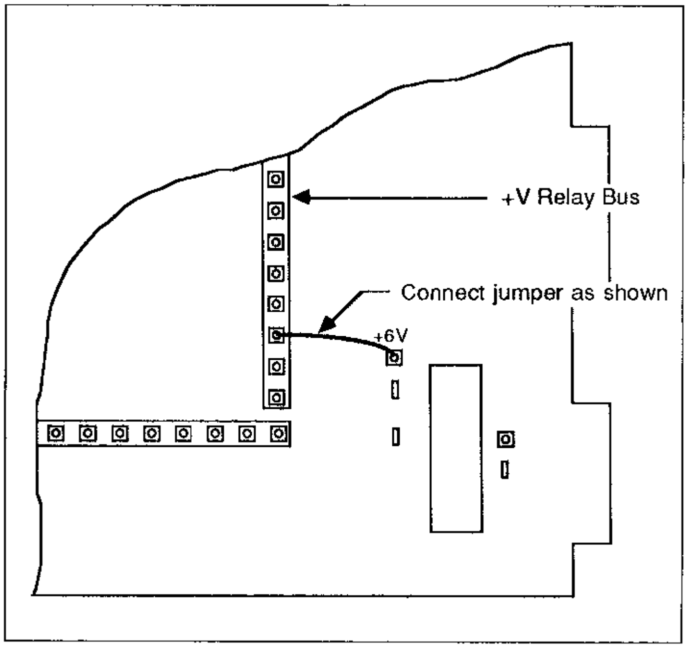


Figure 2-7. Jumper Installation for Internal Relay Supply

External Relay Supply

In cases where more current or a higher voltage than is available from the +6V supply is required, an external supply of up to +35V can be connected to the card, as shown in Figure 2-8. Connect the positive terminal to the +V RELAY BUS, and connect the negative terminal to the DIGITAL COMMON BUS.

CAUTION
Do not exceed 35V for the external supply. Also, make sure to disconnect the internal +6V supply when using an external supply, or damage to the card or mainframe may occur.

Splitting the Relay Supply

In some cases, you may wish to split up the power supply allotment among the relays because of different relay voltages or other factors such as current constraints. To do so, simply cut the +V RELAY BUS at a convenient location, and connect the two sections to the internal and external supplies, as required. Be careful to avoid a short between the two sections, or instrument damage may occur.

Power Supply Decoupling

Active circuits wired on the prototyping board should be properly decoupled to ensure proper operation and minimum EMI radiation. For example, digital circuits typically use a 0.1μF capacitor between +5V and digital common, with one capacitor per IC for MSI and LSI packages, and one capacitor for every three or four packages for small scale integration ICs. Each capacitor should be mounted as close to the IC as possible, and only low equivalent series resistance capacitors such as ceramic film types should be used.

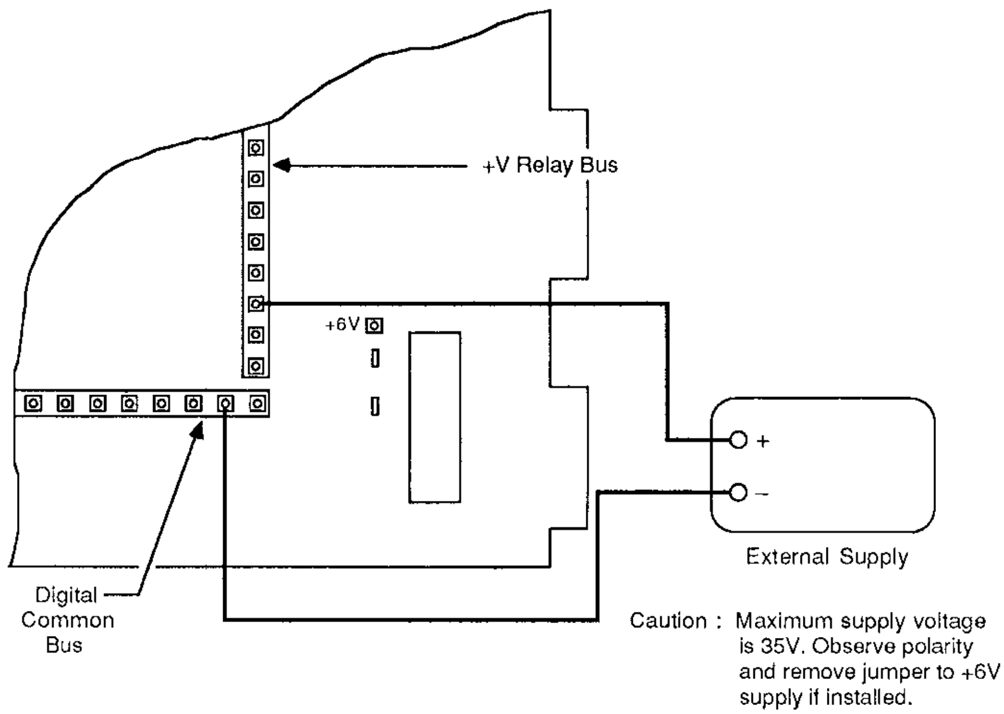


Figure 2-8. External Supply Connections

2.5.6 Digital Common Connections

The DIGITAL COMMON BUS, which is located along the bottom edge of the prototyping area, provides a common bus for any active circuits located on the card, including those using the +5V supply. Digital common also provides a return path for the relay drivers located on the card.

2.5.7 Relay Coil Connections

Each relay driver has an open-collector output capable of sinking a maximum of 140mA. A typical driver output is shown in Figure 2-9.

To wire your relay coils, simply connect one side of each coil to the +V RELAY BUS, and connect the other side of the coil to the relay driver connection pad. An example of such connections for all 12 columns of row A is shown in Figure 2-10. Note that it is not necessary to use clamping diodes across the relay coils because they are integral within the driver ICs. Also, the +V RELAY BUS must be connected to +6V or an external power source as previously described.

The specified operating voltage of each relay should, of course, agree with the relay supply voltage. Since each relay driver output has a specified saturation voltage of 1.1V (at 100mA), the specified relay coil voltage should be approximately 1V less that the supply voltage being used. With the +6V supply voltage, for example, 5V relays should be used. In any case, the specified relay current must not exceed 140mA, as stated above.

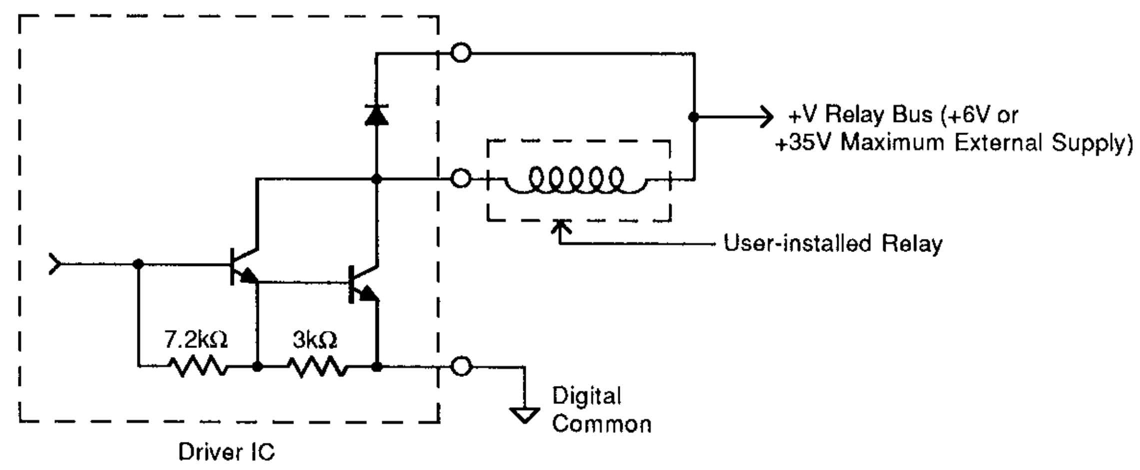


Figure 2-9. Typical Relay Driver Output

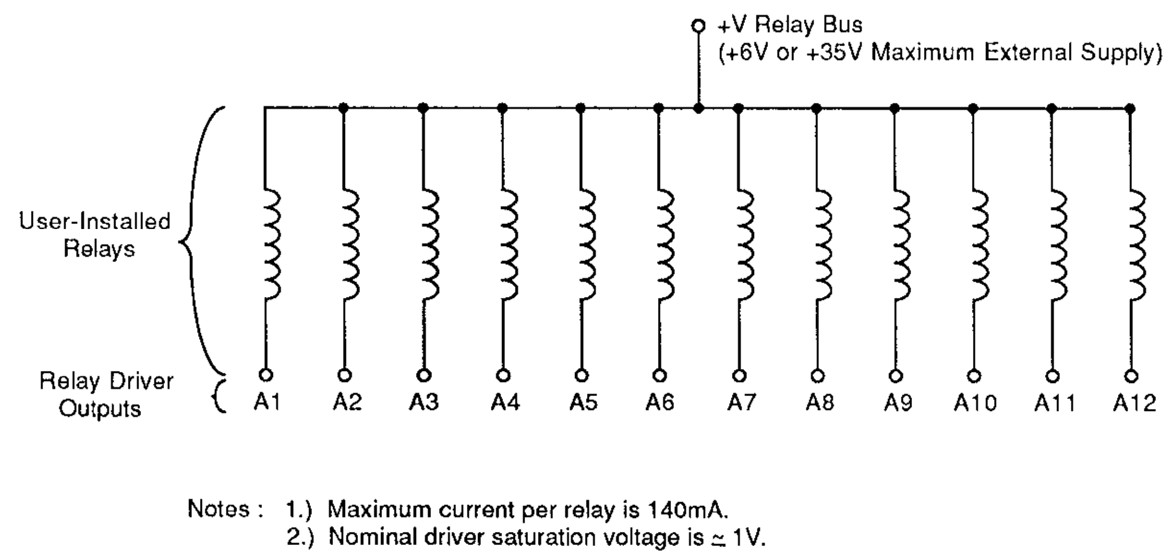


Figure 2-10. Typical Relay Coil Connections (Row A Shown)

2.5.8 Relay Matrix Wiring

The exact way you wire your relay contacts will, of course, depend on your particular requirements. Typically, such relays will be wired in a row-column matrix configuration, as shown in Figure 2-11 (for the sake of clarity, we have shown only a few relays on the diagram). Note that 3-pole switching is shown, with HI, LO, and guard all switched. If the relays are equipped with shields, guard would be connected to the relay shields.

In order to complete the matrix, the like contacts of the relays must be connected together to complete the row-column format. One end of each row and column group would typically be connected to the input/output connectors, while the other end of each row and column group would be connected to the pathway extension pads, if matrix expansion to other cards in the mainframe is required.

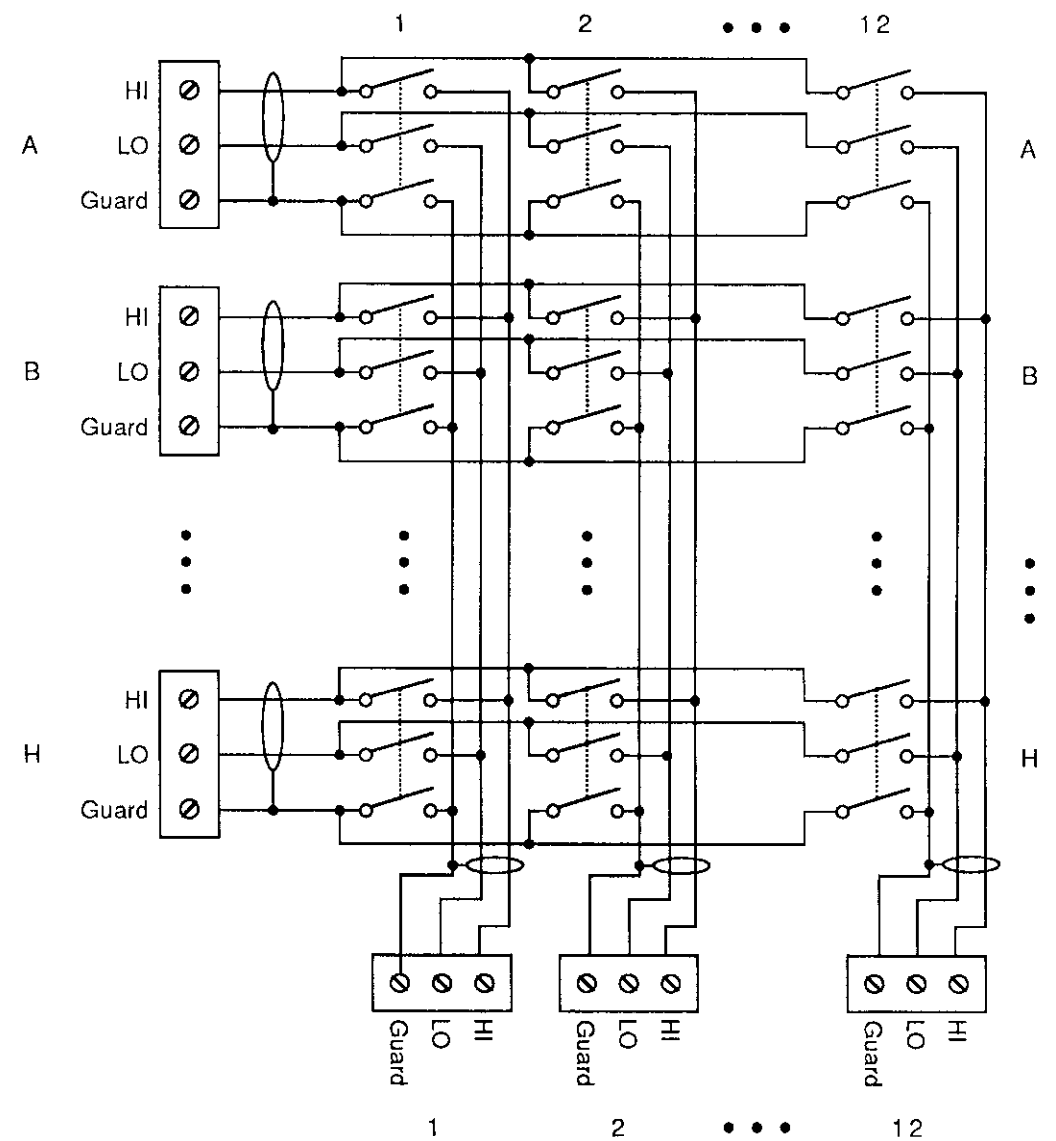


Figure 2-11. Relay Matrix Wiring

2.5.9 Relay Settling Time

Any mechanical relay takes a finite length of time to make contact and settle completely. The other cards in the Model 707 system have a hardware settling time that is dependent on the type of relays programmed into their ROMs. However, since there is no way to anticipate the type of relays you will use, the Model 7070 has a hardware settling time of 1msec programmed into its ROM. For that reason, it will be necessary for you to program a suitable settling time into the Model 707. The required settling time will, of course, depend on your particular relays; see the relay specifications for information. Settling time can be programmed using the front panel SETTLING TIME key (or over the bus with the S command). The allowable range for the settling time is 1msec to 65.535sec in 1msec increments.

2.5.10 High-Voltage Switching Considerations

The unplated prototyping area can be populated with suitable relays to switch voltages higher than the 200V available with the plated prototyping area or other cards in the Model 707 system. The following precautions must be observed when prototyping high-voltage circuits on the card.

1. Minimum terminal spacing, as recommended by the IEC-348 standard, must be observed. A partial list of minimum distances for various recommended voltages is shown in Table 2-3. The clearance values are distances in free air, while the creepage values are distances across the board surfaces. For more detailed information, consult IEC (International Electrotechnical Commission) Publication 348.
2. All wiring, relays, and connectors must have adequate voltage rating for the expected voltage levels. Do not use the input/output connectors supplied with the adapter card.
3. Use shielded wire for input/output connections to minimize EMI radiation. Connect the shields to the card chassis ground screws.
4. Do not connect any high-voltage circuit to pads or components on any area of the card other than the designated high-voltage (unplated) prototyping area.
5. If the card is to be operated outside the mainframe (for example, with a second Model 7070 used as an extender card), it must be properly shielded for safety and to minimize EMI radiation. The shield must be connected to the mainframe chassis using a heavy ground wire.

Table 2-3. Partial List of Recommended Spacing for High-Voltage Circuits

Voltage Between Conductors		Minimum Spacing Between Conductors	
DC or AC RMS Sinusoidal	AC Peak	Clearance mm (in.)	Creepage Distance mm (in.)
>130V, ≤250V	>184V, ≤355V	3 (0.118)	3 (0.118)
>250V, ≤450V	>354V, ≤630V	3.5 (0.138)	4.5 (0.177)
>450V, ≤660V	>630V, ≤933V	4 (0.157)	6 (0.236)
>660V, ≤1000V	>933V, ≤1400V	5.5 (0.217)	9 (0.354)

2.5.11 Prototype Card Installation

After prototyping your circuits, install the card in the desired slot of the mainframe. The detailed installation procedure is covered in paragraph 2.4.4.

WARNING
The card mounting screws must be secured to ensure a good connection to chassis ground.

2.5.12 Switching Matrix

As shown in Figure 2-12, the each Model 707 matrix card is organized as an 8 × 12 (eight row by 12 column) matrix. The rows are labelled A through H, while the columns on the card are numbered 1 through 12. The actual column number to use when programming depends on the slot and unit number, as summarized in Table 2-4. For example, card column number 2 on a card in slot 5 of unit 1 is accessed as matrix column 62.

Each intersecting point in the matrix is called a crosspoint that can be individually closed or opened by programming the Model 707 mainframe. The switching form depends on the type of user-installed relays: one, two, or three pole switching can be used. With single-pole switching, only HI would be switched; with two-pole switching, both HI and LO would be switched; and, with three-pole switching, HI, LO, and guard are switched. These three basic switching configurations are shown on Figure 2-12.

