

KEITHLEY

Model 2000-SCAN-20 Scanner Card

Instruction Manual

A GREATER MEASURE OF CONFIDENCE



Model 2000-SCAN-20 Scanner Card Instruction Manual

©1997, Keithley Instruments, Inc.
All rights reserved.
Cleveland, Ohio, U.S.A.
Third Printing, July 2003
Document Number: 2000-20-901-01 Rev. C

Manual Print History

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

Revision A (Document Number 2000-20-901-01)	February 1998
Revision B (Document Number 2000-20-901-01)	June 1998
Revision C (Document Number 2000-20-901-01)	July 2003

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 and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

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 properly, 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 Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. 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.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators 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  symbol indicates a connection terminal to the equipment frame.

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.

Table of Contents

1	General Information	
	Introduction	1-2
	Features	1-2
	Manual addenda	1-3
	Safety symbols and terms	1-3
	Specifications	1-3
	Unpacking and inspection	1-3
	Inspection for damage	1-3
	Handling precautions	1-4
	Shipment contents	1-4
	Instruction manual	1-4
	Repacking for shipment	1-4
	Optional accessories	1-5
2	Card Connections and Installation	
	Introduction	2-2
	Handling precautions	2-2
	Connections	2-3
	Connection precautions	2-3
	Card configuration	2-4
	Card connectors	2-5
	Typical connecting schemes	2-8
	Voltage connections	2-8
	Resistance connections	2-9
	Current measurements	2-11
	Card installation and removal	2-14
	Scanner card installation	2-14
	Output connections to multimeter	2-16
	Scanner card removal	2-17

3

Operation

Introduction	3-2
Signal limitations	3-2
Relay input signal limitations	3-2
Scanner card detection	3-3
Power-up detection	3-3
Scanner option bus query	3-3
Model 2000-20 multimeter front panel scanner controls and	
SCPI scanner commands	3-4
Closing channels	3-4
Opening channels	3-5
Selecting measurement function	3-5
Configuring scan parameters	3-6
SCPI scanner commands	3-8
Typical applications	3-9
Resistor testing	3-9
Current measurements	3-11
Measurement considerations	3-12
Path isolation	3-12
Magnetic fields	3-13
Electromagnetic interference (EMI)	3-13
Ground loops	3-14
Keeping connectors clean	3-15

4

Service Information

Introduction	4-2
Handling and cleaning precautions	4-2
Handling precautions	4-2
Soldering precautions	4-3
Performance verification	4-3
Environmental conditions	4-3
Recommended equipment	4-4
Path resistance tests	4-4
Contact potential tests	4-6
Isolation tests	4-7
Special handling of static-sensitive devices	4-10
Principles of operation	4-10
Block diagram	4-10
Relay control	4-11
Switching circuits	4-11
Power-on safeguard	4-11

5 **Replaceable Parts**

Introduction	5-2
Parts list	5-2
Ordering information	5-2
Factory service	5-2
Component layout and schematic diagram	5-3

A **Specifications**

List of Illustrations

2	Card Connections and Installation	
Figure 2-1	Model 2000-SCAN-20 simplified schematic	2-4
Figure 2-2	Card connectors	2-5
Figure 2-3	Input and output connector terminal identification	2-6
Figure 2-4	Connections for voltage scanning	2-8
Figure 2-5	Typical connections for 2-wire resistance scanning	2-9
Figure 2-6	Typical connections for 4-wire resistance scanning	2-10
Figure 2-7	Current shunt locations	2-11
Figure 2-8	Current connections	2-13
Figure 2-9	Card installation	2-15
Figure 2-10	2-pole output connections	2-16
Figure 2-11	4-pole output connections	2-17
3	Operation	
Figure 3-1	2-wire resistance test connections	3-9
Figure 3-2	4-wire resistance test connections	3-10
Figure 3-3	Connections for current measurements	3-11
Figure 3-4	Path isolation resistance	3-12
Figure 3-5	Voltage attenuation by path isolation resistance	3-13
Figure 3-6	Power line ground loops	3-14
Figure 3-7	Eliminating ground loops	3-15
4	Service Information	
Figure 4-1	Connections for path resistance checks	4-5
Figure 4-2	Connections for contact potential tests	4-6
Figure 4-3	Connections for same-channel isolation tests	4-7
Figure 4-4	Connections for channel-to-channel isolation tests	4-8
Figure 4-5	Connections for HI and LO input-to-chassis ground isolation tests	4-9
Figure 4-6	Block diagram	4-11

List of Tables

2	Card Connections and Installation	
Table 2-1	Input connector J1036 pin designations	2-7
Table 2-2	Output connector J1035 pin designations	2-7
3	Operation	
Table 3-1	Summary of SCPI scanner commands	3-8
4	Service Information	
Table 4-1	Recommended verification equipment	4-4
5	Replaceable Parts	
Table 5-1	Model 2000-SCAN-20 parts list	5-3

1 General Information

Introduction

This section contains general information about the Model 2000-SCAN-20 scanner card. The Model 2000-SCAN-20 provides 20 channels of 2-pole relay switching. The channels can be configured for 4-pole operation.

Section 1 is arranged in the following manner:

- Features
- Manual addenda
- Safety symbols and terms
- Specifications
- Unpacking and inspection
- Repacking for shipment
- Optional accessories

Features

The Model 2000-SCAN-20 is a scanner card designed to be installed in the Model 2000-20 Multimeter. (The Model 2000-SCAN-20 is not designed for the Models 2000 or 2010 Multimeters.)

Key features include:

- Twenty channels of 2-pole relay input.
- Channels configurable for 4-pole operation.
- Multiplex one of twenty 2-pole or one of ten 4-pole channels into a Model 2000-20 Multimeter.

Manual addenda

Any improvements or changes concerning the scanner card or manual will be explained in an addendum included with the card. Addenda are provided in a page replacement format. Simply replace the obsolete pages with the new pages.

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 scanner card. Such damage may invalidate the warranty.

Specifications

Model 2000-SCAN-20 specifications are found in Appendix A. These specifications are exclusive of the multimeter specifications.

Unpacking and inspection

Inspection for damage

The Model 2000-SCAN-20 is packaged in a re-sealable, anti-static bag to protect it from damage due to static discharge and from contamination that could degrade its performance. Before removing the card from the bag, observe the following handling precautions.

Handling precautions

- Always grasp the card by the side edges and covers. Do not touch the board surfaces or components.
- When the card is not installed in a multimeter, keep the card in the anti-static bag and store it in the original packing carton.

After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately.

Shipment contents

The following items are included with every Model 2000-SCAN-20 order:

- Model 2000-SCAN-20 Scanner Card
- Model 2000-20-901-00 Instruction Manual
- Test lead set for output connections (two red, two black)
- Additional accessories as ordered

Instruction manual

If an additional Model 2000-SCAN-20 Instruction Manual is required, order the manual package, Keithley part number 2000-20-901-00. The manual package includes an instruction manual and any pertinent addenda.

Repacking for shipment

Should it become necessary to return the Model 2000-SCAN-20 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 scanner card.
- Write ATTENTION REPAIR DEPARTMENT on the shipping label.
- Fill out and include the service form located at the back of this manual.

Optional accessories

The following accessories are available for use with the Model 2000-SCAN-20 scanner card:

- **Models 2000-MTC-2 and 2000-MTC-4 Cable Assemblies** — This 2m or 4m cable assembly is terminated with a DB44 female connector on one end and is unterminated at the other end. The female end mates to the male DB44 connector on the scanner card.
- **Model 2000-MTCD-2 Cable Assembly** — This 2m cable assembly is terminated with a DB44 female connector on one end and a DB50 male connector at the other end. The female end mates with the scanner card.

2 Card Connections and Installation

Introduction

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

This section includes information on making connections to the Model 2000-SCAN-20 and installing the card in a Model 2000-20 Multimeter. This section is arranged as follows:

- **Handling precautions** — Explains precautions that must be followed to prevent contamination to the scanner card assembly. Contamination could degrade the performance of the scanner card.
- **Connections** — Covers the basics for connecting external circuitry to the scanner card.
- **Typical connection schemes** — Provides some typical connection schemes for 2-pole and 4-pole operation.
- **Card installation and removal** — Summarizes the procedure to install the scanner card in a multimeter, outlines scanner card output connections, and describes how to remove the card.

Handling precautions

To maintain high impedance isolation between channels, take care when handling the scanner card to avoid contamination from such foreign materials as body oils. Such contamination can substantially lower leakage resistances and degrade card performance. To avoid possible contamination, always grasp the scanner card by the side edges. Do not touch board surfaces, components, or areas adjacent to electrical contacts.

Dirt buildup over a period of time is another possible source of contamination. To avoid this problem, operate the multimeter and scanner card in a clean environment. If the card becomes contaminated, thoroughly clean it as explained in [Section 4](#).

Connections

This paragraph provides the information necessary to connect your external test circuitry to the scanner card.

NOTE All connections must be connected to the card before it is installed in a multimeter.

Connection precautions

WARNING Connection information for the Model 2000-SCAN-20 is intended for qualified service personnel. Do not attempt to connect the DUT or external circuitry to a scanner card unless qualified to do so.

To prevent electric shock that could result in serious injury or death, adhere to the following safety precautions:

- Before making or breaking connections to the scanner card, make sure the DMM power is turned off and power is removed from all external circuitry.
- Do not connect signals that will exceed the maximum specifications of the scanner card.

If both the front panel terminals and the scanner card terminals are connected at the same time, the maximum signal ratings of the front panel terminals are reduced to the maximum signal ratings of the scanner card.

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, scanner cards are Installation Category I and must not be connected to mains.

Card configuration

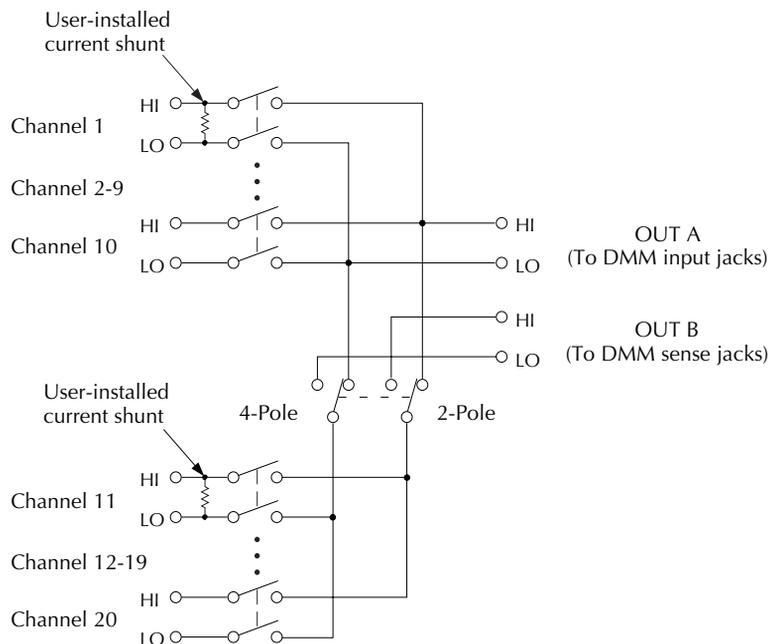
Figure 2-1 shows a simplified schematic diagram of the Model 2000-SCAN-20. The scanner card has 20 input channels and two outputs. Channels 1 through 20 are all switched by relays.

In 2-pole mode, the OUT A HI and LO connections are for all 20 channels. In 4-pole mode, the OUT A HI and LO connections are for channels 1 through 10 and the OUT B HI and LO connections are for channels 11 through 20.

4-pole paired channels are as follows:

- Channels 1 and 11
- Channels 2 and 12
- Channels 3 and 13
- Channels 4 and 14
- Channels 5 and 15
- Channels 6 and 16
- Channels 7 and 17
- Channels 8 and 18
- Channels 9 and 19
- Channels 10 and 20

Figure 2-1
Model 2000-SCAN-20 simplified schematic



Card connectors

Figure 2-2 shows the input and output connectors for the card. Card connector J1036 provides the HI and LO input connections for all 20 channels, and J1035 provides the HI and LO outputs. Terminal identification for connectors J1035 and J1036 is provided in Figure 2-3 and Table 2-1 and Table 2-2, respectively

The J1035 connects to a plug that has four separate test leads. These test leads connect to the rear HI and LO INPUT and SENSE jacks on the multimeter. Refer to “Output connections to multimeter” on page 2-16 for more information.

NOTE It is not necessary to connect the OUT B leads for 2-pole mode operation.

The J1036 connects to a DB44 mass-terminated connector.