Table 2-4. Column Numbering by Slot and Unit

Unit	Slot	Columns (1-12)
1	1	1-12
	2	13-24
	3	25-36
	4	37-48
	5	49-60
	6	61-72
2	1	73-84
	2	85-96
	3	97-108
	4	109-120
	5	121-132
	6	133-144
3	1	145-156
	2	157-168
	3	169-180
	4	181-192
	5	193-204
	6	205-216
4	1	217-228
	2	229-240
	3	241-252
	4	253-264
	5	265-276
	6	277-288
5	1	289-300
	2	301-312
	3	313-324
	4	325-336
	5	337-348
	6	349-360

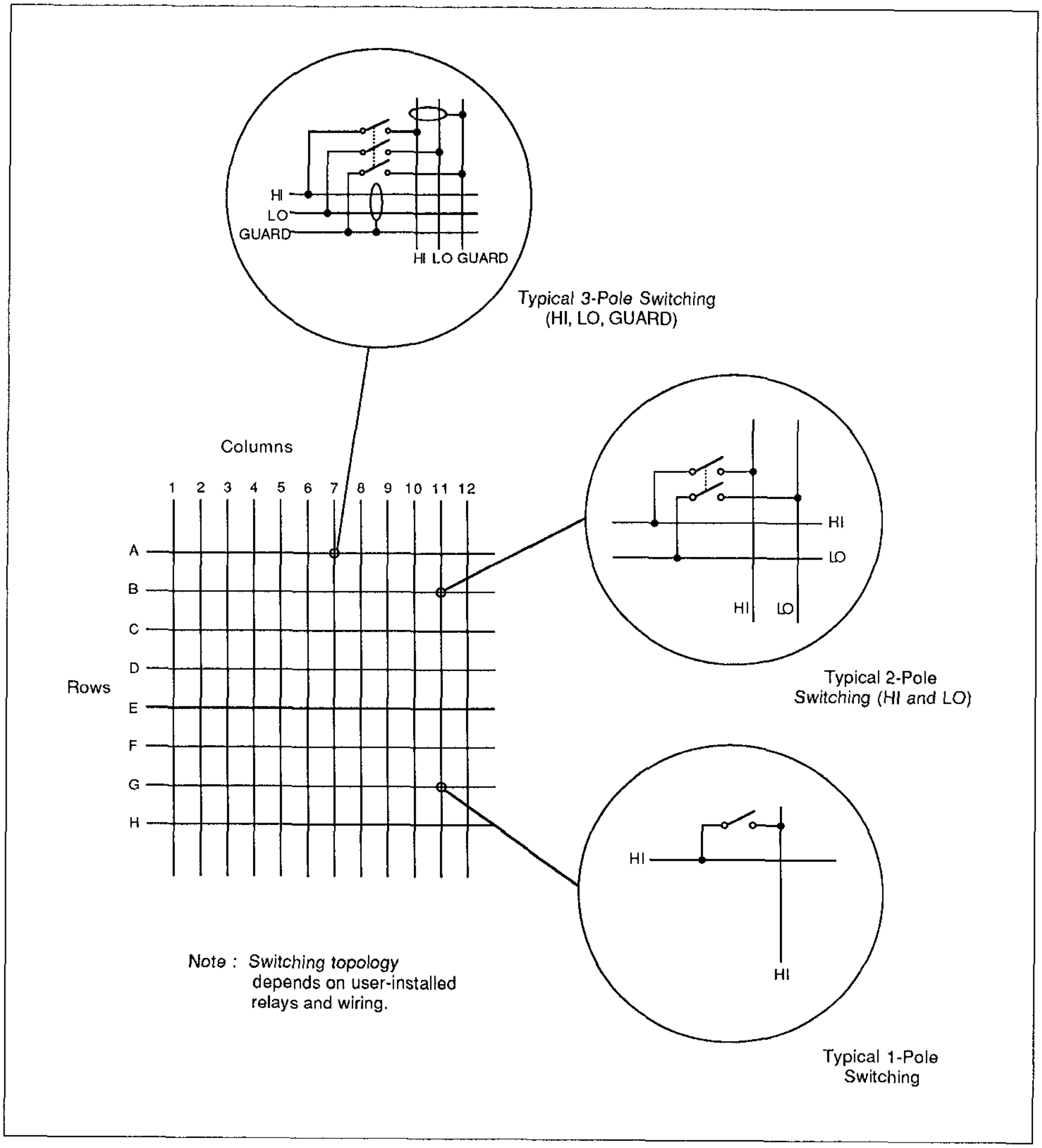


Figure 2-12. Matrix Organization

2.5.13 Internal Matrix Expansion

Two to six matrix cards can be connected together within the mainframe to yield an 8 × N matrix, where N depends on the number of cards. Figure 2-13 shows an internally expanded matrix with three cards, resulting in an 8 × 36 (eight row by 36 column) matrix. As summarized in Table 2-2, the actual column number used when programming the unit is determined by the slot.

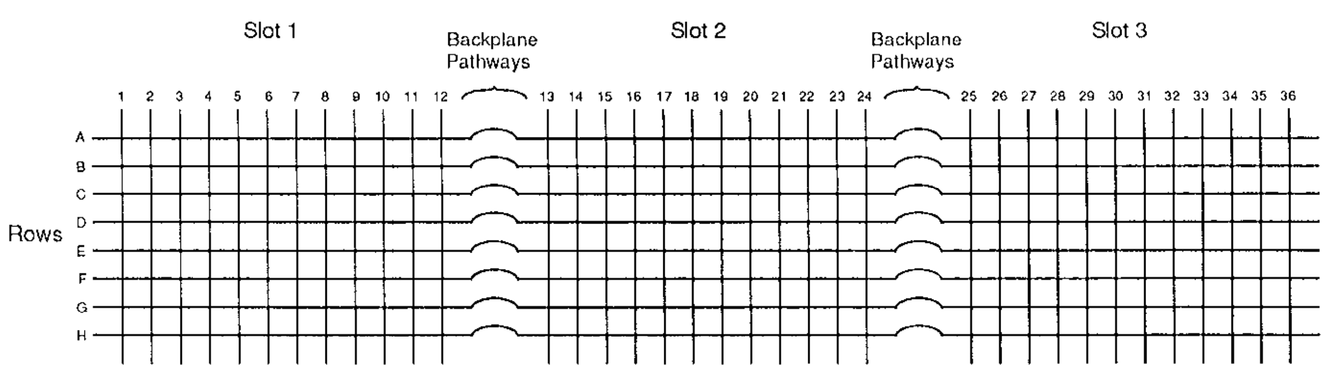
For ANALOG #2 and ANALOG #3 pathways, all rows (A through H) are automatically connected together through the backplane of the mainframe (you must of course make the necessary on-card connections from your relay buses to the appropriate pathway pads). For ANALOG #1, pathways C through F are connected through the backplane, while rows A, B, G, and H use the SMB connectors. As discussed previously, ANALOG #1 connects to Model 7072 cards, ANALOG #2 connects to Model 7071 cards, and ANALOG #3 connects to Model 7073 cards.

The mainframe can be configured for two sets of three cards each by removing jumpers from the backplane of the mainframe; see Section 3 of the Model 707 Instruction Manual for details on removing the jumpers. With the row jumpers removed, cards in slots 1 through 3 are connected, and cards in slots 4 through 6 are connected together.

Because of more critical signal paths, rows A, B, G, and H of ANALOG #1 are not jumpered through the backplane. Instead, you must install the coaxial jumpers (supplied with the Model 7072) between appropriate connectors on Model 7070 and 7072 cards. Each card has one or two SMB coaxial connectors for each row, allowing daisy chaining of card rows. These connectors can be reached by lifting the access door on the top of the mainframe; it is not necessary to remove cards to install the jumpers.

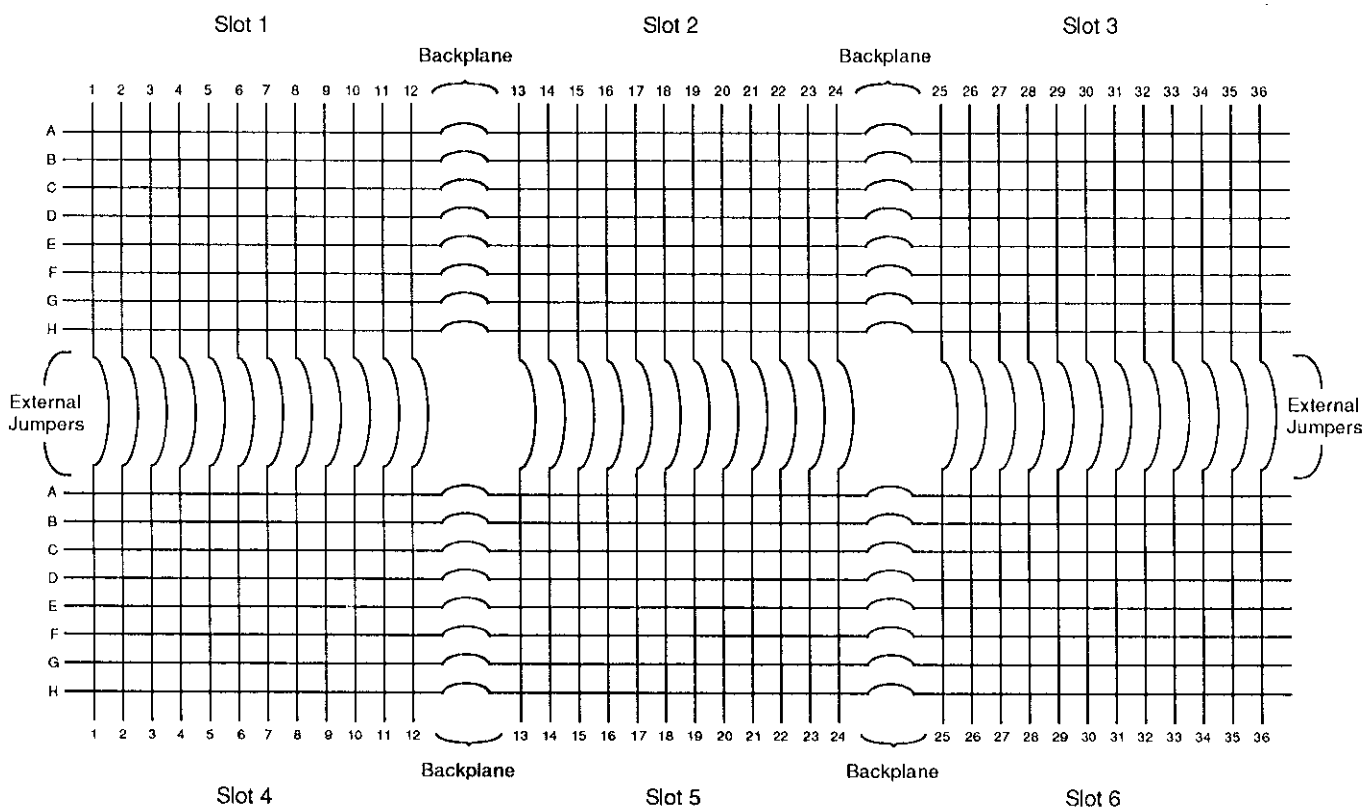
2.5.14 External Matrix Expansion

External jumper wires must be used to expand the number of rows in the matrix, or to connect between columns of cards installed in different mainframes. An example of such an expanded matrix is shown in Figure 2-14. Here, six cards are configured as a 16 × 36 matrix. Since the rows are internally jumpered, only columns must be jumpered externally in this configuration. Note that the backplane jumpers must be removed to separate the cards into two groups.



Note : Rows A-H of ANALOG #2 and ANALOG #3, and rows C-F of ANALOG #1 jumpered through backplane.
Rows A, B, G, and H of ANALOG #1 require installation of coaxial jumpers.

Figure 2-13. Connecting Three Cards for 8 × 36 Matrix



Notes : 1. Backplane jumpers between slot 3 and 4 must be removed.
2. Internal rows A, B, G, and H of ANALOG #1 require coaxial jumpers.

Figure 2-14. 16 × 36 Matrix Constructed by External Jumpering

2.6 MEASUREMENT CONSIDERATIONS

Many measurements made using the Model 7070 concern low-level signals. Such measurements are subject to various types of noise that can seriously affect low-level measurement accuracy. The following paragraphs discuss possible noise sources that might affect these measurements.

2.6.1 Magnetic Fields

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

Two ways to reduce these effects are: (1) reduce the lengths of the test leads, and (2) minimize the exposed circuit area. In extreme cases, magnetic shielding may be required. Special 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.

2.6.2 Radio Frequency Interference

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

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

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

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

2.6.3 Ground Loops

When two or more instruments are connected together, care must be taken to avoid unwanted signals caused by ground loops. Ground loops usually occur when sensitive instrumention is connected to other instrumentation with more than one signal return path such as power line ground. As shown in Figure 2-15, 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.

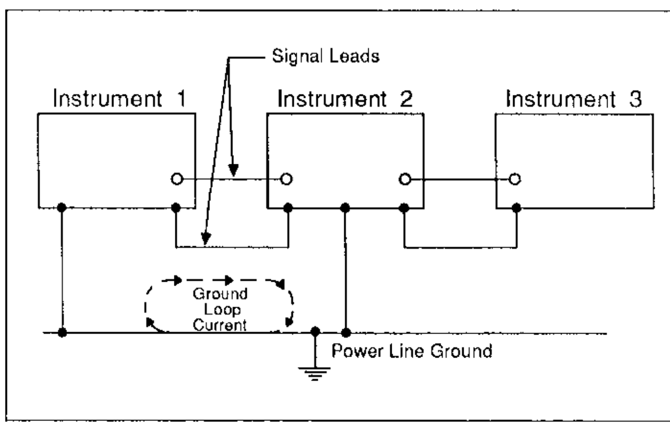


Figure 2-15. Power Line Ground Loops

Figure 2-16 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, only one instrument is connected to power line ground.

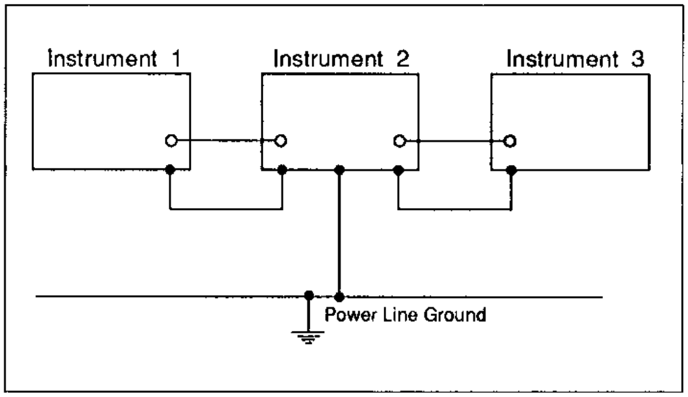


Figure 2-16. Eliminating Ground Loops

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

2.6.4 Keeping Connectors Clean

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

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.

2.6.5 Shielding

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

In order for shielding to be effective, the shield should be connected to signal LO (or chassis ground for instruments without isolated LO terminals). If the device under test is to be shielded, the shield should also be connected to the LO terminal. Figure 2-17 shows typical shielding configuration for a matrix card using 2-pole switching.

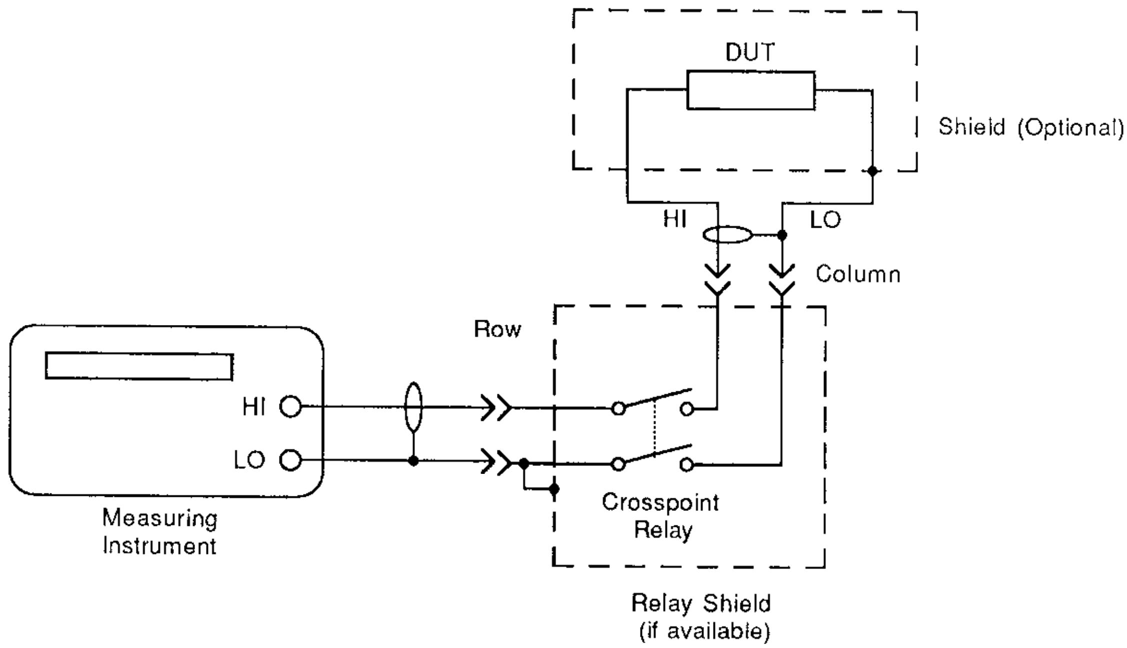


Figure 2-17. Shielding Example

2.6.6 Guarding

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

Guarding minimizes leakage resistance effects by driving the cable shield with a unity gain amplifier, as shown in Figure 2-18. 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, RL. Leakage between inner and outer shields may be considerable, but that leakage is of little consequence because that current is supplied by the buffer amplifier rather than the signal itself.

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

In order to use guarding effectively with the Model 7070, the GUARD path of the matrix card should be connected to the guard output of the sourcing or measuring instrument. Each guard path should be switched by the crosspoint relay; thus 3-pole switching should be used with guarding (assuming that both HI and LO are also switched). Figure 2-19 shows a typical matrix card guarded configuration.

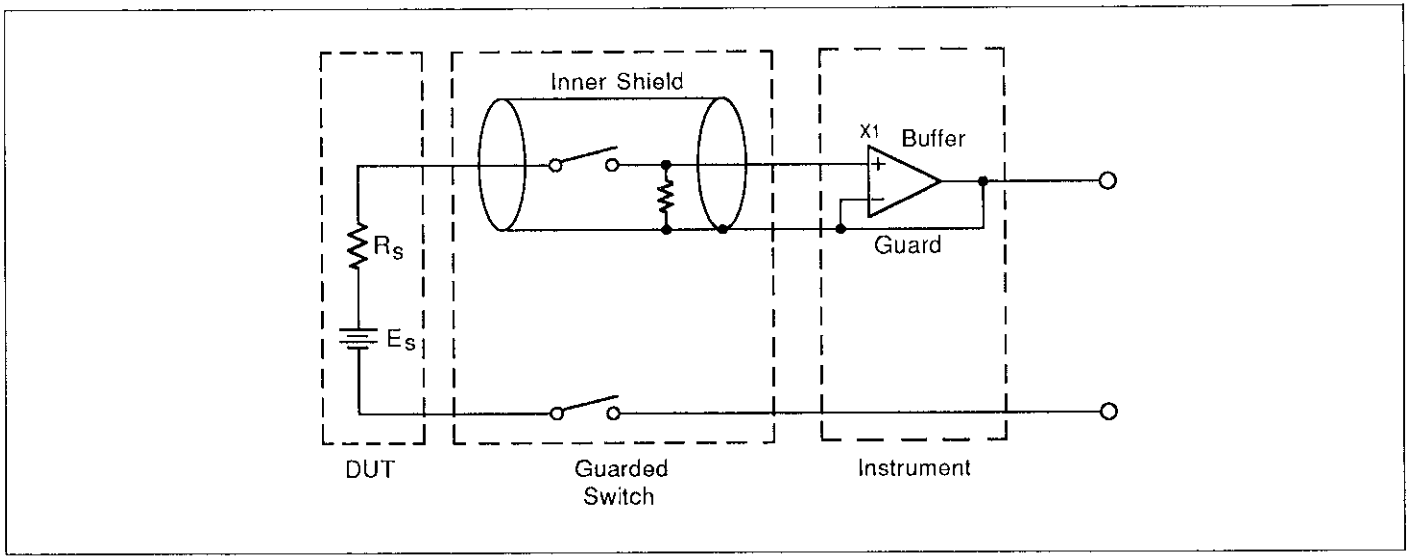


Figure 2-18. Guarded Circuit

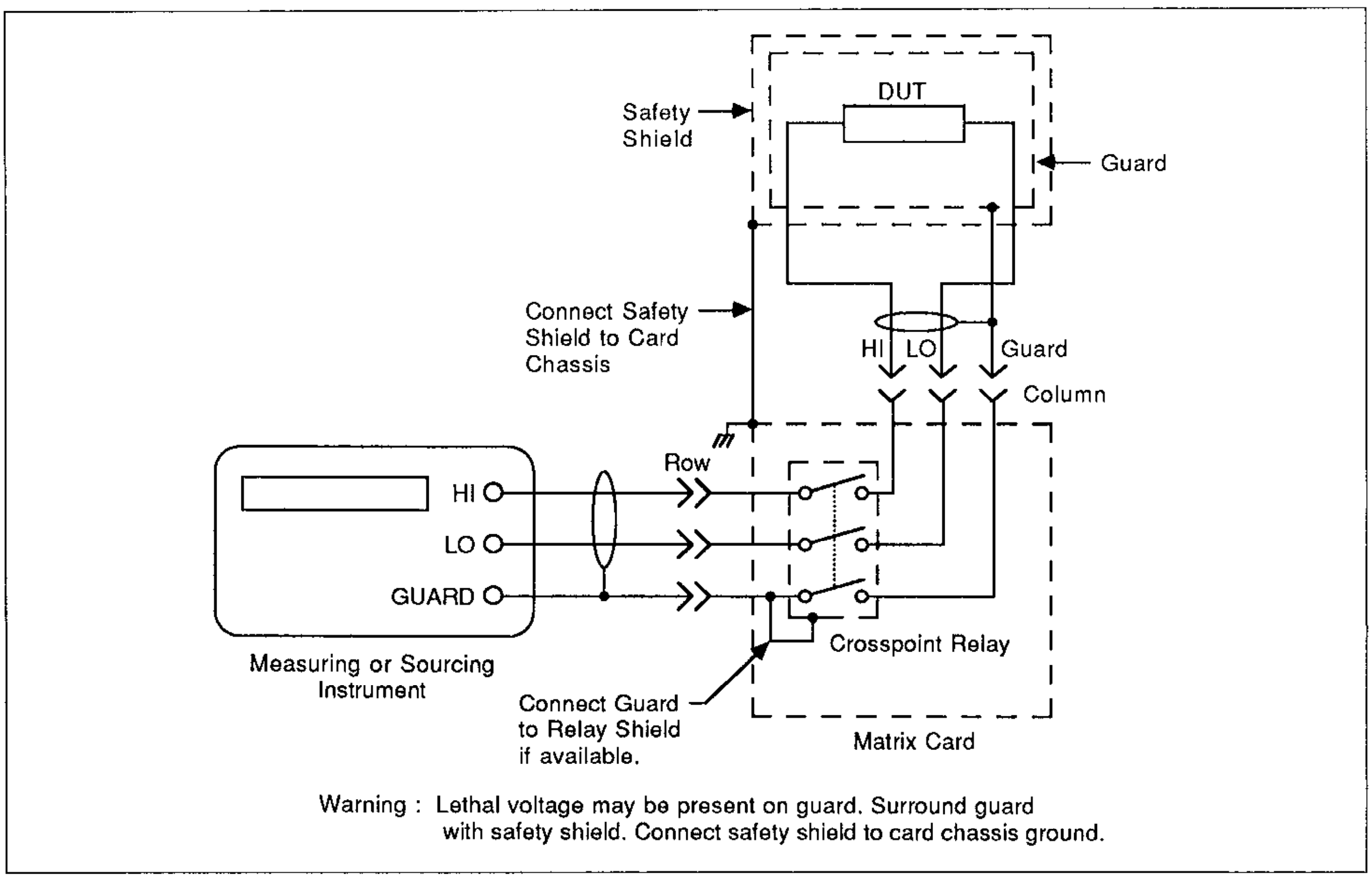


Figure 2-19. Typical Guarded Connections

SECTION 3
Applications

3.1 INTRODUCTION

Applications for the Model 7070 Universal Adapter Card will depend, of course, on your particular needs. This section presents some typical applications for the Model 7070 used as a prototyping card, and it is arranged as follows.

3.2 **Scanner Switching:** Outlines methods to use the card as a scanner instead of as a switching matrix.

3.3 **On-Card Buffering:** Details using on-card buffers to minimize the effects of leakage resistance.

3.4 **Solid-state Relays:** Covers solid-state relay switching for such purposes as power control.

3.5 **High-Speed Analog Switching:** Describes the use of solid-state switching ICs to provide high-speed switching not possible with relays.

3.6 **Using the Adapter Card with Other Matrix Cards:** Gives two typical applications for using the Model 7070 with other matrix cards.

3.2 SCANNER SWITCHING

Although the primary configuration of a Model 707 is as a switching matrix, there are situations where a scanner switching system can do the job better. The following paragraphs discuss various aspects of building a scanner switching system on the Model 7070.

3.2.1 Scanner Configuration

Functionally, a scanner can be thought of as a rotary switch, as shown in Figure 3-1. Each switch position is actually a set of relay contacts, giving the switch 1, 2, 3, or even 4-pole switching capability.

A scanner operates by stepping through its inputs or channels in sequence. Thus, with the example in Figure 3-1, the switch would begin at channel 1, advance to channel 2, and so on until all channels have been sequenced. After the last channel in the sequence, the unit will start over again with channel 1. Note that only one channel is connected to the output at any given time.

3.2.2 Relay Wiring

Figure 3-2 shows how to connect eight 2-pole relays together to construct an 8-input, 2-pole scanner. Note that one side of each set of relay contacts serves as a channel input, while the other side of each set of relay contacts are paralleled together as the scanner output. Other relay types could be used for 1, 3, or even 4-pole switching, as required. Additional relays could be added to increase the number of scanner inputs, as required, up to a maximum of 96 relays per card.

For control, the relay coils must be wired to the relay driver outputs and the +V RELAY BUS (which must itself be connected to the desired relay voltage). Figure 3-3 shows the relays wired to columns 1 through 8 of row A. Of course, you can connect the relays to any unused driver outputs; simply keep in mind which "crosspoints" to close when programming the unit, as discussed in the paragraph below.

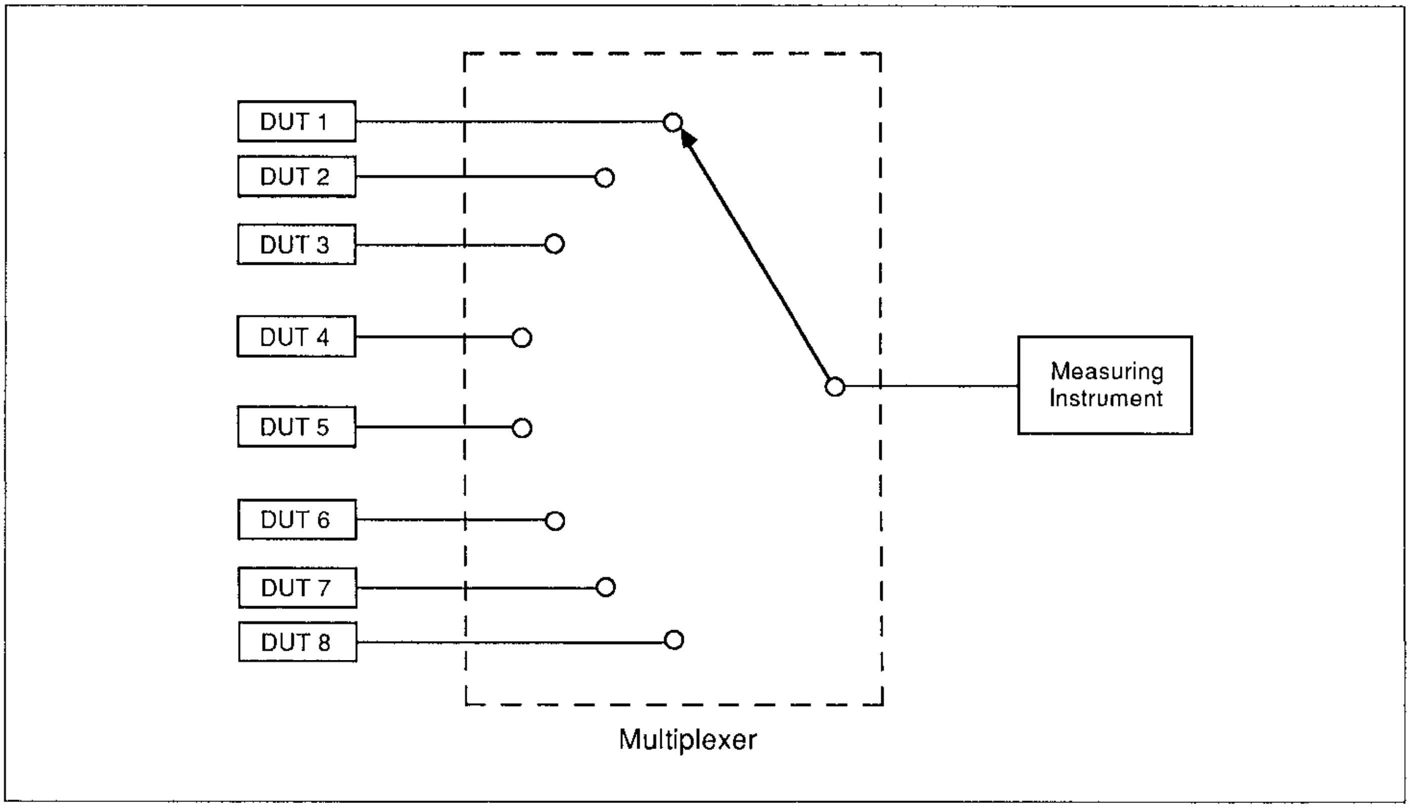


Figure 3-1. A Scanner as a Rotary Switch

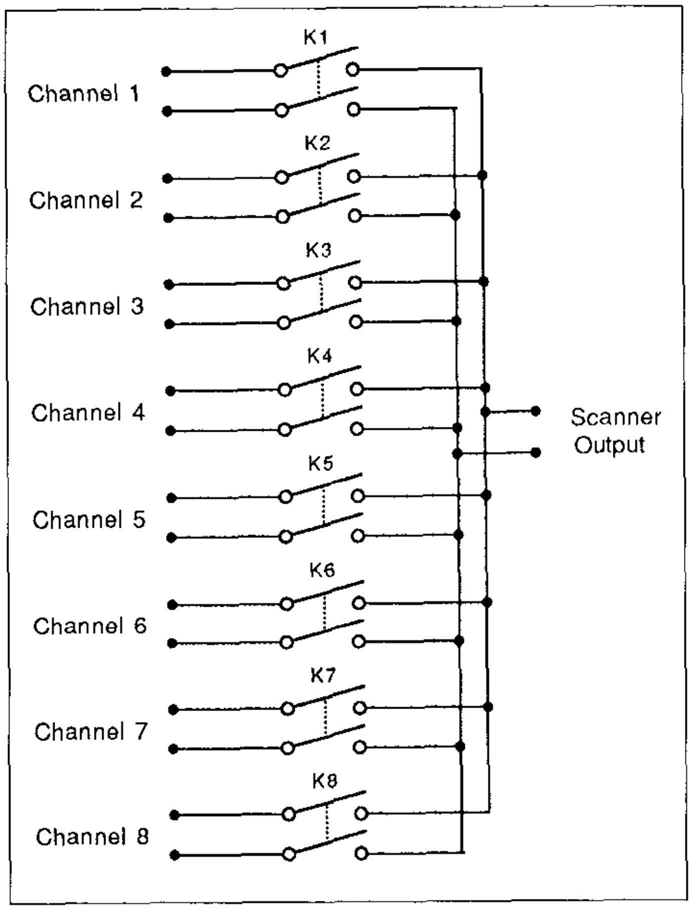


Figure 3-2. 8-Input, 2-Pole Relay Scanner

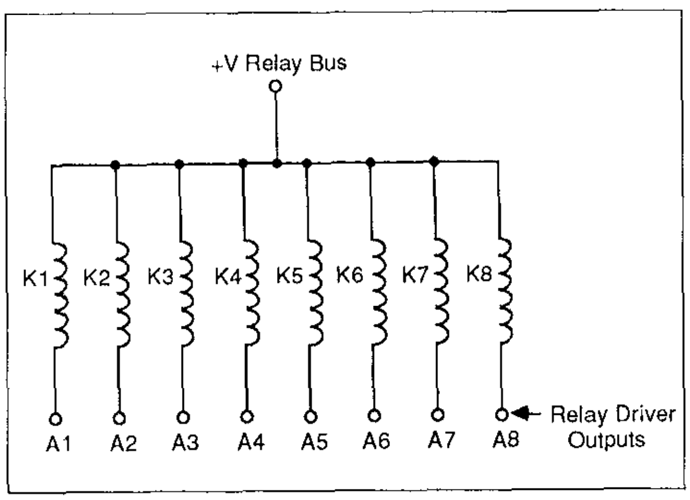


Figure 3-3. Scanner Relay Coil Wiring

3.2.3 Programming the Scanner

Since the Model 707 is designed as a switching matrix, the intelligence necessary to control a scanner must be designed into a controlling program (or appropriate front panel setups can be used to sequence through the relays). Program 1 below, which is written in Hewlett-Packard BASIC, demonstrates the basic principles of controlling the scanner with programming. Figure 3-4 is a flowchart of the program. One feature included in the program is a programmable channel settling time. As written, the program assumes that the Model 7070 is located in slot 1 of the Model 707. Note that user-defined code must be added to line 80 to control any measurement instrument.

Program 1 Simple Scanner Program Control

Program	Comments
10 REMOTE 718	Put 707 in remote.
20 OUTPUT 718 ;''R0X''	Return 707 to default.
30 INPUT ''SETTLING TIME (MSEC)'', Settle	Input settling time.
40 Settle=Settle/1000	Settle time in msec.
50 FOR I= 1 TO 8	Loop for all eight channels.
60 OUTPUT 718 ;''CA'';I; ''X''	Close A, I.
70 WAIT Settle	Settling time.
80 ! USER'S MEASUREMENT CODE.	Add code for measurement instrument.
90 OUTPUT 718 ;''NA'';I; ''X''	Open channel.
100 NEXT I	Loop back for next channel.
110 END	

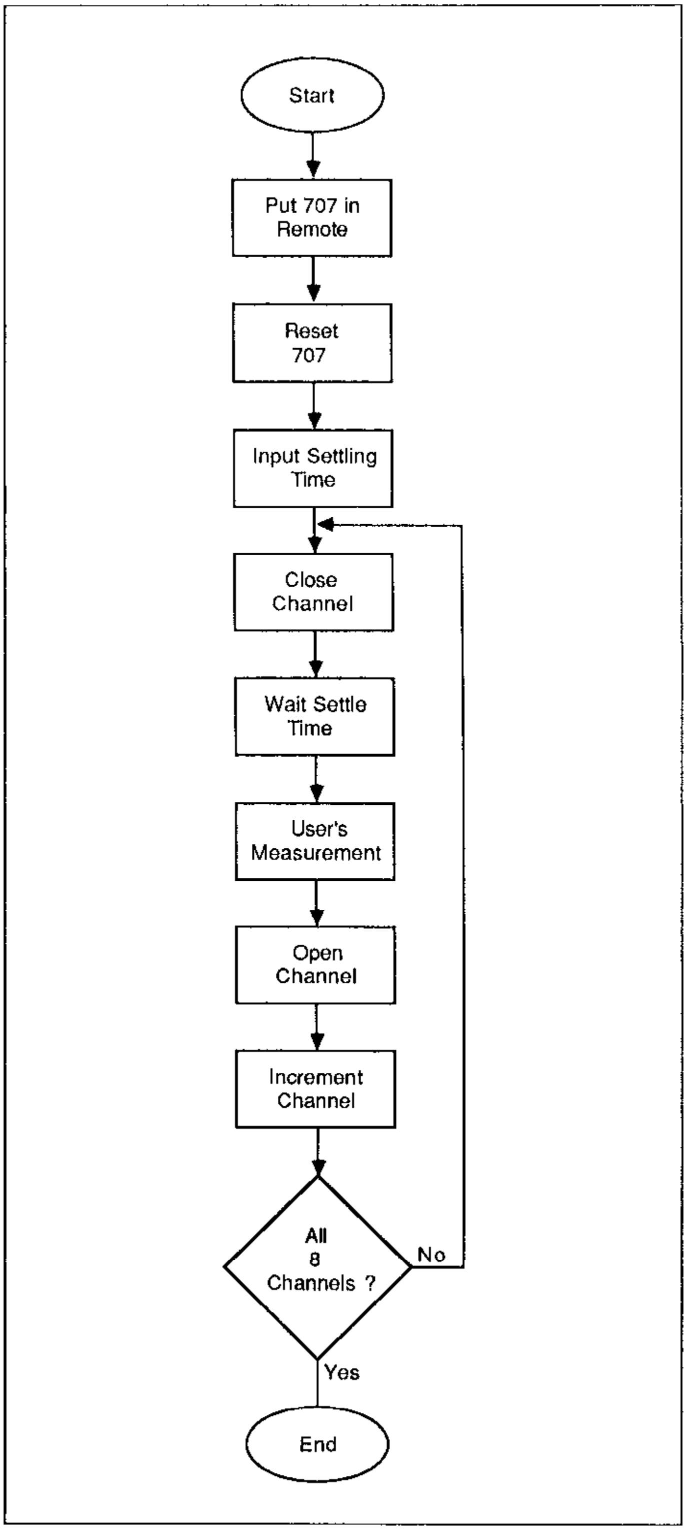


Figure 3-4. Program 1 Flowchart

3.2.4 A Practical Scanner Application

A scanner performs well at switching a number of devices to one instrument. One possible application for a scanner is shown in Figure 3-5. Here, we are using the scanner to select among the eight resistances located in a thick-film resistor package. A Model 196 DMM is used to make the resistance measurement. For lower-value resistors, the 4-wire measurement method shown should be used for maximum accuracy. Note that only 2-pole switching is required because of the common device terminal. For other 4-wire measurements, 4-pole switching may be required.

Program 1 above can be modified to make the resistance measurements. Program 2 below provides the basic test capability for the system, including the basic scanner sequencing, and obtaining and displaying a reading from the DMM. Figure 3-6 is a flowchart of the program. Keep in mind that this program may require modification for your particular requirements.