Figure 2-2
Card connectors

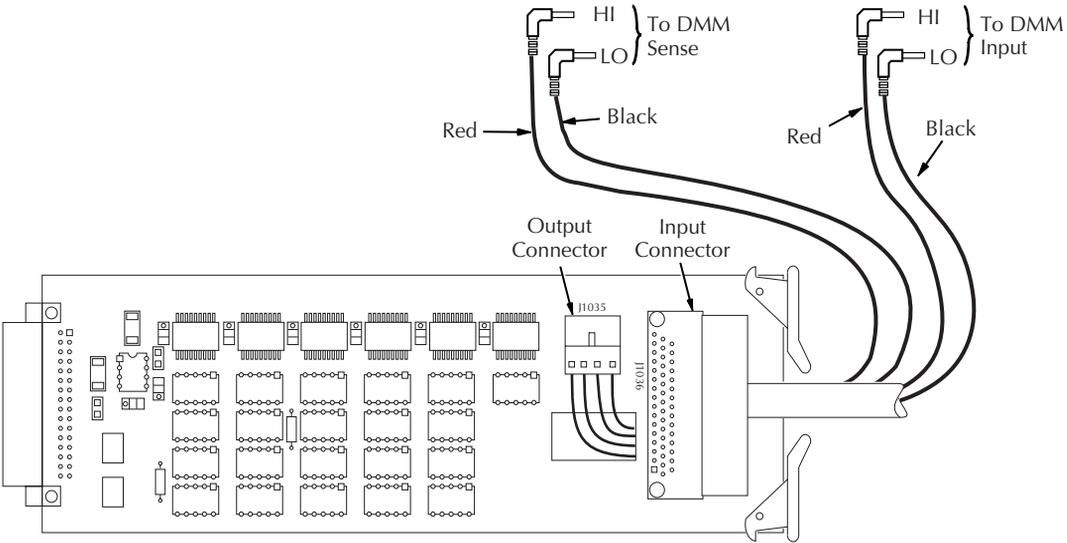


Figure 2-3
Input and output connector terminal identification

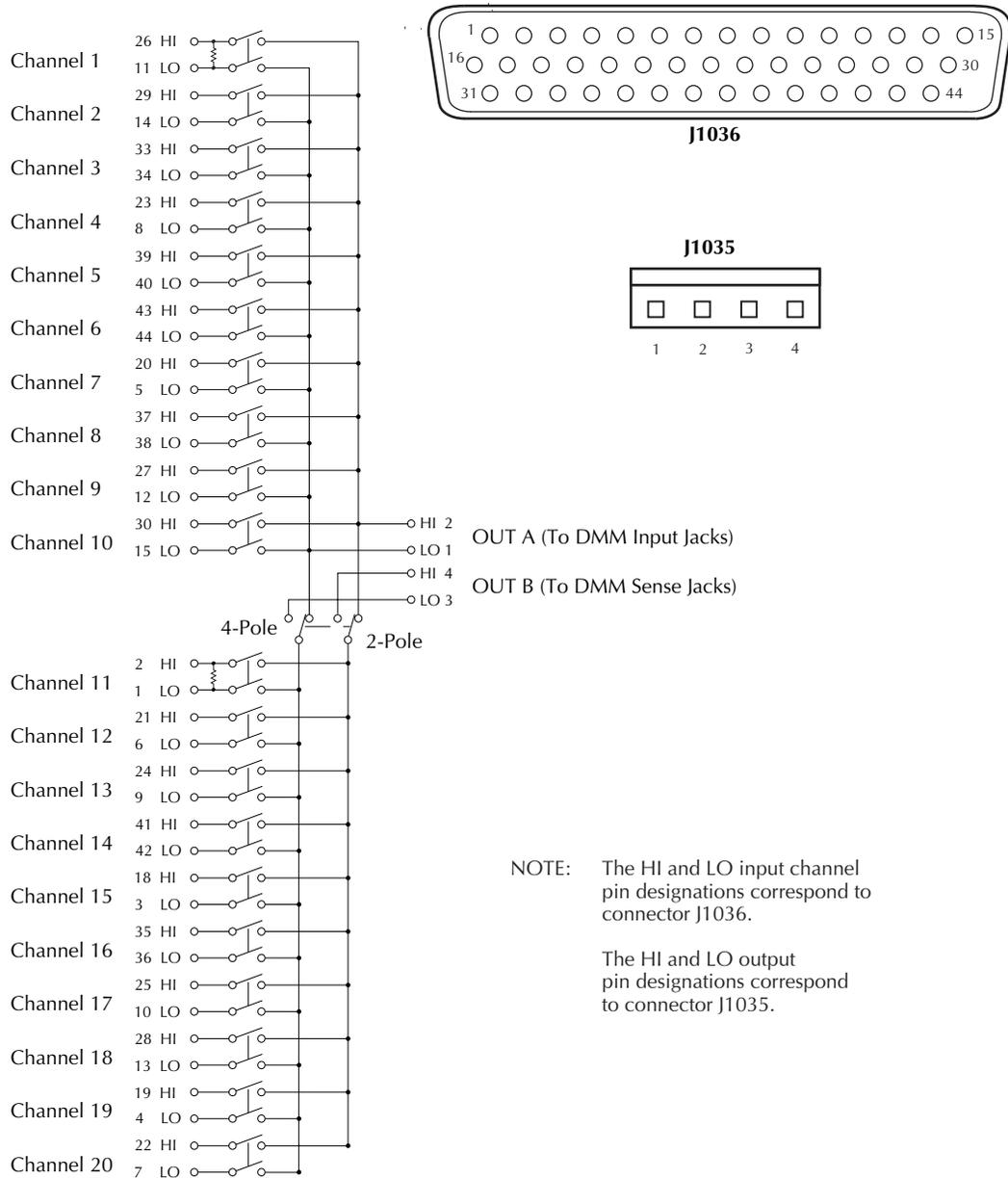


Table 2-1
Output connector J1035 pin designations

Terminal	Pin Designator	Terminal	Pin Designator
Output A, LO	1	Output B, LO	3
Output A, HI	2	Output B, HI	4