Program 2 Resistor Test Program

Program	Comments
10 REMOTE 718	Put 707 in remote.
20 REMOTE 707	Put 196 in remote.
30 OUTPUT 718 ;''R0X''	Return 707 to default.
40 OUTPUT 707 ;''F2R0X''	196 ohms function, autorange.
50 INPUT ''SETTLING TIME (MSEC)'', Settle	Input settling time.
60 SETTLE=Settle/1000	Settle time in msec.
70 FOR I= 1 TO 8	Loop for all eight channels.
80 OUTPUT 718 ;''CA'';I;''X''	Close A, I.
90 WAIT Settle	Settling time.
100 ENTER 707 ;A$	Get 196 reading.
110 PRINT A$	Display 196 reading.
120 OUTPUT 718 ;''NA'';I;''X''	Open channel.
130 NEXT I	Loop back for next channel.
140 END	

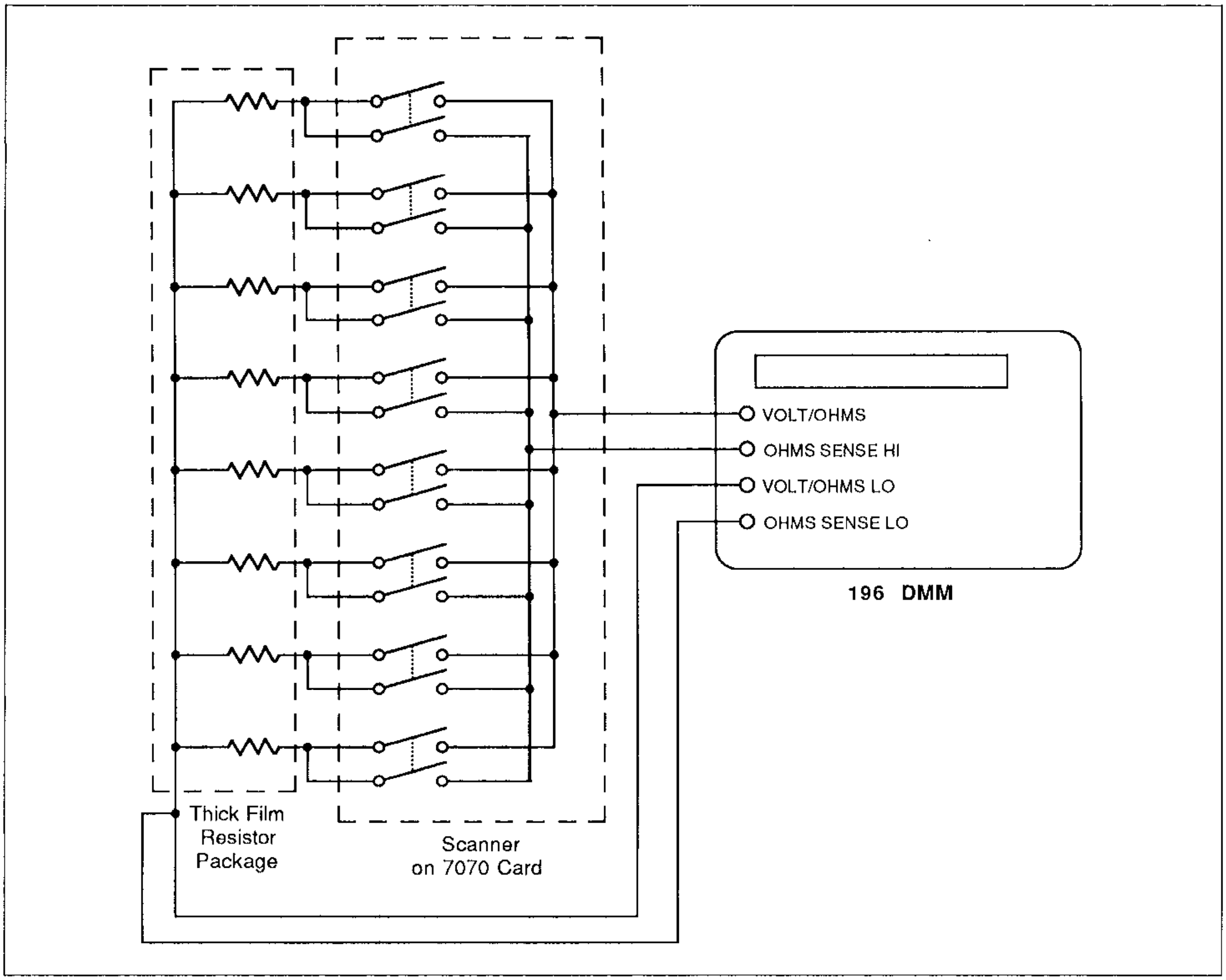


Figure 3-5. Testing Thick Film Resistor with a Scanner

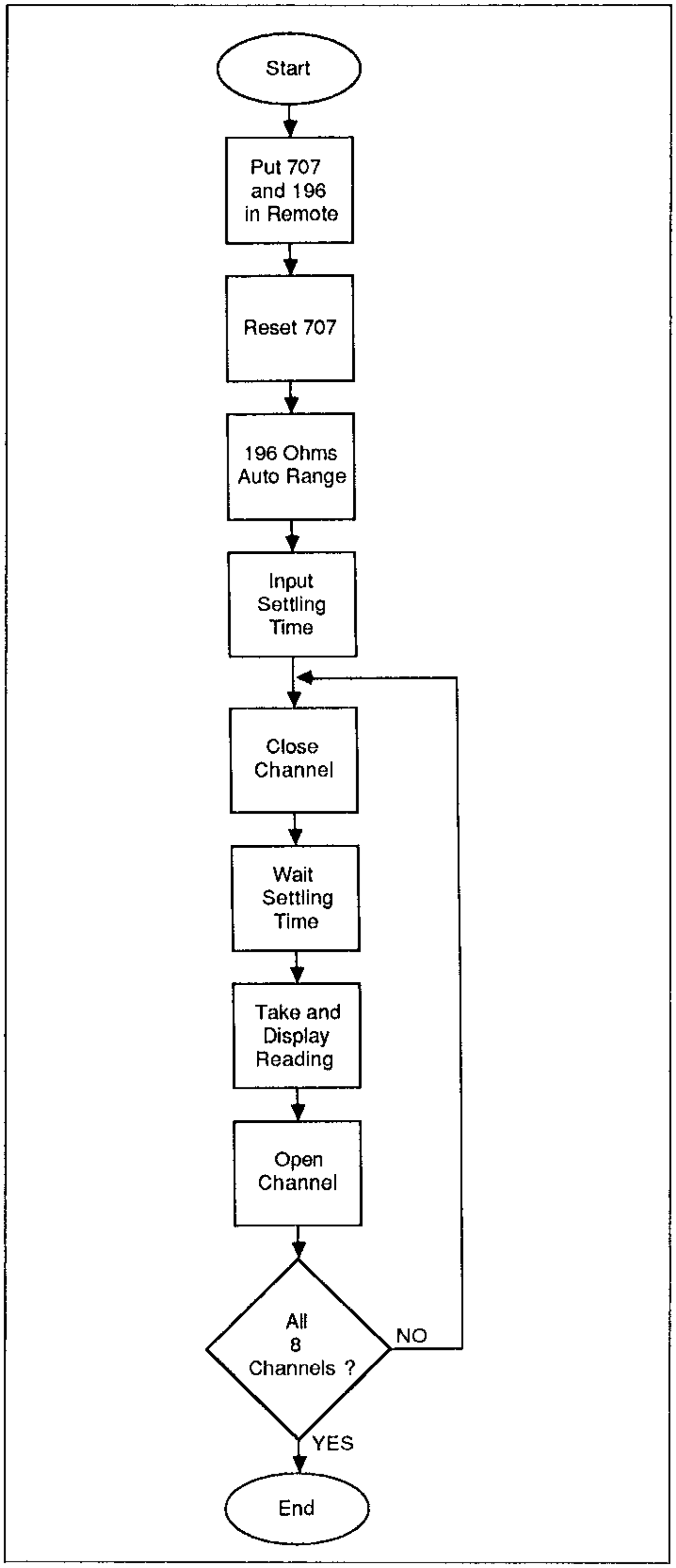


Figure 3-6. Program 2 Flowchart

3.3 ON-CARD BUFFERING

Buffers can be incorporated into a switching matrix constructed on a Model 7070 card in order to minimize the effects of loading on the circuit under test. Such buffering can extend the measurement range of the card to higher-impedances than would otherwise be possible by minimizing the effects of leakage resistance and capacitance, as well as providing drivers for guarding. The following paragraphs discuss buffer configuration, powering the buffers, as well as a typical application for on-card buffers.

3.3.1 Buffer Configuration

The chief advantage of buffers is that they provide isolation between a device under test and the switching and measurement pathways. Typically, buffers would be placed between the row or column inputs and any switching relays, as shown in the simple matrix of Figure 3-7. In this instance, a simple 2 × 2 matrix is shown, but the same general configuration would be used for larger matrices.

Since a buffer is a unity-gain operational amplifier, its output voltage is the same as the input. Because the buffer typically has much lower output impedance than the device being buffered, loading effects of pathways and test instrumentation are minimized.

A buffer output can also be used to provide a driven guard signal, which is also shown in Figure 3-7. The guard should be connected to the shield surrounding the signal pathway of the high-impedance input circuitry. Either coaxial or triaxial cables can be used (triaxial cable should be used for safety considerations for guard voltages above 30V, with the outer shield connected to chassis ground). If the associated switching relays are shielded, guard can be connected to the relay shields.

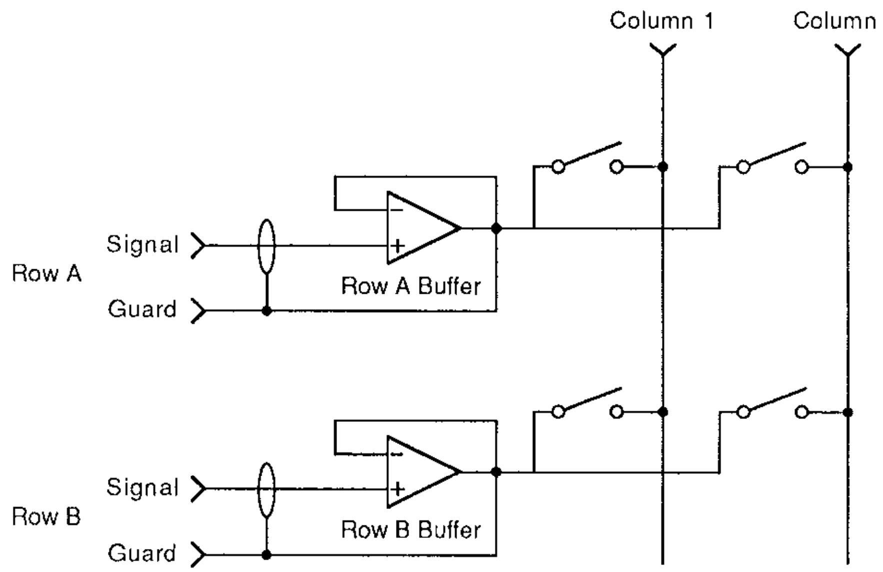


Figure 3-7. Buffer Configuration

3.3.2 Buffer Considerations

For best performance, only high-quality op amps should be used for buffers. Specified offset current and offset voltage should be <1pA and <1mV respectively. Typical of available high-quality ICs is the OPA104 (Keithley Part Number IC-519), which is one op amp recommended for this application.

Care in component selection should not stop at the buffer ICs. All components on the buffer input side should be carefully selected to ensure that high isolation resistance is maintained. BNC and triax connectors used on the input should be Teflon® insulated. Also, do not connect any high-impedance nodes to the circuit board itself; instead, mount Teflon® insulators on the board, and make all connections at the insulator terminals.

3.3.3 Powering the Buffer ICs

Typical ICs used as buffers require both positive and negative power supplies in the neighborhood of ±15V dc. This situation presents a small problem with the Model 7070 because only +5V and +6V supplies are available. Fortunately, there is a fairly simply solution: a dc converter, which can convert the available supply voltage to positive and negative voltages usable by the on-card buffers, can be mounted on one of the prototyping areas.

Figure 3-8 shows a typical power supply arrangement using a dc converter module (Keithley part #MO-15). The converter is powered by the +5V supply available on the card, and it supplies ±18V at a maximum current of ±170mA. In order to reduce and regulate the supply voltages, +15V and -15V regulator ICs are used along with the usual filter capacitors.

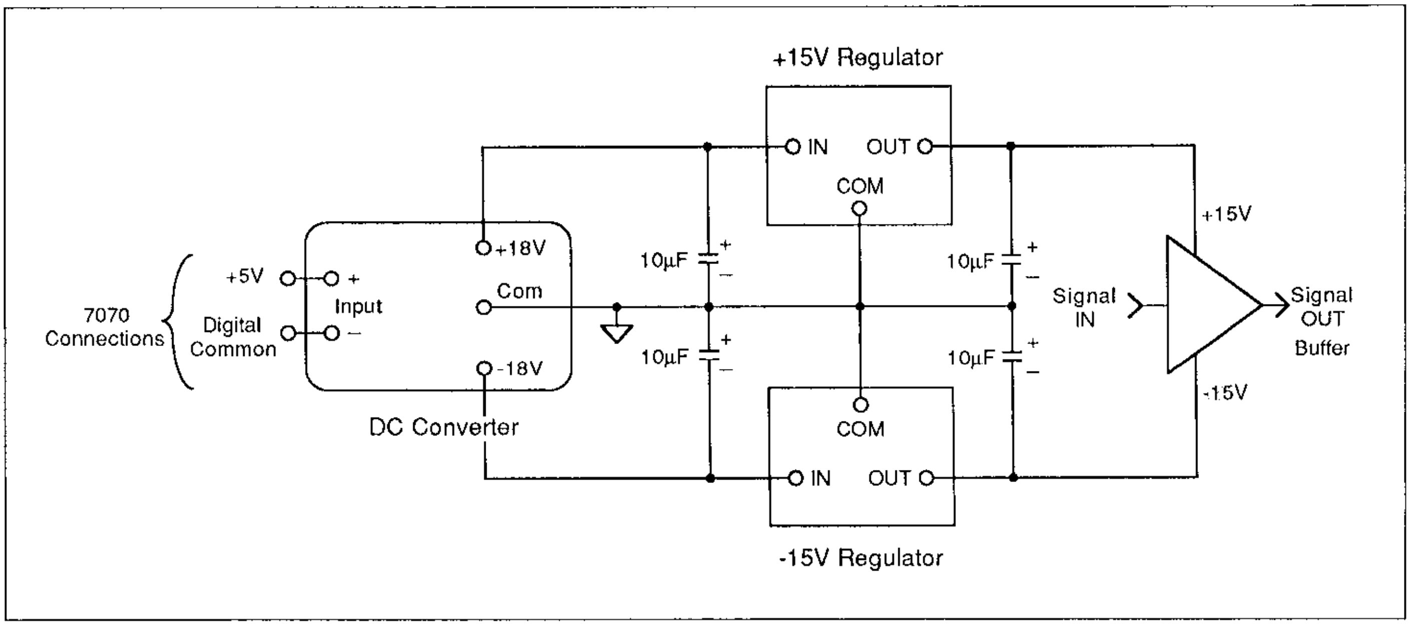


Figure 3-8. DC Converter Used to Power Buffer ICs

3.3.4 A Typical Buffer Application

On-card buffering can be used whenever high-impedance circuits are involved. One possible application for such on-card buffering is for high-resistivity measurements on semiconductors. Such measurements can help in yielding important information about semiconductors such as doping concentration.

Figure 3-9 shows a typical test system that can be used to perform such tests. Basically, resistivity is determined by forcing a current through the sample under test, and then measuring the voltage across the sample. In this example, the current is sourced by a Model 220 current source, and the voltage is measured by a Model 196 DMM. The switching matrix provides the flexibility necessary to make the various connections for the measurements, and the on-card buffers isolate the sample under test from the DMM to minimize the effects of loading, which would otherwise degrade accuracy for measurements above 1MΩ.

In order to compensate for such factors as thermal EMFs, a total of eight voltage measurements are generally made on a typical sample, as shown in Figure 3-10. The resulting voltages are then used to compute the resistivity of the sample.

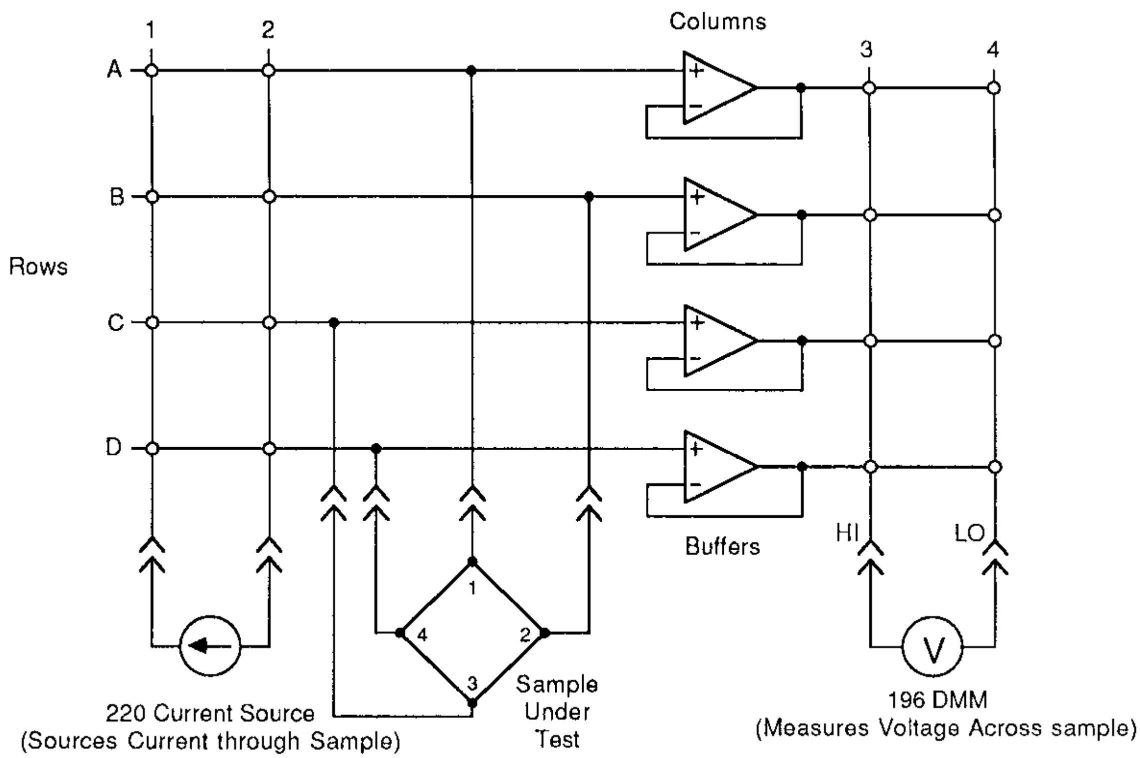


Figure 3-9. Typical High-Resistivity Test System

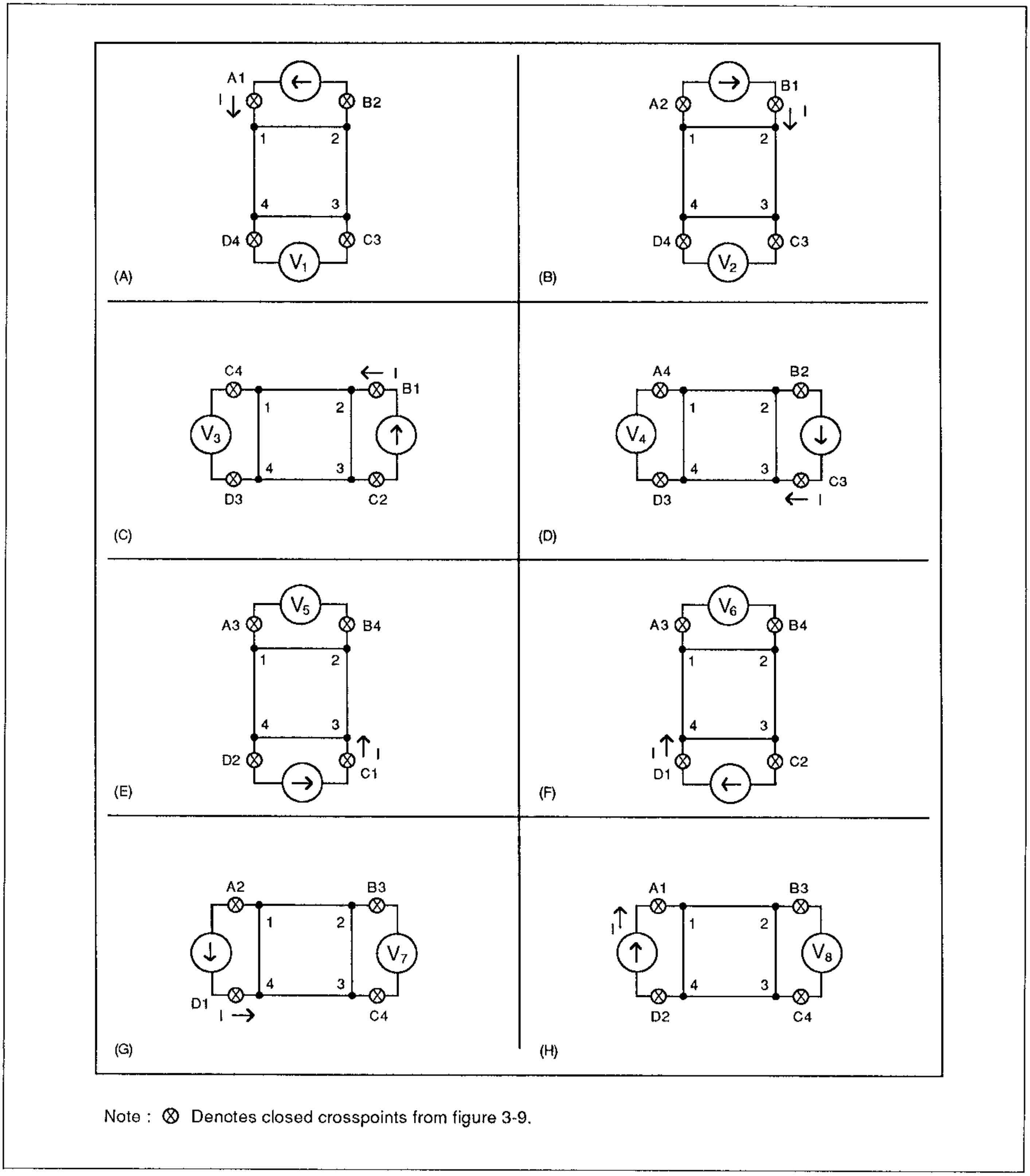


Figure 3-10. Voltages Necessary to Determine Resistivity

3.4 SOLID-STATE RELAYS

The Model 7070 can be populated with solid-state relays to provide switching capabilities not available with other Model 707 cards. The following paragraphs discuss the advantages of using solid-state relays, give a typical example of how to wire them, and also summarize several considerations to observe when using solid-state relays.