Table 2-2
Input connector J1036 pin designations

Mux Terminal	Pin Designator	Mux Terminal	Pin Designator
Channel 1, HI	26	Channel 11, HI	2
Channel 1, LO	11	Channel 11, LO	1
Channel 2, HI	29	Channel 12, HI	21
Channel 2, LO	14	Channel 12, LO	6
Channel 3, HI	33	Channel 13, HI	24
Channel 3, LO	34	Channel 13, LO	9
Channel 4, HI	23	Channel 14, HI	41
Channel 4, LO	8	Channel 14, LO	42
Channel 5, HI	39	Channel 15, HI	18
Channel 5, LO	40	Channel 15, LO	3
Channel 6, HI	43	Channel 16, HI	35
Channel 6, LO	44	Channel 16, LO	36
Channel 7, HI	20	Channel 17, HI	25
Channel 7, LO	5	Channel 17, LO	10
Channel 8, HI	37	Channel 18, HI	28
Channel 8, LO	38	Channel 18, LO	13
Channel 9, HI	27	Channel 19, HI	19
Channel 9, LO	12	Channel 19, LO	4
Channel 10, HI	30	Channel 20, HI	22
Channel 10, LO	15	Channel 20, LO	7
NC	16	NC	31
NC	17	NC	32

Typical connecting schemes

The following paragraphs discuss typical connections for the scanner card.

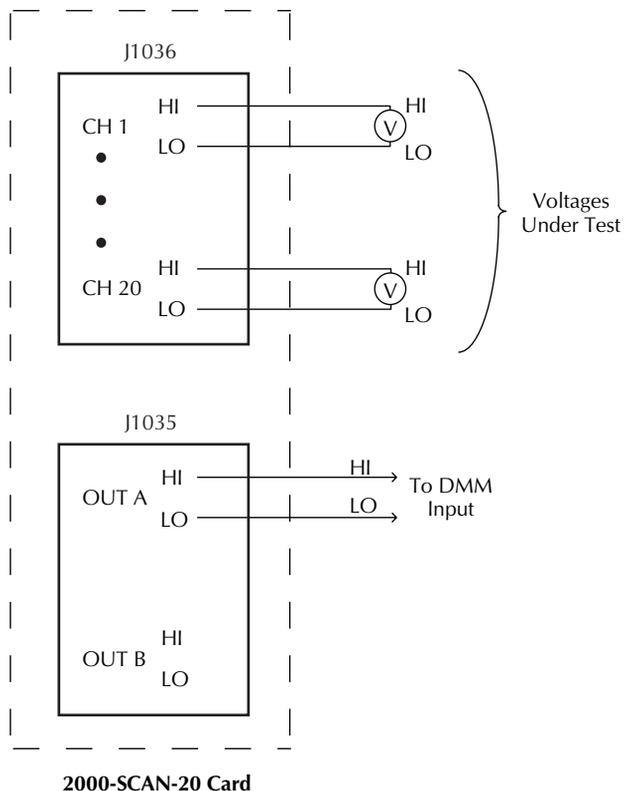
Voltage connections

Figure 2-4 shows typical connections for voltage measurements. Note that all channels are used in the 2-pole mode and that up to 20 voltage sources can be switched with this configuration. This basic configuration can be used for the following types of measurements:

- DCV
- ACV
- Frequency (voltage only)

All channels (1 through 20) can be used with this configuration.

Figure 2-4
Connections for voltage scanning

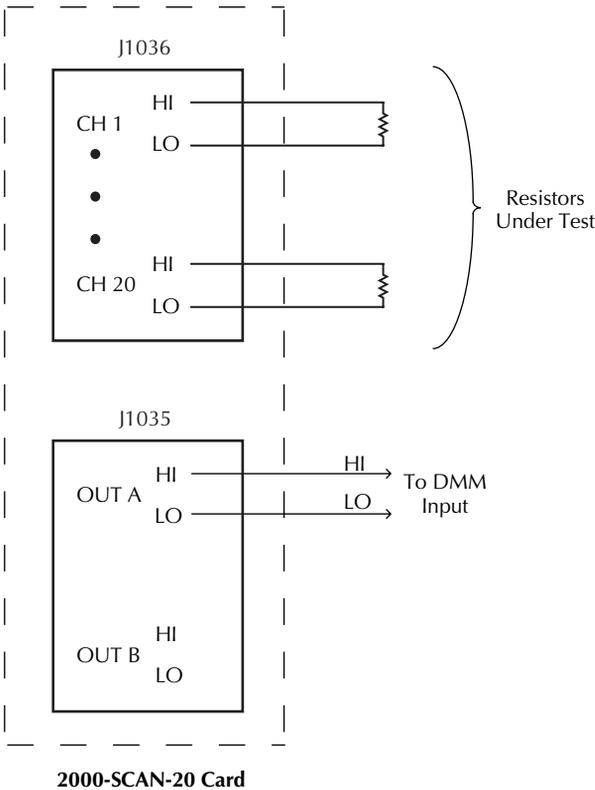


Resistance connections

2-Pole connections

Figure 2-5 shows typical 2-pole resistor test connections. The 2-pole resistance configuration can be used to test up to 20 DUTs.