3.4.1 Solid-state Relay Advantages

There are several advantages to using solid-state relays, including long life, zero-crossing turn off, and high isolation, as discussed below.

High Reliability

Because the switching component of a solid-state relay is, by definition, solid state, such relays generally last indefinitely, in contrast to their mechanical counterparts, which have a limited contact life. The actual switching component used depends on the application. Relays designed to switch dc use a simple power transistor, while relays designed for ac use a triac.

Zero-crossing Switching

Virtually all relays designed for ac switching have zero-crossing turn off, and many incorporate zero-crossing turn on. Zero-crossing action simply means that the switching action of the relay occurs at the point when the ac signal crosses the zero axis, as indicated in Figure 3-11. Zero-crossing switching minimizes EMI radiation when controlling inductive loads such as motors, solenoids, or transformers. Such switching can be beneficial when sensitive digital and analog circuits must be operated in the same electrical environment as power circuits.

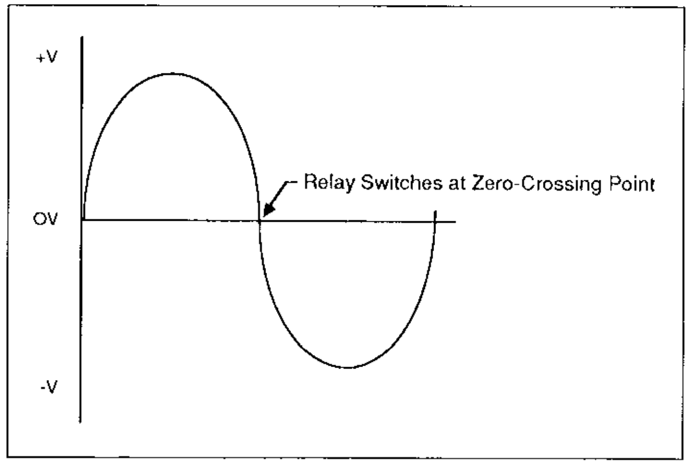


Figure 3-11. Zero-crossing Switching

High Isolation

Many solid-state relay modules have a high degree of electrical isolation (typically 2.5-4kV) between the control input and the switching output. This type of relay should always be used with the Model 7070 to ensure proper isolation between the card and high-voltage circuits.

WARNING
Do not use non-isolated solid-state relays with the Model 7070.

Isolated relays use optical coupling between control circuits and the output stages. Figure 3-12 shows a simplified schematic diagram of an ac solid-state relay, and Figure 3-13 shows a simplified diagram of a typical dc solid-state relay. The main difference between the two relays is the type of device used in the switching circuit: the dc relay uses a transistor, while the ac relay uses a triac.

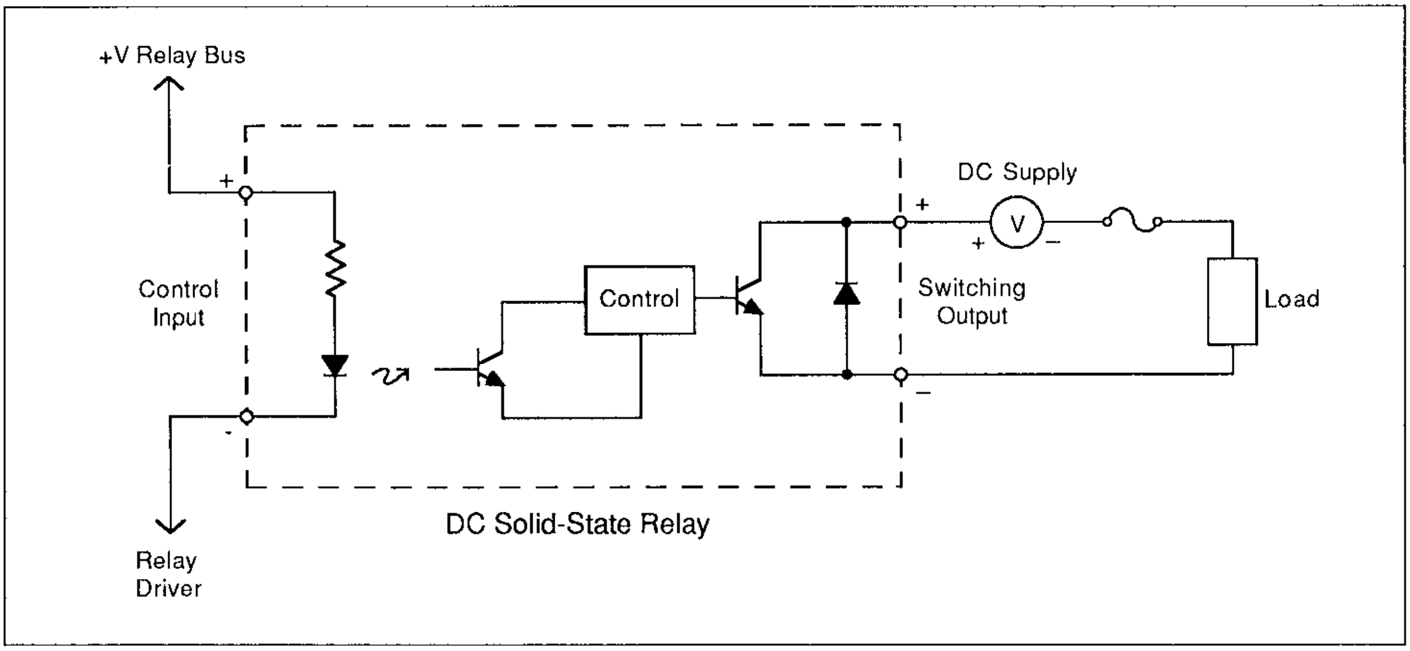


Figure 3-12. Typical DC Solid-state Relay

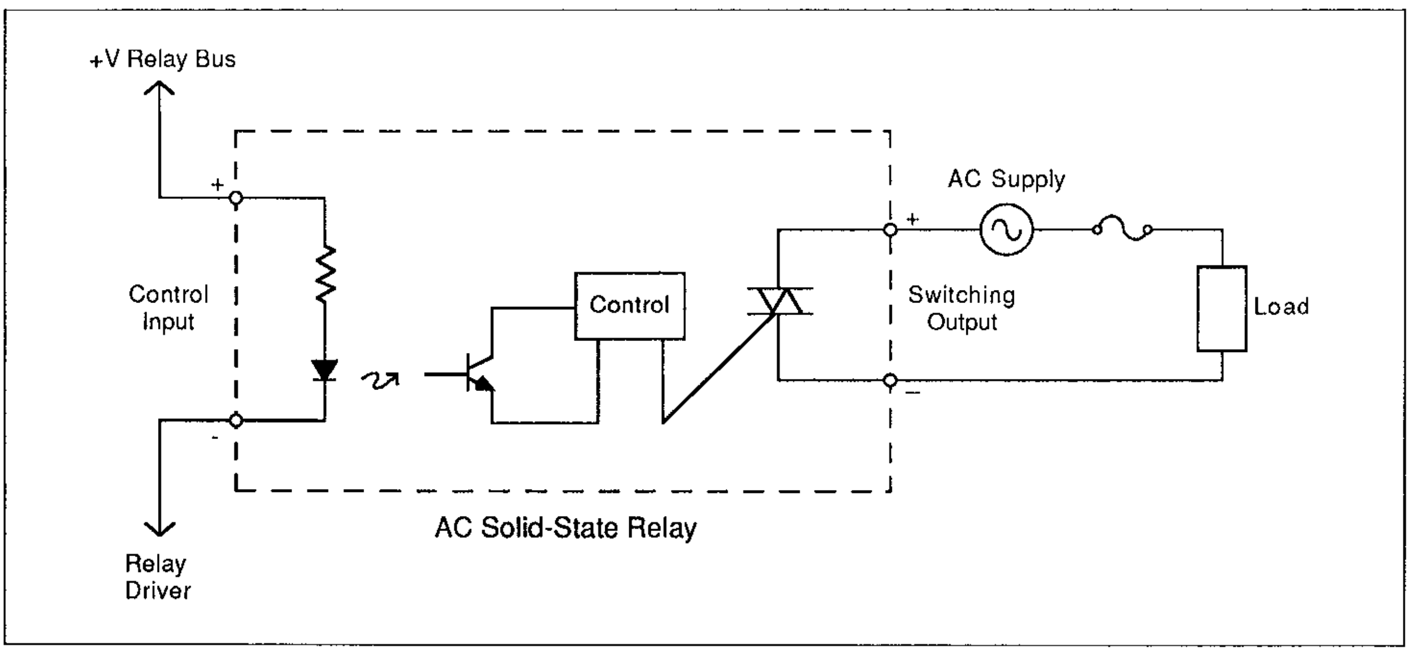


Figure 3-13. Typical AC Solid-state Relay

3.4.2 Typical Application

Figure 3-14 shows a typical configuration using solid-state relays. Note that the + terminal of the relay control circuit is connected to the +V RELAY BUS, while the – terminal of the control circuit is connected to the desired driver output.

The relay output is connected in series with the ac supply and the load, which could be any appropriate ac device such as a motor or solenoid. In this application we have added an MOV (Metal Oxide Varistor) across the output terminals to protect the device from transients. A series fuse is included to protect the relay from over-current situations. Fusing is recommended for all solid-state relays as they are much less tolerant of abuse than mechanical relays.

This particular application uses a Teledyne 675-6 relay (Keithley part number RL-78). The control voltage for this device is in the range of 3VDC to 32VDC, and the unit can switch a maximum of 140V, 3A RMS. The minimum turn-on current for this relay is 100mA.

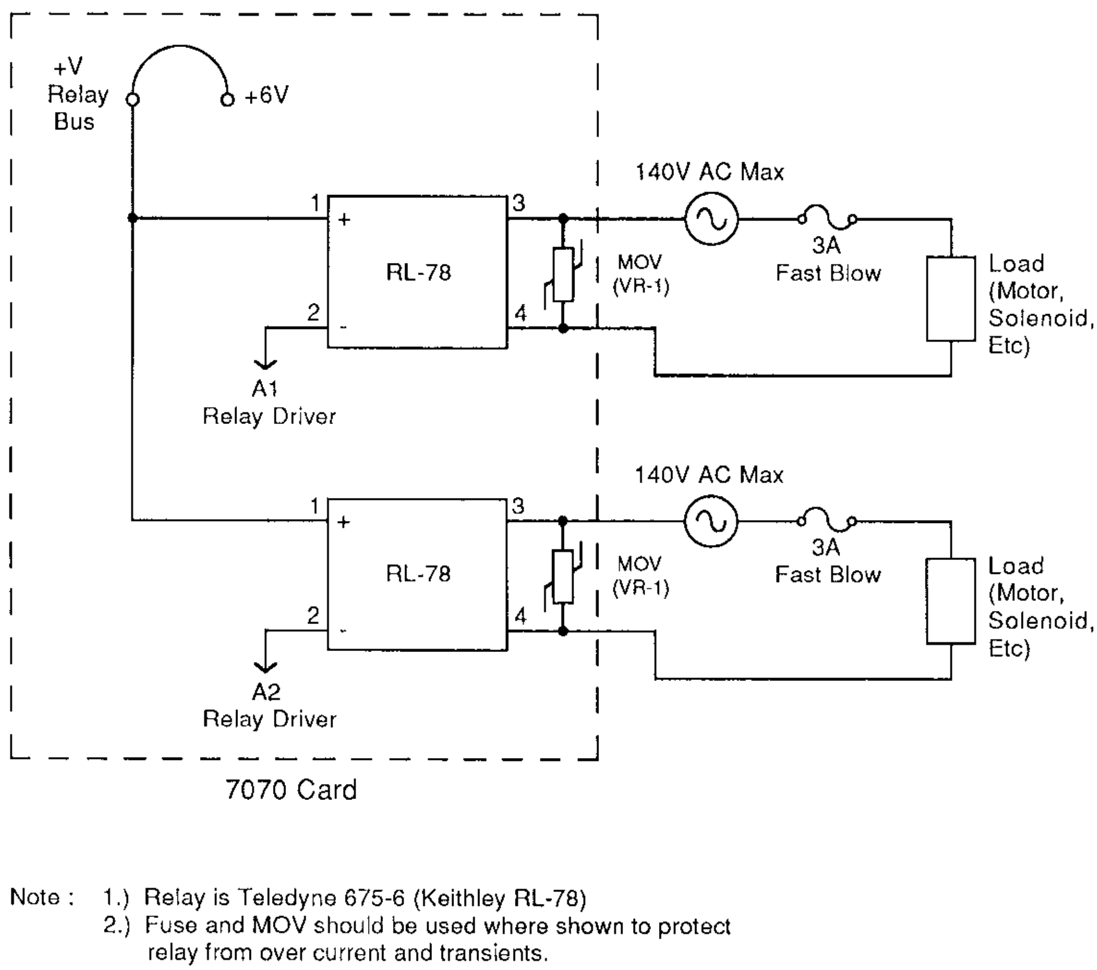


Figure 3-14. Typical Solid-state Relay Application

3.4.3 Solid-state Relay Considerations

While solid-state relays do have their advantages, there are a number of considerations to keep in mind when using them, including:

1. Solid-state relays are usually specified for either dc or ac voltages only. You cannot use a dc switching relay for control ac or vice versa.
2. In addition to a maximum current, such relays often have a specified minimum turn-on current below which the relay will not operate. You can determine the approximate relay current from Ohm's law by dividing the supply voltage by the load resistance.
3. The control voltages for both dc and ac relays are dc, so you must carefully observe polarity. Connect the + control terminal to the +6V (or external) supply, and connect the – terminal to the relay driver output. Proper polarity must also be observed on the output terminals of a dc relay.
4. When switching voltages above 200V, mount the relays on and make connections to only the unplated prototyping area of the card. Be sure to observe proper voltage spacing, as discussed in paragraph 2.5.10.
5. Use only isolated solid-state relays, and make sure the outputs are fused according to the current rating of the device. Fast blow fuses should be used to ensure proper protection. Also, a transient-suppression device, such as an MOV, should be connected across the output terminals.

3.4.4 Programming Solid-state Relays

To control solid-state relays, simple close or open the appropriate crosspoint as you would with any mechanical relay. The relay will turn on when the crosspoint is closed, and it will turn off when the crosspoint is open (assuming proper wiring). For example, for a relay connected to relay driver terminal A1, close crosspoint A1 from the front panel, or send the "CA1X" command over the bus.

3.5 HIGH-SPEED ANALOG SWITCHING

The following paragraphs discuss solid-state analog switching with higher speed than is usually possible with electro-mechanical relays. Typical circuits and a control program are also presented.

3.5.1 Analog Multiplexer ICs

Functionally, a multiplexer IC can be thought of as a series of solid-state switches, as shown in Figure 3-15. In this instance, an 8-input multiplexer is shown, although 4-input and 16-input multiplexer ICs are also available. Note that only one switch can be closed at any given time, as determined by IC control circuitry.

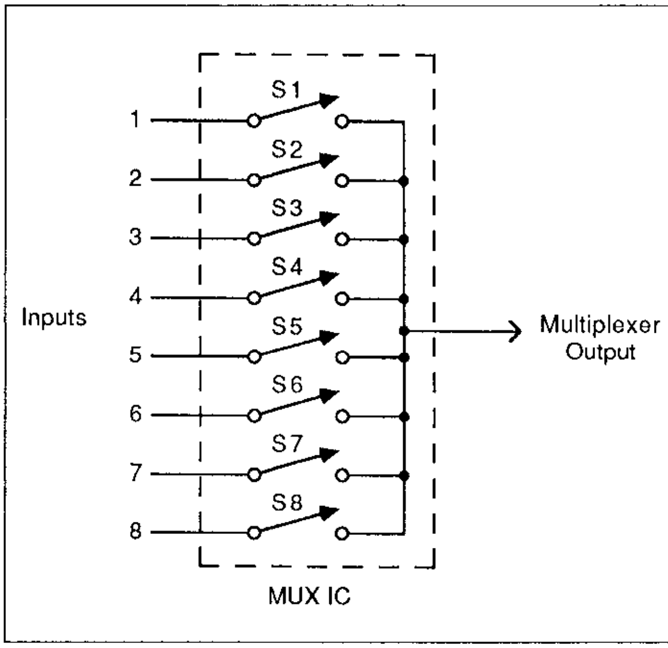


Figure 3-15. Typical Multiplexer IC

Solid-state multiplexer ICs have several advantages over mechanical relay-based units, including:

- Solid-state switching gives higher reliability.
- Much faster switching than is possible with relays (typically in the μsec range).
- Smaller size than relays, allowing much higher circuit density.
- Lower power requirements
- Lower cost per switch.

Although such ICs are better suited to many applications, they do have some disadvantages, such as:

- Limited voltage capability (typically ±10V).
- Relatively high on resistance (typically hundreds of ohms).
- Susceptability to damage from electrical discharge.
- Require positive and negative supply voltages.

3.5.2 Typical Analog Switching Circuit

Figure 3-16 shows a typical circuit using an analog multiplexing IC. Additional control circuitry includes a programmable timer to allow specific intervals between channels to be programmed. The same type of operation could be performed by programming the Model 707, but at the expense of speed. This circuit will allow you to scan channels at rates as high as 100kHz. Note that the timer is configured for astable operation. For monostable operation, disconnect timer RESET from main RESET, and connect timer RESET to COUNT instead.

The various sections of the circuit are discussed below.

Relay Driver Interfacing

The circuit is interfaced to the Model 7070 relay drivers A1 through A10. A1-A8 provide timer programming information, while A9 is the RESET signal for the timer and the counter. A10 is the TRIGGER signal which starts the programmable timer.

Since the relay driver outputs are open collector, they must be pulled up to +5V through the 1kΩ resistors, R1-R10. Note that closing a specific "crosspoint" will result in a low logic level, while opening the "crosspoint" sets the logic level high.

Quad Switches

Two quad switches, IC1 and IC2, provide the interface between the timer programming information and the timer itself. The logic levels on A1-A8 control whether or not a specific timer output is connected to the COUNT output of the timer, and thus the timer interval.

Programmable Timer

IC3, a 7240 programmable timer, provides the fundamental time base for the scanning sequence. The unit is capable of intervals in the range of 1-255 timer units, where the basic unit interval is determined by the values of R_T and C_T as follows:

$$t = R_T\,C_T$$

For example, typical values for a 1msec minimum interval are 100kΩ and 0.01μF. Two or more timer ICs can be cascaded to increase the programmable interval range. For example, one additional timer IC will increase the range to 65,535 interval counts. Note that the maximum timer frequency is 100kHz, for a minimum interval between channels of 10μsec.