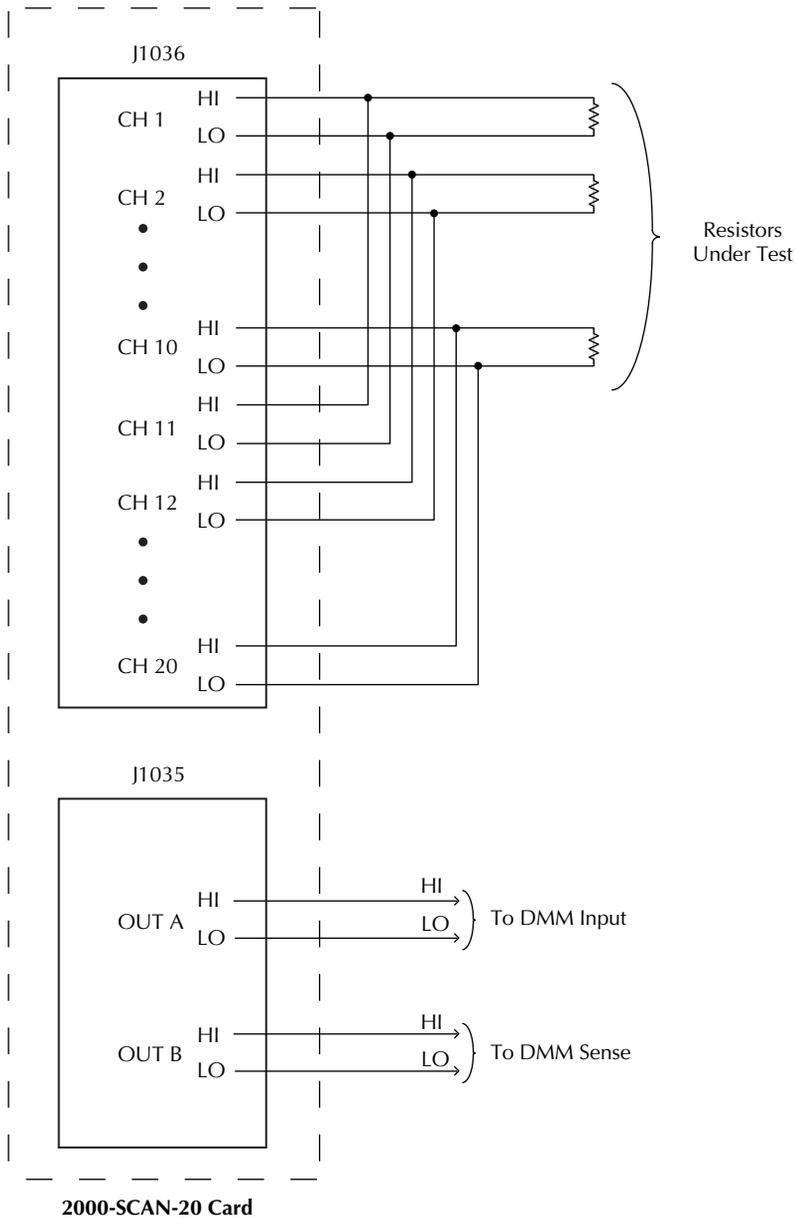
Figure 2-5
Typical connections for 2-wire resistance scanning



4-Pole connections

Typical 4-pole resistance connections are shown in Figure 2-6. This general configuration can be used with all channels to scan 4-wire resistance measurements.

Figure 2-6
Typical connections for 4-wire resistance scanning



Current measurements

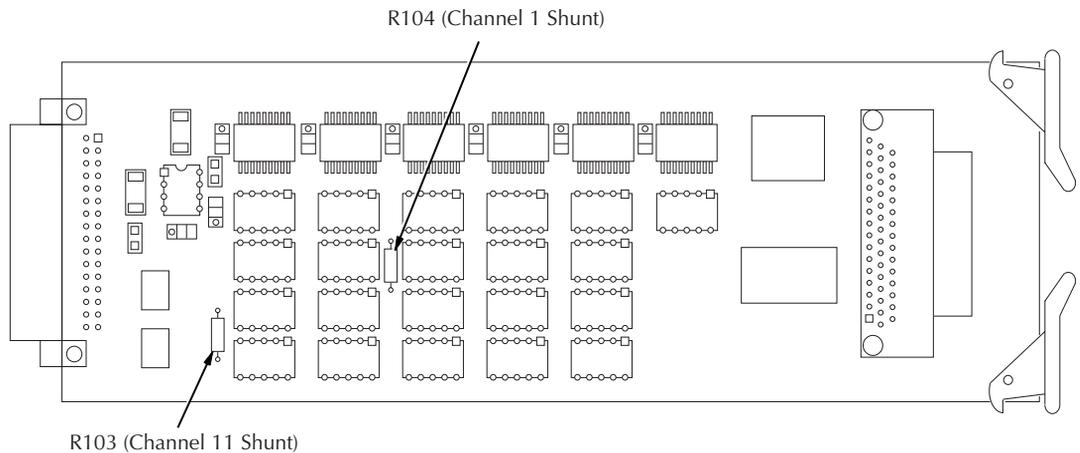
Current shunts can be installed on the circuit board to measure indirect AC and DC currents through channels 1 and 11 only. The following paragraphs discuss installing current shunts and the basic methods used to determine currents.

CAUTION Board-mounted current shunt resistors can be installed only for channels 1 and 11. A channel that has been modified with a current shunt resistor should not be used for voltage or resistance measurements.

Current shunt locations

Figure 2-7 shows the locations for the user-installable current shunts. Location R103 is for channel 11, and location R104 is for channel 1.

Figure 2-7
Current shunt locations



Recommended current shunt values

Hole spacing on the circuit board is intended for 1/10W resistors. The resistance value will depend on the current you intend to measure; 1k Ω resistors should be optimum for many applications. A 1k Ω resistor will allow you to switch currents up to 10mA without exceeding the power rating of the resistor.

For larger currents, decrease the shunt value. Conversely, the shunt value can be increased for smaller currents.

CAUTION Do not exceed the maximum card signal levels:

- DC signals: 60V DC, 0.5A switched, 30VA maximum.
- AC signals: 30V AC, 0.5A switched, 15VA maximum.

Board soldering and cleaning precautions

NOTE Failure to observe the following precautions may result in degraded card performance.

When soldering resistors, only touch areas associated with resistor installation and do not spread flux to other areas of the circuit board. Use solder with an OA (organic activated) flux. Thoroughly clean the circuit board with pure water after soldering to remove all contaminants. After cleaning with water, swab the area with pure methanol and allow the board to dry for several hours in a 50°C environment before use.

Current measurements

Even with the current shunts installed, you cannot make direct current measurements with the scanner card. Instead, you must close the channel to be measured and measure the voltage across the shunt. The current can then be calculated as follows:

$$I = V/R$$

Where: I = current being determined
V = voltage measured by multimeter
R = shunt resistance value

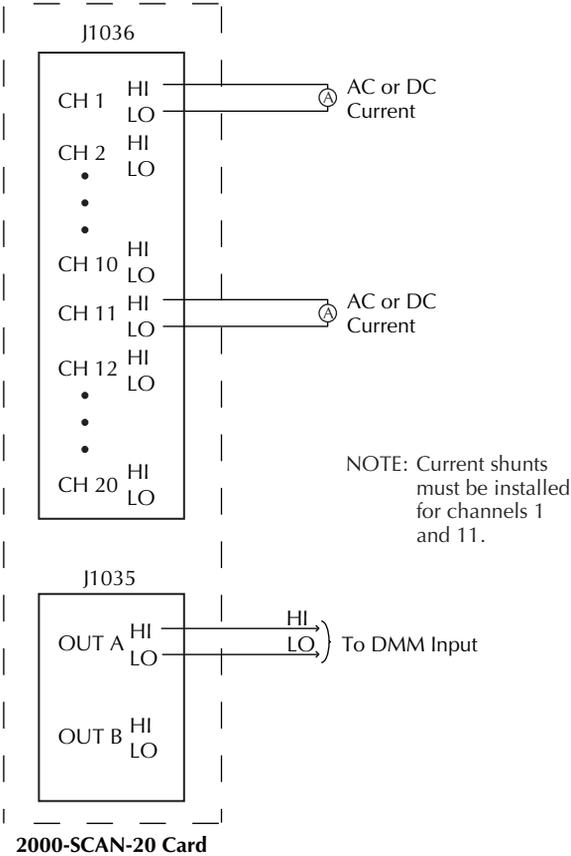
Instead of manually calculating current, set up a Model 2000-20 mX + b math calculation function. (Here, $m = 1/R$ and $b = 0$.) The multimeter will then display the actual current value. Refer to the multimeter manual for details on using math functions.