Counter

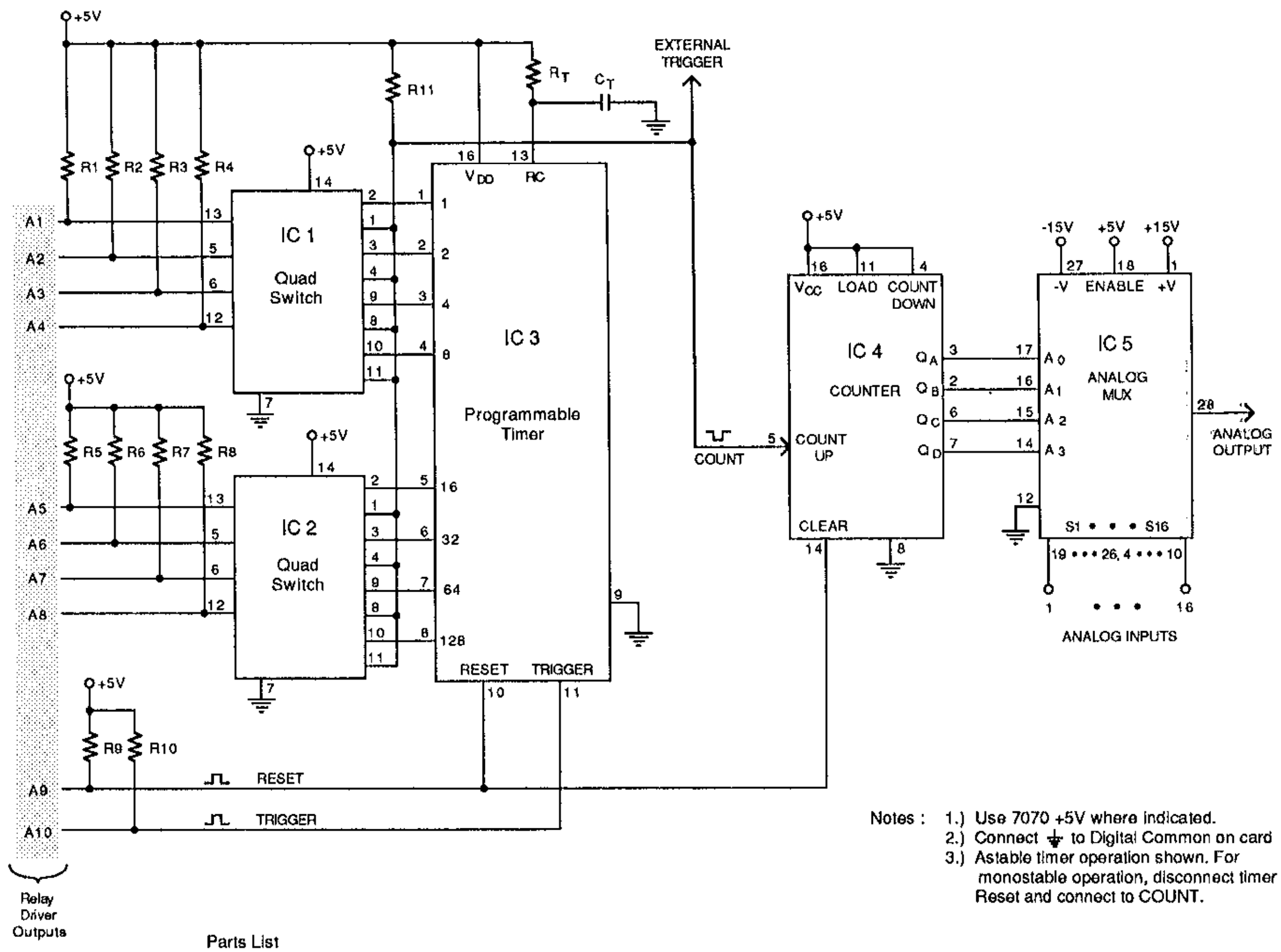
The output pulses of the programmable timer are used to sequence a 4-bit binary counter, IC5. As pulses occur, the counter counts from 0000 to 1111 in sequential order, modulo 16. The counter outputs are used to select multiplexer inputs, as described below.

Multiplexer IC

IC5 is the analog multiplexer IC (6116), which has 16 analog inputs. The input that is routed to the output is determined by the logic level on the A0-A3 inputs, as outlined in the truth table shown in Table 3-1. Note that the multiplexer requires ±15V supply voltages, and the maximum input is limited to ±11V. The DC converter discussed in paragraph 3.3 could be used to supply the mux IC.

Table 3-1. Multiplexer IC Truth Table

A_3	A_2	A_1	A_0	Selected Input
0	0	0	0	1
0	0	0	1	2
0	0	1	0	3
0	0	1	1	4
0	1	0	0	5
0	1	0	1	6
0	1	1	0	7
0	1	1	1	8
1	0	0	0	9
1	0	0	1	10
1	0	1	0	11
1	0	1	1	12
1	1	0	0	13
1	1	0	0	14
1	1	1	0	15
1	1	1	1	16



Notes :
1.) Use 7070 +5V where indicated.
2.) Connect ⏚ to Digital Common on card
3.) Astable timer operation shown. For monostable operation, disconnect timer Reset and connect to COUNT.

Parts List

IC1, IC2	74HC4016	Analog Switch
IC3	7240	Programmable Timer
IC4	74HC193	Synchronous Up/Down Counter
IC5	6116	16-Input Analog Multiplexer
R1-R10	1kΩ, 1/4W	
R11	10kΩ, 1/4W	
RT,CT	Determine Timer Interval ; See Text	

Figure 3-16. High-Speed Analog Multiplexer with Control Circuit

Circuit Operation

Basically, the circuit operates in the manner below.

1. The circuit is first reset by pulsing the RESET line high. This pulse resets the programmable timer, and it also clears the counter IC so that channel 1 is selected.
2. Lines A1-A8 are then set to the desired timer interval. Note that a simple binary value is used to program the timer, with A1 the LSB, and A8 the MSB of the programming byte. The actual interval will depend on the fundamental time unit determined by R_T and C_T, as described above.
3. The timer is triggered by pulsing TRIGGER high. The timer then sequences the counter at programmed intervals, and the analog multiplexer then sequences through the channels. Note that the same pulse used to sequence the counter can be used as an external trigger pulse for measuring instruments. An externally-generated delay will probably be required to ensure circuit settling time before each measurement.

3.5.3 Control Program

Program 3 below is simple program that demonstrates basic techniques for controlling the circuit shown in Figure 3-16. The program, which is written in HP BASIC 4.0, will prompt you to input the timer interval and then program the interval accordingly. As discussed previously, the timer interval depends on the values of R_T and C_T. Figure 3-17 is a flowchart of the program.

Program 3 Multiplexer Control Program

Program	Comments
10 REMOTE 718	Put 707 in remote.
20 DIM CMD$[50]	Dimension command string.
30 CMD$ = ''N''	Define open command letter.
40 OUTPUT 718 ;''R0X''	Reset 707.
50 OUTPUT 718 ;''CA1, A2,A3,A4,A5,A6,A7, A8,A9,A10X''	Set control lines low.
60 INPUT ''TIMER INTERVAL (1-255)'', Timer	Input timer control value.
70 FOR I = 0 TO 7	Convert time to crosspoints.
80 IF BIT(Timer, I) THEN CMD$ = CMD$ & ''A'' & VAL$(I+1) & '',''	
90 NEXT I	
100 CMD$=CMD$[1,LEN (CMD$)-1] & ''X''	Complete timer control string.
110 OUTPUT 718 ; CMD$	Program timer.
120 OUTPUT 718 ; ''NA9X''	Reset time and counter.
130 WAIT 0.1	Wait 100msec.
140 OUTPUT 718 ; ''CA9X''	Set RESET pulse low.
150 INPUT ''PRESS ENTER TO SCAN'',A$	Prompt to start scan.
160 OUTPUT 718 ; ''NA10X''	Trigger timer, start scan.
170 WAIT 0.1	Wait 100msec.
180 OUTPUT 718 ; ''CA10X''	Reset trigger pulse.
190 END	

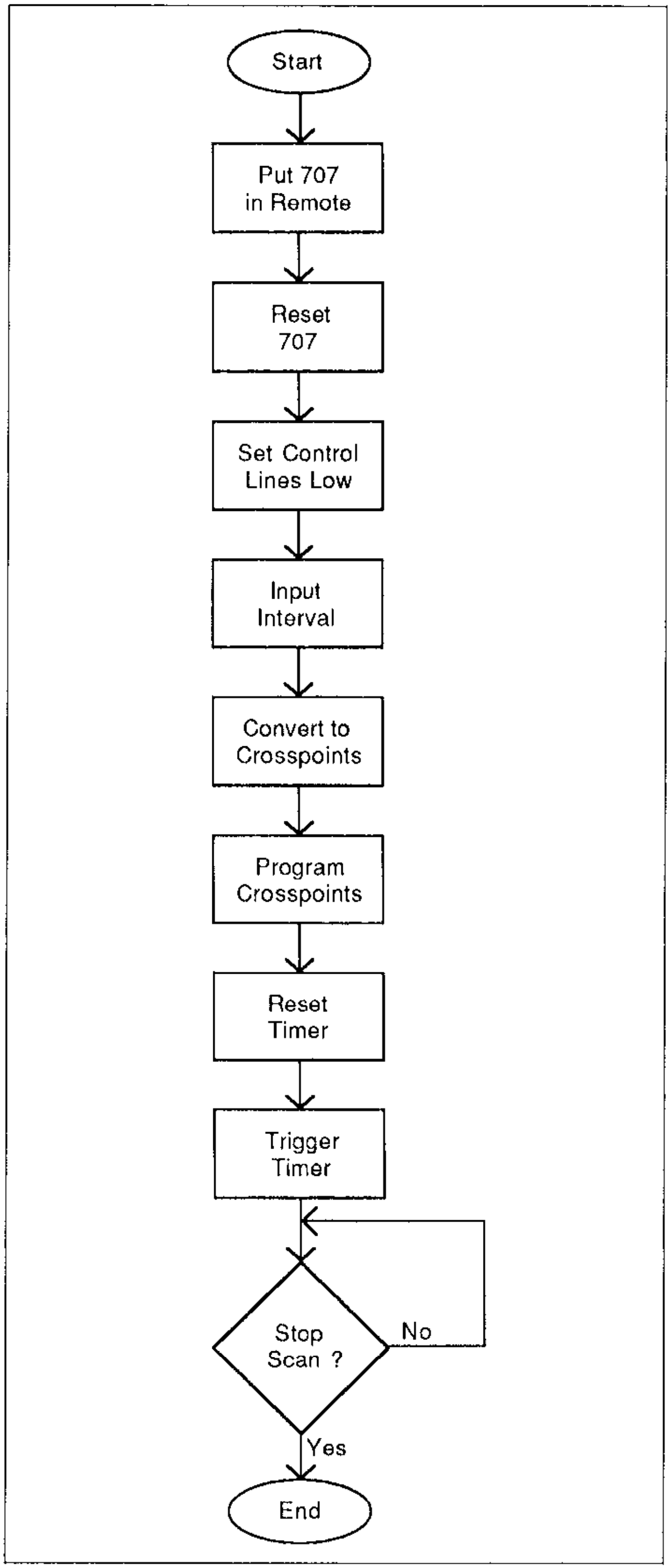


Figure 3-17. Program 3 Flowchart

3.6 USING THE ADAPTER CARD WITH OTHER MATRIX CARDS

Special circuits mounted on the Model 7070 can be used with other matrix cards to enhance system capabilities. Two possible applications are using a scanner-matrix combination, and on-card signal conditioning, as discussed in the following paragraphs.

3.6.1 Scanner-Matrix Combination

A scanner similar to the one discussed in paragraph 3.2 could be used with a matrix card to add additional switching capabilities to that matrix. As shown in Figure 3-18, the scanner could be used as preselector to add additional input/output capabilities to a particular row. In this instance, the scanner is being used in conjunction with a Model 7071 General Purpose Matrix Card, which utilizes 3-pole switching (HI, LO, and guard). To take full advantage of the switching capabilities of the Model 7071, 3-pole switching should be used with the scanner constructed on the breadboard. External wiring between the two cards is not necessary; simply connect the scanner output to the row terminals of the ANALOG #2 pathway on the Model 7070.

3.6.2 Signal Conditioning

All matrix cards in the Model 707 system have a 200V signal limit. To switch higher voltages, signal conditioning circuits, in the form of voltage dividers, can be mounted on the adapter card. Figure 3-19 shows voltage dividers with 10:1 ratios, which would, for example, attenuate a 1000V signal to 100V-- well within the range of the Model 7071.

WARNING
Mount high-voltage circuits only on the unplated prototyping area of the Model 7070, and maintain proper voltage spacing, as discussed in paragraph 2.5.10.

In order for the division ratio to be accurate, the input resistance of any measuring instrument used with the divider should be much higher than the values of the divider resistor. An instrument with an input resistance of 10MΩ will result in a loading error of about 1% with the resistance values shown in Figure 3-19.

As with the scanner example above, external connections between the two cards are not necessary because connections are automatically made through the backplane. To take advantage of the backplane pathways, simply connect the divider outputs to the row pads of the ANALOG #2 pathways located on the Model 7070. The attenuated signals will be routed through the mainframe backplane to the corresponding rows of the Model 7071 card.

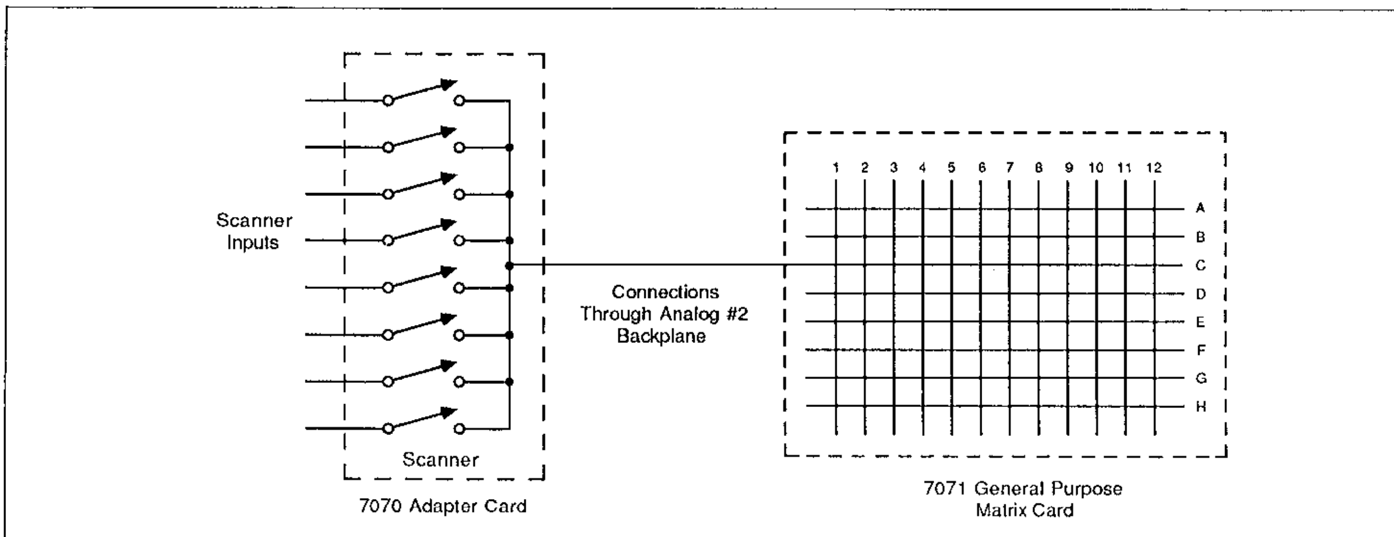


Figure 3-18. Adding a Scanner to a Switching Matrix

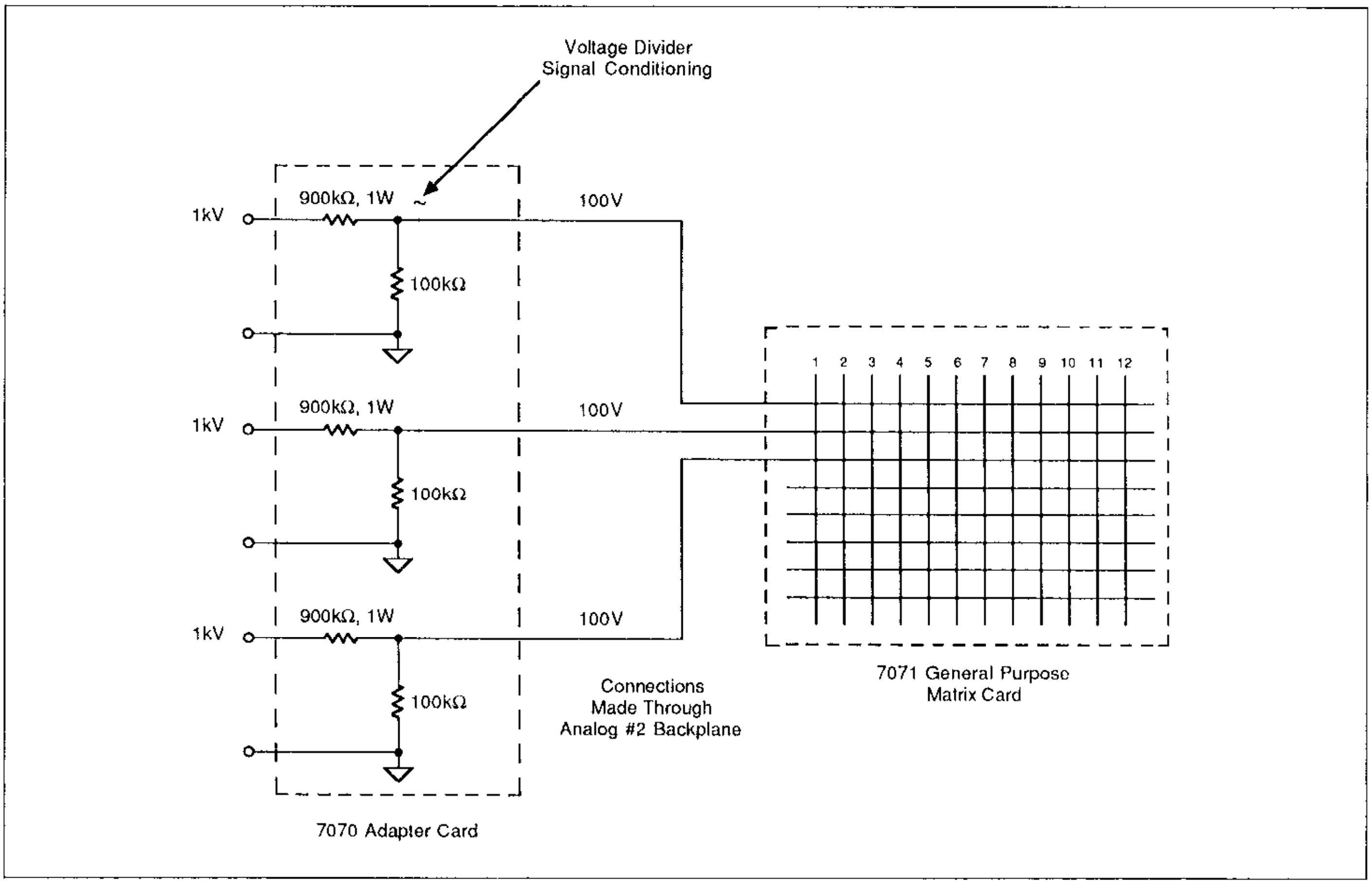


Figure 3-19. Signal Conditioning Example

SECTION 4
Service Information

4.1 INTRODUCTION

This section contains information necessary to service the Model 7070 Universal Adapter 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 Special Handling of Static-Sensitive Devices: Reviews precautions necessary when handling static-sensitive devices.

4.4 Troubleshooting: Presents some troubleshooting tips of the Model 7070.

4.5 Principles of Operation: Briefly discusses circuit operation.

4.2 HANDLING AND CLEANING PRECAUTIONS

Care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be taken when servicing the card.

1. Handle the card only by the edges and handle. Do not touch any board surfaces or components not associated with the repair.
2. Do not store or operate the card in an environment where dust could settle on the circuit board. Use dry nitrogen gas to clean dust off the board if necessary.
3. After soldering on the circuit board, remove the flux from the work areas when the repair has been completed. Use Freon TMS or TE or the equivalent along with clean cotton swabs or a clean, soft brush to remove the flux. Take care not to spread the flux to other areas of the circuit board. Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.
4. After cleaning, the card should be placed in a 50°C low-humidity environment for several hours before use.

4.3 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

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

NOTE

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

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

4.3.1 Rear Shield

Copper cladding has been added to the rear shield of the matrix card in order to provide increased protection from static discharge. The copper shield is electrically connected to chassis ground of the matrix card by a jumper wire.

In order to service the matrix card, it may be necessary to remove the rear shield. Referring to Figure 4-1, perform the following procedure to remove and reinstall the rear shield:

1. Disconnect the jumper wire from the matrix card chassis. The wire is secured to the matrix card chassis with a screw.
2. The rear shield is secured to the matrix card by eight standoffs. Carefully slide the rear shield upward until the eight standoffs align with the large clearance holes in the shield and remove the shield.
3. To reinstall the shield, reverse the above procedure. Make sure the metal side of the shield is facing outward.

CAUTION

Failure to observe the following precautions could result in damage not covered by the warranty:

1. **The shield must be installed such that the metal side is facing away from the matrix card. Backward installation will cause PC board connections to short out against the metal shield.**
2. **The jumper wire must be connected as shown in order to provide circuit protection from static discharge.**

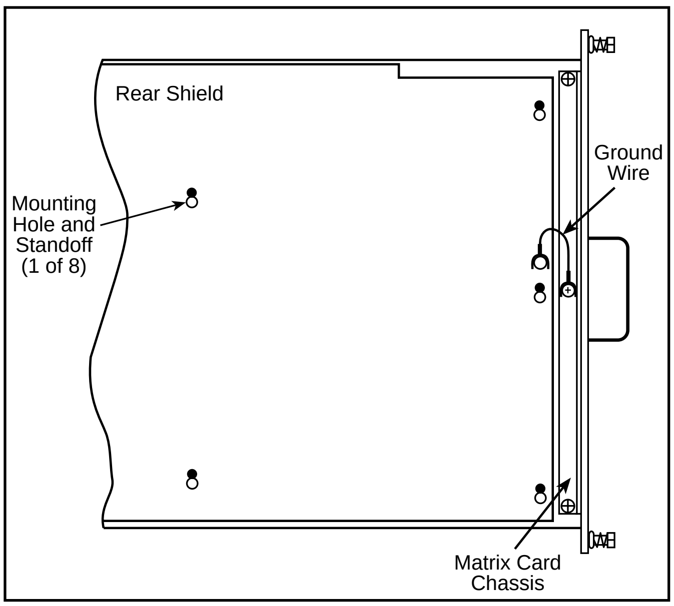


Figure 4-1. Removing the Rear Shield

4.4 TROUBLESHOOTING

4.4.1 Recommended Equipment

Table 4-1 summarizes the recommended equipment for general troubleshooting. Note that a second Model 7070, used as an extender card, will be necessary to gain access to the board components for troubleshooting.

WARNING

Disconnect all external equipment from the card before troubleshooting.

Table 4-1. Recommended Troubleshooting Equipment

Description	Manufacturer and Model	Application
5½-Digit DMM	Keithley 199	Measure DC voltages
Oscilloscope	TEK 2243	View logic waveforms
Extender Card	Keithley 7070*	Allow circuit access

*A second Model 7070 will be necessary to access the card.

4.4.2 Troubleshooting Procedure

Table 4-2 summarizes the troubleshooting procedure for the Universal Card. Some of the troubleshooting steps refer to the ID data timing diagram shown in Figure 4-2. Also, refer to paragraph 4.5 for an overview of operating principles.

NOTE

The Model 7070 should be in the LOCAL mode when troubleshooting.

Table 4-2. Troubleshooting Procedure

Step	Item/Component	Required Condition	Comments
1	TP2		All voltages referenced to TP2 (digital common)
2	TP1	+6VDC	Relay voltage
3	TP3	+5VDC	Logic voltage
4	TP4	NEXT ADDR pulses	Power up only (Fig. 4-2)
5	TP5	CLR ADDR pulse	Power up only (Fig. 4-2)
6	TP6	ID data pulses	Power up only (Fig. 4-2)
7	TP7	STROBE pulse	End of relay data sequence
8	TP8	Relay data (128 bits)	Present when updating relays
9	TP9	CLK pulses	Present during relay data or ID data
10	TP10	High on power up until first STROBE sets low.	Power on safe ground
11	U30-U41, pins 10-18	Low with relay energized, high with relay de-energized.	Relay driver outputs must be pulled up through relay coil to operate.

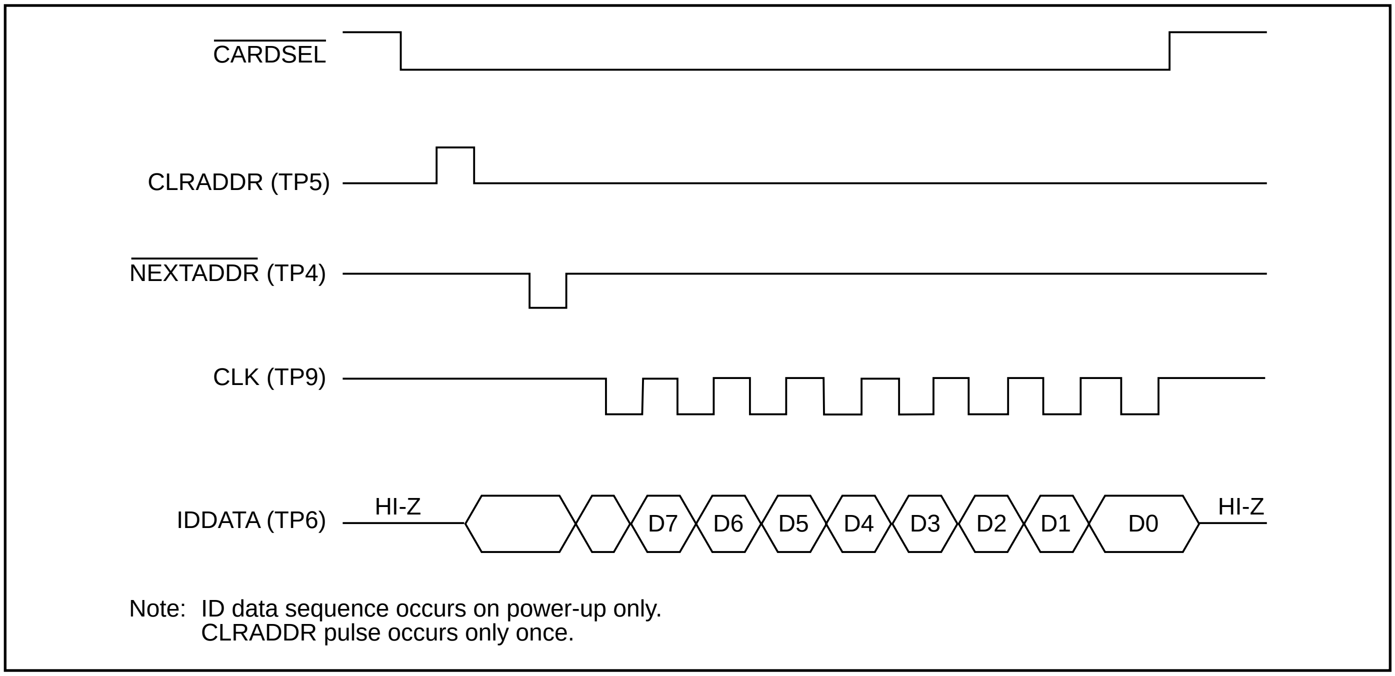


Figure 4-2. ID Data Timing

4.5 PRINCIPLES OF OPERATION

The following paragraphs discuss the basic operating principles for the Model 7070. A schematic diagram of the adapter card may be found in drawing number 7070-106, located at the end of Section 5.

4.5.1 Block Diagram

Figure 4-3 shows a simplified block diagram of the Model 7070. Key elements include the buffer (U44), ID data circuits (U45, U46, and U47), relay drivers (U35-U41), and power-on safeguard (U42). The major elements are discussed below.

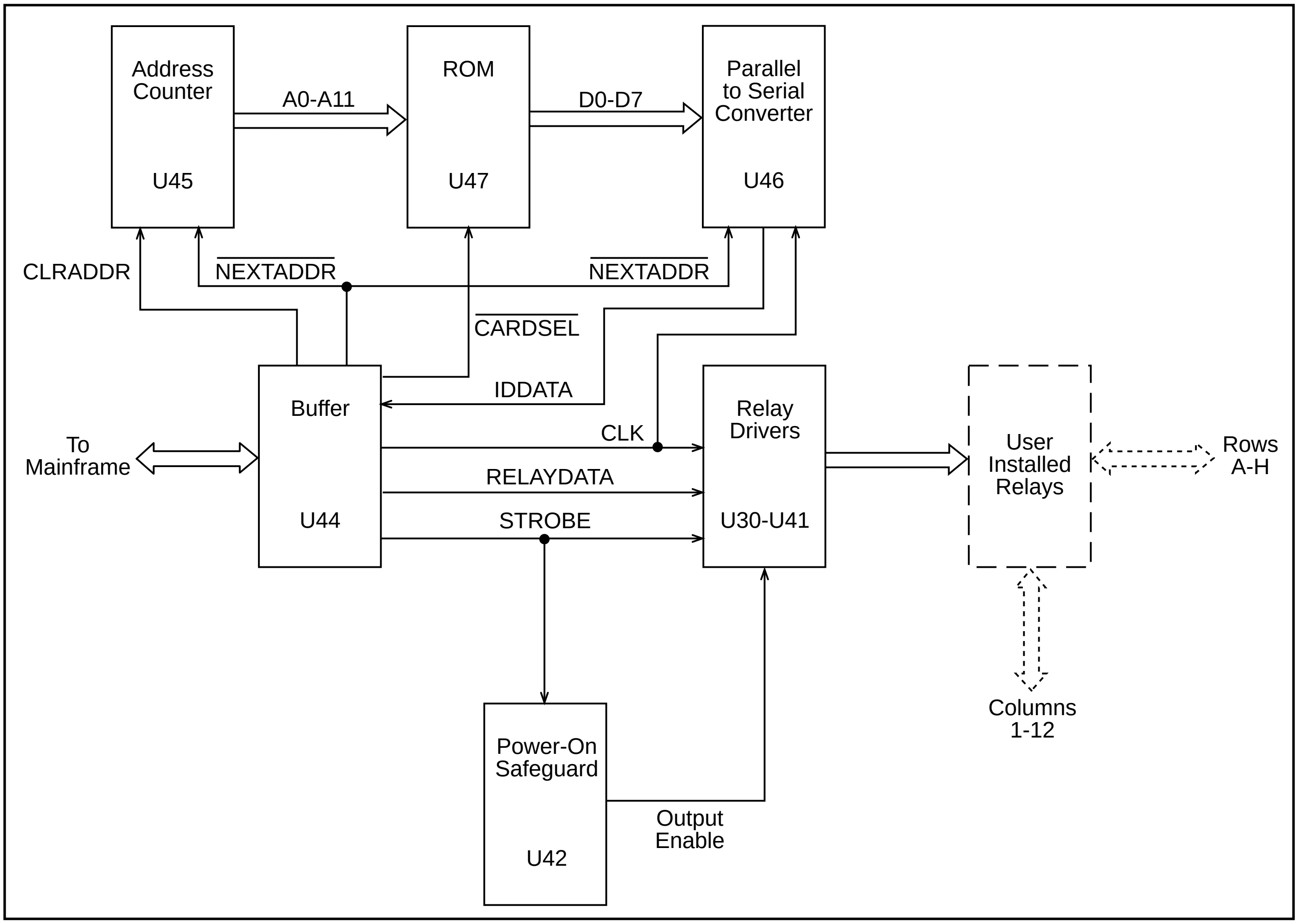


Figure 4-3. Model 7070 Block Diagram

4.5.2 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. This configuration table is necessary because some cards require the closing of more than one relay to close a specific crosspoint.

ID data is contained within an on-card ROM, U47. In order to read this information, the sequence below is performed upon power-up. Figure 4-2 shows the general timing of this sequence.

1. The CARDSEL line is brought low, enabling the ROM outputs. This line remains low throughout the ID data transmission sequence.
2. The CLRADDR line is pulsed high to clear the address counter and set it to zero. At this point, a ROM address of zero is selected. This pulse occurs only once.
3. The NEXTADDR line is set low. NEXTADDRS 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 process in steps 3 and 4 repeats until all the necessary ROM locations have been read. A total of 498 bytes of information are read by the mainframe during the card ID sequence.

4.5.3 Relay Control

User-installed relays are controlled by serial data transmitted via the RELAYDATA line. A total of 16 bytes for each card are shifted in in serial fashion (only 12 are used in the Model 7070, however) into latches located in the 12 relay drivers, U30-U41. 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 the bytes have been shifted into the card, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate user relays are energized (assuming the driver outputs are enabled, as discussed below). Logic convention is such that the corresponding relay driver output must be low to energize the associated relay, while the output is high when the relay is de-energized.

4.5.4 Power-on Safeguard

A power-on safeguard circuit, made up of U42 and associate components, ensures that relays do not randomly energize upon power-up. The two NAND gates, U42, make up an R-S flip-flop. Initially, the Q output of the flip-flop (pin 3 of U42) is set high after the RC combination at pin 1 times out. Since the OEN terminals of the relay drivers U30-U41 are held high, their outputs are disabled, and all relays remain de-energized regardless of the relay data information present at that time.

The first STROBE pulse that comes along (in order to load relay data) clears the R-S flip-flop, setting the OEN lines of U30-U41 low to enable their outputs. This action allows the relays to be controlled by the transmitted relay data information.

A hold-off period of approximately 2.209sec 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 R1 and C20.

SECTION 5
Replaceable Parts

5.1 INTRODUCTION

This section contains a list of replaceable electrical and mechanical parts for the Model 7070, as well as a component layout drawing and schematic diagram of the adapter card.

5.2 PARTS LISTS

Electrical parts for the main board are listed in order of circuit designation in Table 5-1. Table 5-2 lists parts for the extender board. Table 5-3 summarizes mechanical parts.

5.3 ORDERING INFORMATION

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

1. Card model number (7070)
2. Card serial number
3. Part description
4. Circuit designation, if applicable
5. Keithley part number

5.4 FACTORY SERVICE

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

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

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

5.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

Figure 5-1 is the component layout for the main circuit board. Figure 5-2 shows a schematic diagram of the main board. Figures 5-3 and 5-4 show the component layout and schematic for the extender board.

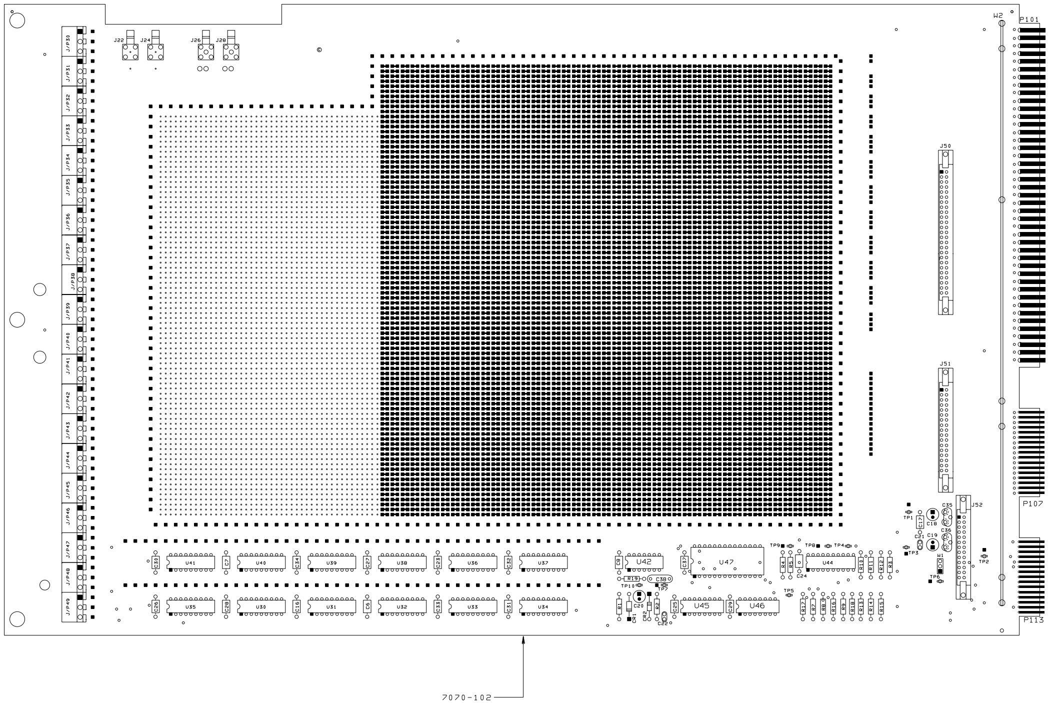
NOTE

Figure 5-3 and Figure 5-4 do not apply to the Model 7070-PCA.

TABLE 5-1. MAIN CIRCUIT BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART No.
C18,C19	CAP,10uF,-20+100%,25V,ALUM ELEC	C-314-10
C20	CAP,47UF,10%,16V,ALUM ELEC	C-321-47
C21,C22	CAP,.01uF,20%,50V,CERAMIC	C-237-.01
C35,C36	CAP,270pF,20%,100V,CERAMIC/FERRITE	C-386-270P
C38	CAP,.01uF,10%,1000V,CERAMIC	C-64-.01
C6..C8,C16,C17,	CAP,.1uF,20%,50V,CERAMIC	C-365-.1
CR1	DIODE,SILICON,IN4148 (DO-35)	RF-28
CR2	DIODE,SCHOTTKY,1N5711	RF-69
J22,J24,J26,J28	CONN,SMB,MALE	CS-580
J50	CONN,MALE HEADER 50-PIN	CS-368-50
J51	CONN,MALE HEADER 34-PIN	CS-368-34
J52	CONN,MALE HEADER 26-PIN	CS-368-26
J/P30..J/P49	CONN,3 PIN	CS-570-3
R1	RES,47K,5%,1/4W,COMPOSITION OR FILM	R-76-47K
R13..R18	RES,100K,5%,1/4W,COMPOSITION OR FILM	R-76-100K
R19	RES,200,5%,1/4W,COMPOSITION OR FILM	R-76-200
R2	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R3	RES,120K,5%,1/4W,COMPOSITION OR FILM	R-76-120K
R4	RES,11K,5%,1/4W,COMPOSITION OR FILM	R-76-11K
R5	RES,910,5%,1/4W,COMPOSITION OR FILM	R-76-910
R7..R12	RES,1K,5%,1/4W,COMPOSITION OR FILM	R-76-1K
TP1..TP10	CONN,TEST POINT	CS-553
U30..U41	IC,8 STAGE SHIFT/STORE REGISTER,4094	C-536
U42	IC,QUAD 2 INPUT NAND,74HCT00	IC-399
U44	IC,OCTAL BUFFER/LINE DRIVER,74LS244	IC-483
U45	IC,12 STAGE BINARY COUNTER,74HCT4040	IC-545
U46	IC,8-BIT PARALLEL TO SERIAL,74HCT165	IC-548
U47	IC, PROGRAMMED ROM	7070-800
W1	CONN,3 PIN (JUMPER)	CS-339-3
W2	STIFFENER,BOARD	J-16

LTR.	ECO NO.	REVISION	ENG.	DATE
B	12396	RELEASED	SZ	11-23-87
C	12594	REVISED	SZ	2-17-88
D	13157	REVISED PER REV.D ARTWORK	SZ	11-03-89



NOTE:
FOR COMPONENT INFORMATION,
REFER TO BILL OF MATERIAL
7070-000-00.