Current connections

Figure 2-8 shows typical connections for measuring currents using the Model 2000-SCAN-20 with current shunts installed. As noted previously, only channels 1 and 11 have current shunts installed. This configuration can be used to scan the following:

- DC current
- AC current

Figure 2-8
Current connections



Card installation and removal

This paragraph explains how to install and remove the Model 2000-SCAN-20 card assembly from the Model 2000-20 Multimeter.

WARNING Installation or removal of the Model 2000-SCAN-20 should be performed only by qualified service personnel. Failure to recognize and observe standard safety precautions could result in personal injury or death.

NOTE To prevent contamination to the scanner card that could degrade performance, handle the card assembly only by the card edges.

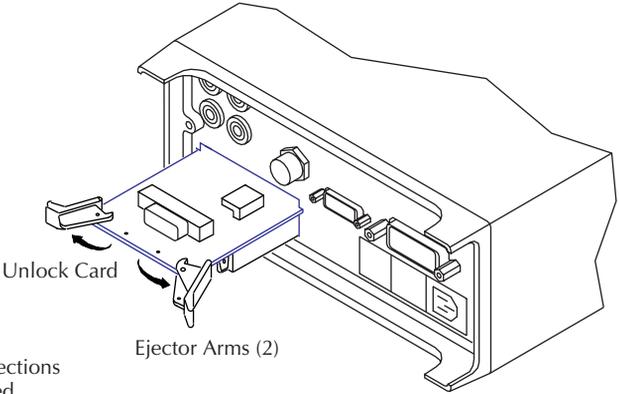
Scanner card installation

Perform the following steps and refer to [Figure 2-9](#) to install the card assembly in the multimeter:

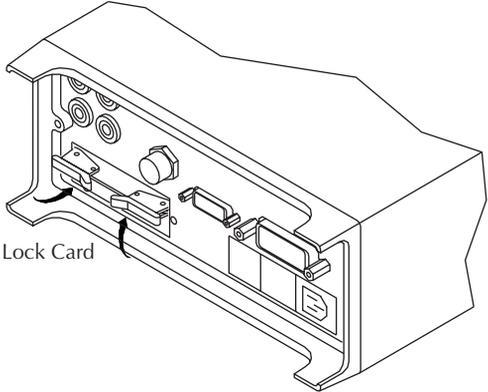
WARNING Turn off power to all instrumentation (including the multimeter) and disconnect all line cords. Make sure all power is removed and any stored energy in the external circuitry is discharged.

1. Pry out the two fasteners holding the OPTION SLOT cover plate to the rear panel of the multimeter. Remove the cover plate.
2. Slide the card edges, component side up, into the guide rails inside the multimeter.
3. With the ejector arms in the unlocked position, carefully push the card all the way forward until the arms engage the ejector clips. Push both arms inward to lock the card into the multimeter.
4. After installation, connect the output leads to the multimeter as discussed in the following paragraph.

Figure 2-9
Card installation



NOTE: Card connections are removed for clarity.



Output connections to multimeter

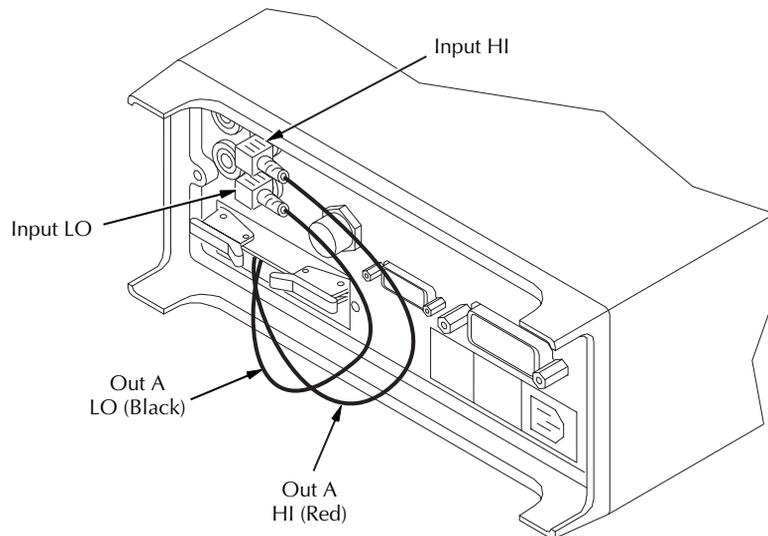
After installation, connect the scanner card output leads to the multimeter rear panel jacks as follows:

WARNING Signals applied to the front inputs of the multimeter cannot exceed the ratings of the scanner card as long as the scanner card output leads are connected to the multimeter rear panel input jacks.

For 2-pole operation, connect OUT A HI (red) to INPUT HI and connect OUT A LO (black) to INPUT LO. See [Figure 2-10](#).

NOTE Be sure to select the rear inputs with the multimeter front panel *INPUTS* switch when using the scanner.