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING

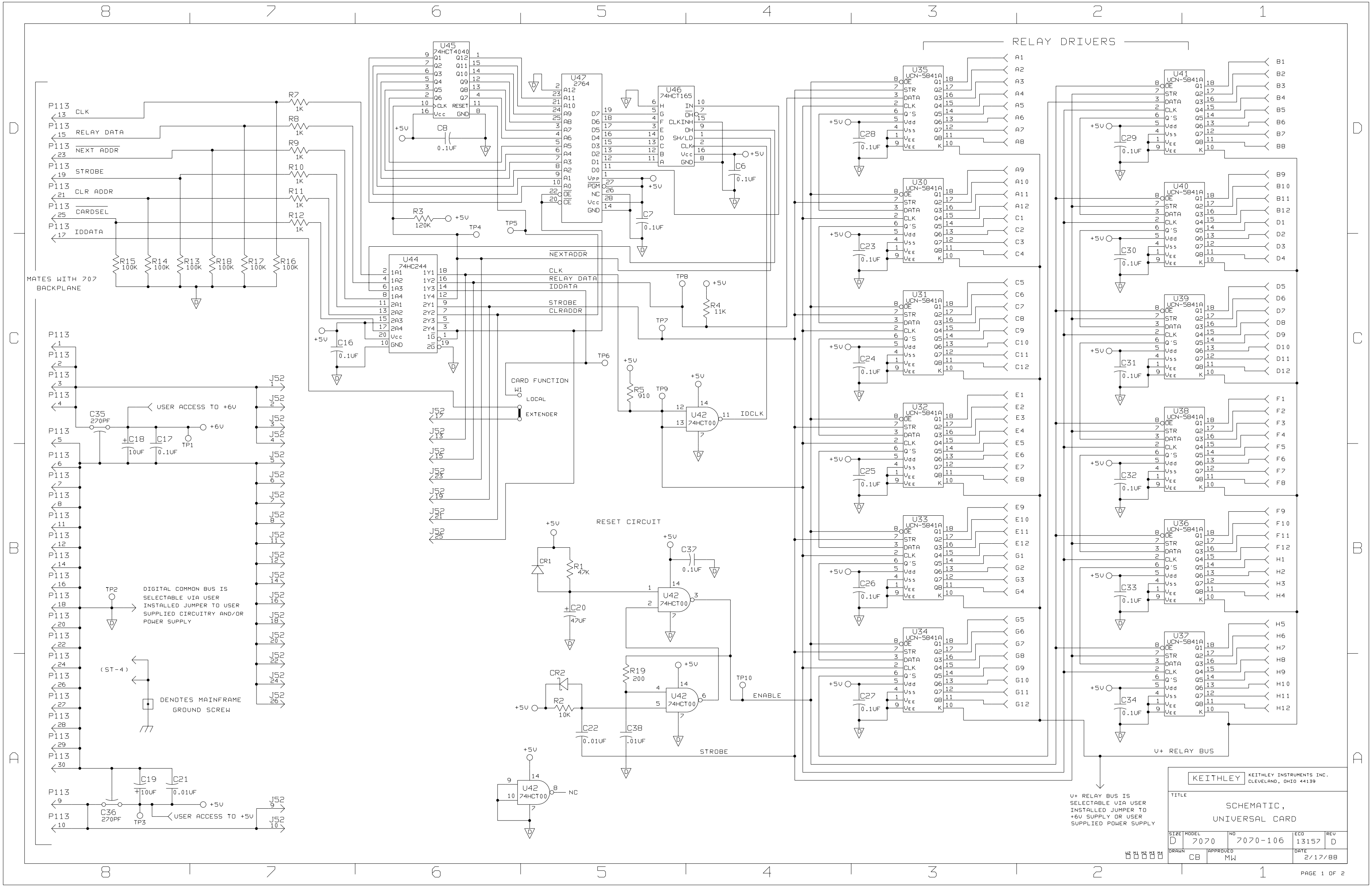
KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

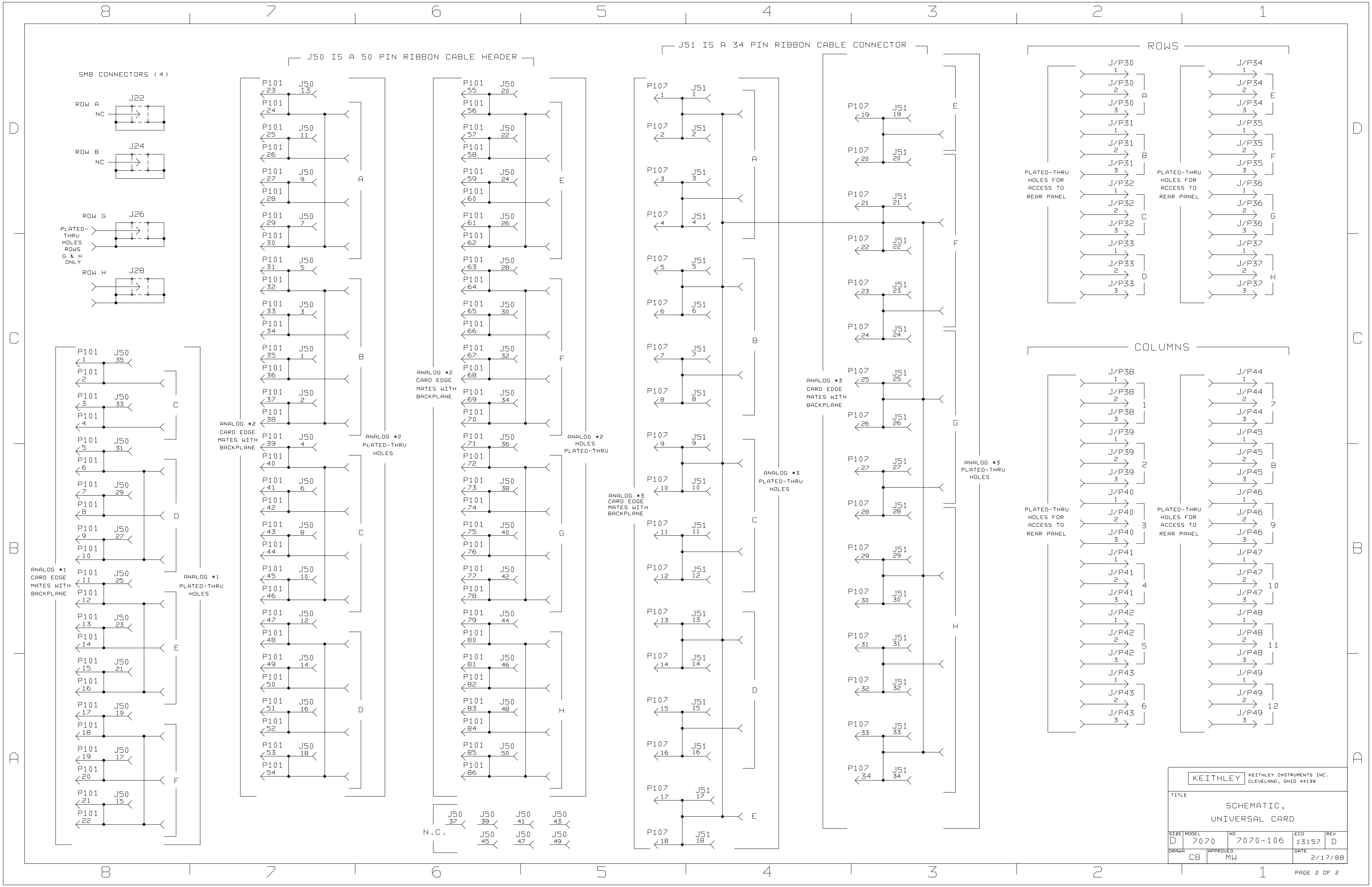
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX=±.015 ANG.=±1°
XXX=±.005 FRAC.=±1/64
SURFACE MAX. 63

DATE 2/17/88
SCALE 1:1
DRN. CB
ENG. APPR.
MATERIAL
FINISH

TITLE COMPONENT LAYOUT UNIVERSAL CARD

D NO. 7070-100


RELAY DRIVERS
MATES WITH 707 BACKPLANE
CARD FUNCTION
W1
LOCAL
EXTENDER
USER ACCESS TO +6V
USER ACCESS TO +5V
DIGITAL COMMON BUS IS SELECTABLE VIA USER INSTALLED JUMPER TO USER SUPPLIED CIRCUITRY AND/OR POWER SUPPLY
(ST-4)
DENOTES MAINFRAME GROUND SCREW
RESET CIRCUIT
ENABLE
STROBE
IDCLK
V+ RELAY BUS
V+ RELAY BUS IS SELECTABLE VIA USER INSTALLED JUMPER TO +6V SUPPLY OR USER SUPPLIED POWER SUPPLY
KEITHLEY
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139
TITLE
SCHEMATIC, UNIVERSAL CARD
SIZE D
MODEL 7070
NO 7070-106
ECO 13157
REV D
DRAWN CB
APPROVED MW
DATE 2/17/88
PAGE 1 OF 2



SMB CONNECTORS (4)
ROW A
ROW B
ROW G
ROW H
NC
PLATED-THRU HOLES ROWS G & H ONLY
J22
J24
J26
J28
J50 IS A 50 PIN RIBBON CABLE HEADER
J51 IS A 34 PIN RIBBON CABLE CONNECTOR
ANALOG #1 CARD EDGE MATES WITH BACKPLANE
ANALOG #1 PLATED-THRU HOLES
ANALOG #2 CARD EDGE MATES WITH BACKPLANE
ANALOG #2 PLATED-THRU HOLES
ANALOG #2 HOLES PLATED-THRU
ANALOG #3 CARD EDGE MATES WITH BACKPLANE
ANALOG #3 PLATED-THRU HOLES
N.C.
ROWS
COLUMNS
PLATED-THRU HOLES FOR ACCESS TO REAR PANEL
KEITHLEY
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139
TITLE
SCHEMATIC, UNIVERSAL CARD
SIZE D
MODEL 7070
NO 7070-106
ECO 13157
REV D
DRAWN CB
APPROVED MW
DATE 2/17/88
PAGE 2 OF 2

TABLE 5-2. EXTENDER BOARD, PARTS LIST

NOTE

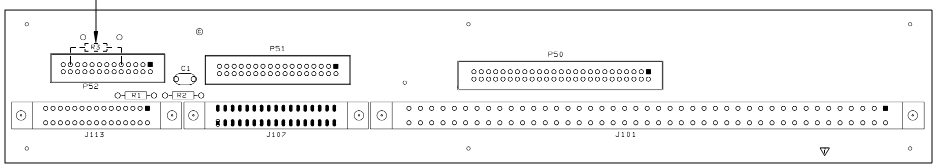
This table does not apply to the Model 7070-PCA.

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART No.
C1	CAP, 150pF, 10%, 1000V, CERAMIC	C-64-150P
J101	CONN, 86 PIN CARD EDGE	CS-579-1
J107	CONN, 34 PIN CARD EDGE	CS-591-2
J113	CONN, 30 PIN CARD EDGE	CS-591-1
P50	CABLE ASSY, 50 PIN	CA-62-3
P51	CABLE ASSY, 34 PIN	CA-62-2
P52	CABLE ASSY, 26 PIN	CA-62-1
R1	RES, 2K, 1%, 1/8W	R-88-2K
R2	RES, 130, 1%, 1/8W	R-88-130

NO. 7070-160

LTR.	ECO NO.	REVISION	ENG.	DATE
A	12396	RELEASED	SZ	11-23-87
A1	13166	REVISED	SZ	1-3-88

R3 TO BE MOUNTED ON
SOLDER SIDE TO PINS
9 & 23 OF P52



NOTE: FOR MORE COMPONENT INFORMATION
SEE BILL OF MATERIAL 7070-000-00

7070		
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 10/16/87	SCALE 1:1	TITLE COMPONENT LAYOUT, EXTENDER BD.
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±1°	DRN. MAH	ENG. APPR. MW	
	XXX=±.005 FRAC.=±1/64	MATERIAL		C
	SURFACE MAX. 63	FINISH		NO. 7070-160

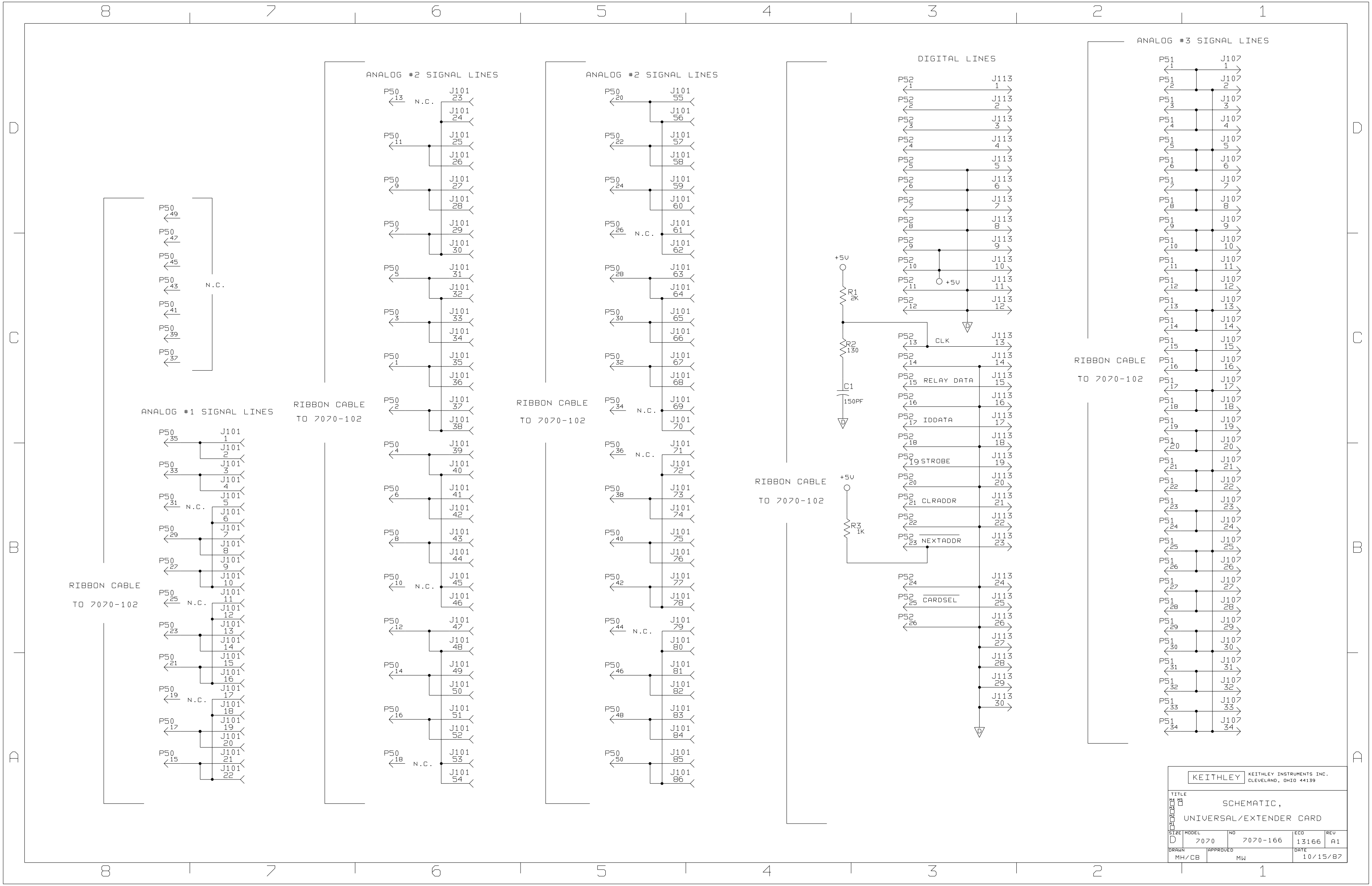

ANALOG #1 SIGNAL LINES
ANALOG #2 SIGNAL LINES
ANALOG #2 SIGNAL LINES
DIGITAL LINES
ANALOG #3 SIGNAL LINES
RIBBON CABLE
TO 7070-102
RIBBON CABLE
TO 7070-102
RIBBON CABLE
TO 7070-102
RIBBON CABLE
TO 7070-102
RIBBON CABLE
TO 7070-102
N.C.
P50
J101
P51
J107
P52
J113
+5V
R1 2K
R2 130
C1 150PF
R3 1K
CLK
RELAY DATA
IDDATA
STROBE
CLRADDR
NEXTADDR
CARDSEL
KEITHLEY
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139
TITLE
SCHEMATIC,
UNIVERSAL/EXTENDER CARD
SIZE D
MODEL 7070
NO 7070-166
ECO 13166
REV A1
DRAWN MH/CB
APPROVED MW
DATE 10/15/87

TABLE 5-3. MISCELLANEOUS MECHANICAL PARTS LIST

QTY.	DESCRIPTION	KEITHLEY PART No.
5	CLAMP, RIBBON CABLE	CC-59
1	CLAMP,LOWER	7071-306
1	CLAMP, UPPER	7071-305
1	SHIELD	7070-305
1	SHIELD,REAR	7071-311
8	STANDOFFS FOR REAR SHIELD	7071-310
2	SOCKET,16 PIN DIP	SO-65
12	SOCKET,18 PIN DIP	SO-82
1	SOCKET,20 PIN DIP	SO-84-20
1	SOCKET,28 PIN DIP	SO-69
1	REAR PANEL	7070-303
1	SOCKET,14 PIN DIP	SO-70

KEITHLEY

SERVICE FORM

Model No. ________________ **Serial No.** ______________________ **Date** __________

Name and Telephone No. ____

Company ____

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

____

____

☐Intermittent ☐Analog output follows display ☐Particular range or function bad; specify ________

☐IEEE failure ☐Obvious problem on power-up ☐Batteries and fuses are OK

☐Front panel operational ☐All ranges or functions are bad ☐Checked all cables

Display or output (circle one)

☐Drifts ☐Unable to zero

☐Unstable ☐Will not read applied input

☐Overload

☐Calibration only ☐C of C required

☐Data required

(attach any additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

____

____

What power line voltage is used? ____________________ Ambient Temperature? ______________ °F

Relative humidity? ________________ Other? ______________________________

Any additional information. (If special modifications have been made by the user, please describe.) __________

____

Be sure to include your name and phone number on this service form.

KEITHLEY

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GERMANY:	**Keithley Instruments GmbH**	Landsberger Strasse 65 • D-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, WILLOCRISSA • 14, Rest House Crescent • Bangalore 560 001 • 91-80-509-1320/21 • Fax: 91-80-509-1322
ITALY:	**Keithley Instruments s.r.l.**	Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
KOREA:	**Keithley Instruments Korea**	2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-130 • 82-2-574-7778 • Fax: 82-2-574-7838
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