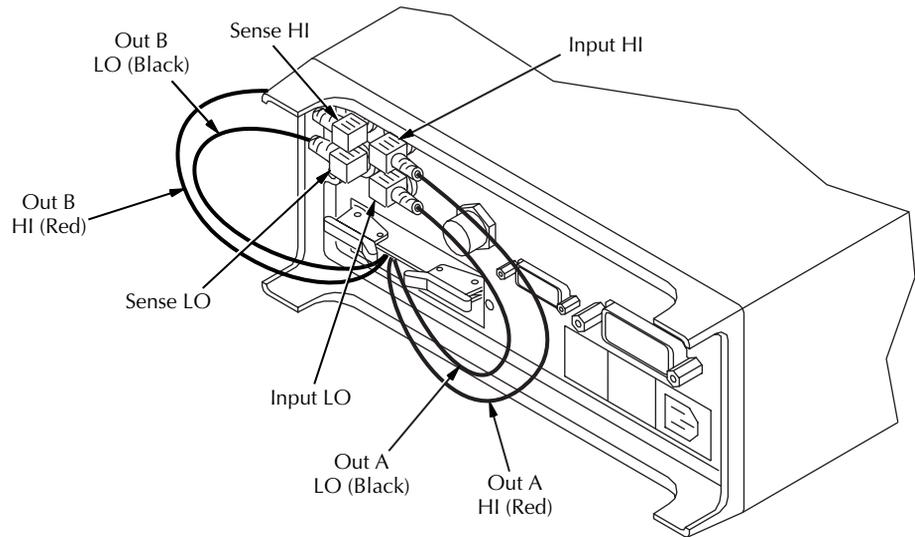
Figure 2-10
2-pole output connections



For 4-pole operation, connect OUT A HI (red) to INPUT HI and connect OUT A LO (black) to INPUT LO. Also connect OUT B HI (red) to SENSE HI and connect OUT B LO (black) to SENSE LO. See Figure 2-11.

NOTE Be sure to select the rear inputs with the multimeter front panel INPUTS switch when using the scanner.

Figure 2-11
4-pole output connections



Scanner card removal

Perform the following steps to remove the scanner card from the multimeter:

WARNING Turn off power to all instrumentation (including the multimeter) and disconnect all line cords. Make sure all power is removed and any stored energy in the external circuitry is discharged.

1. Unlock the card by pulling the ejector arms outward.
2. Carefully slide the card out of the multimeter.
3. Install the cover plate over the OPTION SLOT and secure with the two fasteners if the multimeter is to be operated without the scanner card installed.

3 Operation

Introduction

This section contains detailed information on front panel and IEEE-488 bus operation of the Model 2000-SCAN-20. The information in this section is organized as follows:

- **Signal limitations** — Summarizes the maximum signals that can be applied to the Model 2000-SCAN-20.
- **Scanner card detection** — Discusses how the multimeter detects a scanner card and how to use a bus command to determine whether or not a card is installed in the multimeter and identify the type of card.
- **Model 2000 multimeter front panel scanner controls and SCPI bus scanner commands** — Gives an overview of the Model 2000-20 Multimeter front panel controls and corresponding IEEE-488 bus commands used to control the scanner card.
- **SCPI scanner commands** — Summarizes the bus commands necessary to control the scanner card using the Model 2000-20 Multimeter.
- **Typical applications** — Discusses typical applications for the Model 2000-SCAN-20.
- **Measurement considerations** — Discusses a number of measurement considerations to take into account when using the scanner.

NOTE Before using the Model 2000-SCAN-20 scanner card, you should be thoroughly familiar with the operation of the multimeter. See the multimeter manual for details.

Signal limitations

CAUTION To prevent damage to the Model 2000-SCAN-20, do not exceed the maximum signal level specifications of the card.

Relay input signal limitations

Channels 1 through 20 are all relay inputs. To prevent overheating or damage to the relays, never exceed the following maximum signal levels for these channels:

DC signals: 60V DC, 0.5A switched, 30VA (resistive load).

AC signals: 30V rms or 42.4V AC peak, 0.5A switched, 15VA (resistive load).

NOTE Model 2000-SCAN-20 is limited to non-hazardous voltages only.

Scanner card detection

Power-up detection

The scanner card is detected only at power-on. If the card is plugged in after the power is turned on, the multimeter will not recognize the presence of the card.

CAUTION **Plugging in the scanner card with power turned on may result in damage to both the Model 2000-SCAN-20 and the multimeter.**

If the card is not present at power-on, scanner bus commands or queries will generate a “Missing hardware error,” and front panel operations pertaining to the scanner will inform you that no scanner is present.

Scanner option bus query

*OPT? is an IEEE 488.2 common query that determines whether or not a scanner card is installed. Also, the Model 2000-20 multimeter can distinguish between a Model-2000-SCAN 10-channel card and the Model-2000-SCAN-20 20-channel card. The response to this query is as follows:

- 0: Scanner not installed.
- 0,10CH: Model 2000-SCAN 10-channel card installed.
- 0,20CH: Model 2000-SCAN-20 20-channel card installed.

Refer to the multimeter manual for more details on using the *OPT? query.

Model 2000-20 multimeter front panel scanner controls and SCPI scanner commands

The following paragraphs give an overview of the various Model 2000-20 Multimeter front panel controls and corresponding IEEE-488 SCPI bus commands used with the Model 2000-SCAN-20.

Closing channels

Front panel

Use the front panel CLOSE key to close specific channels as follows:

1. From the normal display, press the CLOSE key. The instrument will display the following:

```
CLOSE CHAN: 01
```

2. Use the ◀, ▶, ▲, and ▼ keys to select the channel you wish to close and press ENTER.

If the channel number is between 1 and 10, the closed channel will display on the front panel along with the normal readings. Selecting a different channel from the one presently closed will cause the closed channel to open and allow a settling time before closing the selected channel.

NOTE For channels 11 through 20, more than one channel annunciator is lit. For example, CH1 and CH10 are lit for channel 11, and CH1, CH9, and CH10 are lit for channel 20.

3. The ◀ and ▶ keys alone will also close the channels. Press the ◀ and ▶ keys until the channel annunciator you want to close appears on the display.

Remote interface

Use the :ROUTe:CLOSE command to close the desired channel. For example, if you wish to close channel 4, use the following command:

```
PRINT #1, "output 16; :route:close (@4)"
```

Use the :ROUTe:MULTiple:CLOSE command to close multiple channels. For example, if you wish to close channels 1, 3, and 5, use the following command:

```
PRINT #1, "output 16; :route:multiple:close (@1,3,5)"
```

NOTE Closing channel 21 selects the 4-pole operating mode.

Opening channels

Front panel

Use the front panel OPEN key to open all the card channels.

Remote interface

Use the :ROUTe:OPEN:ALL command to open all the channels. The command is as follows:

```
PRINT #1, "output 16; :route:open:all"
```

Use the :ROUTe:MULTiple:OPEN command to open specified channels. For example, if you want to open channels 1, 3, and 5, use the following command:

```
PRINT #1, "output 16; :route:multiple:open (@ 1,3,5)"
```

NOTE Opening channel 21 selects the 2-pole operating mode.

Selecting measurement function

Use the following procedure to select a specific measurement function for an internal channel:

1. Use the ◀ and ▶ keys to select the desired channel.
2. Select the desired measurement function with the keys on the front panel. The various measurement functions available are:

DCV: DC volts

ACV: AC volts

Ω2W: 2-wire ohms

Ω4W: 4-wire ohms

(channels 1 through 10)

FREQ: frequency

PERIOD: period

TEMP: simulated temperature

CONT: continuity

: diode test

Configuring scan parameters

This paragraph details how to select internal scanning and how to configure the scan parameters.

Front Panel

Use the SHIFT-CONFIG keys to select the scan type and configure the scan parameters.

1. Press SHIFT and then CONFIG. The instrument will display the following prompt for internal scanning:

TYPE: I20

Use the ▲ or ▼ key if EXT is displayed and press ENTER.

2. The following message will display:

MIN CHAN: 01

Use the ▲ and ▼ keys to select the channel at which the scanning will begin and press ENTER.

3. The unit will display the following message:

MAX CHAN: 20

Use the ◀, ▶, ▲, and ▼ keys to select the channel at which the scanning will stop and press ENTER.

4. The instrument will display the following message:

TIMER? OFF

Use the ◀ or ▶ key to select the ON option if desired and press ENTER. Select the scan time when prompted and press ENTER:

00H:00M:01.000S

5. The unit will display the following message:

RDG CNT: 0020

Use the ◀, ▶, ▲, and ▼ keys to select the desired number of readings from the selected list to be taken and stored by the instrument and press ENTER.

The instrument will store in memory the number of readings specified with RDG CNT. After the scanning has been completed, you can access these readings by pressing the RECALL key on the front panel and using the ◀, ▶, ▲, and ▼ keys to scroll through the stored readings.

6. The following options start the scanning process:

STEP — Pressing the STEP key on the front panel will direct the instrument to begin scanning at channel 1 and scan the number of channels specified with RDG CNT. It will store the same number of readings.

TRIG — Pressing the TRIG key on the front panel will direct the instrument to begin scanning at the present channel setting and scan the number of channels specified with RDG CNT. It will store the same number of readings.

SCAN — Pressing the SCAN key on the front panel will direct the instrument to scan through the channels specified with MIN CHAN and MAX CHAN and store the number of readings specified by RDG CNT.

7. Pressing EXIT will clear the current readings and reset the channel to channel 1.

Remote interface

Use the :ROUTE:SCAN:LSElect command to select internal or external scanning. For example, to select internal scanning, use the following command:

```
PRINT #1, "output 16; :route:scan:lselect internal"
```

If you have selected internal scanning, use the following command to set the list of channels to be scanned:

```
PRINT #1, "output 16; :route:scan[:internal] (@scan list) "
```

For example, to scan channels 1 through 20 inclusively, use the following command:

```
PRINT #1, "output 16; :route:scan[:internal] (@1:20) "
```

SCPI scanner commands

Table 3-1 summarizes commands that control scanner operations over the remote interface. For more detailed information on these and other bus commands, refer to the multimeter manual.

Table 3-1
Summary of SCPI scanner commands

Command	Description
:ROUte	Route subsystem.
:CLOSE <list>	Close channels.
:STATe?	Return all closed channels.
:OPEN ALL	Open channels.
:ALL	Open any closed channels.
:MULTiple	Multiple channel commands:
:CLOSE <list>	Close specified channels (1 through 20).
:STATe?	Query closed channels.
:OPEN <list>	Open specified channels.
:SCAN	Scanning commands.
[:INTernal] <scan list>	Program internal scan list.
:EXTernal <scan list>	Program external scan list.
:LSElect NONE INTernal EXTernal	Select scan list.
[[:SENSe[1]]	Sense subsystem.
:FUNCTion <function list>	Select measurement function.

Notes:

1. The :ROUT:SCAN:LSEL command is coupled to the :ROUT:SCAN:INT command. When the :ROUT:SCAN:INT command is executed, the :ROUT:SCAN:LSEL parameter will be set to INTernal.
2. Uppercase letters indicate short form of commands.
3. Brackets indicate optional command and should not be used when sending commands to instrument.
4. When sending SCPI commands, be sure to include a space character between each command and parameter.

Typical applications

Resistor testing

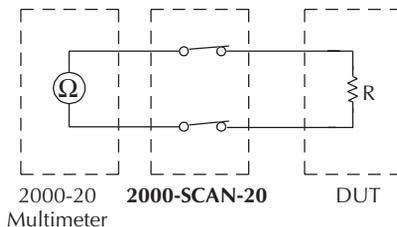
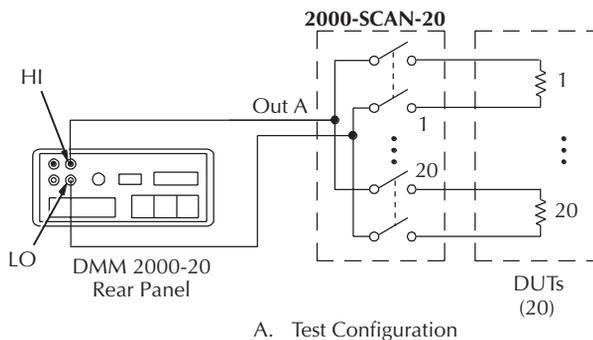
The Model 2000-SCAN-20 can be used to test up to 20 resistors using 2-wire measurements or up to ten resistors using 4-wire measurements. Such tests use the Model 2000-20 $\Omega 2$ and $\Omega 4$ resistance functions.

2-wire resistance tests

Figure 3-1 shows a typical test setup for making 2-wire resistance measurements. The Model 2000-SCAN-20 card provides the switching function, while the Model 2000-20 Multimeter makes the resistance measurements. Since only 2-pole switching is required for this application, one Model 2000-SCAN-20 card can be used to switch up to 20 resistors.

Measurement accuracy can be optimized by minimizing residual resistance: make connecting wires as short as possible and limit the number of connectors to minimize path resistance. Another technique is to short one of the scanner channel inputs, close the shorted channel, and enable the multimeter REL feature to null out path resistance. Leave REL enabled for the entire test.

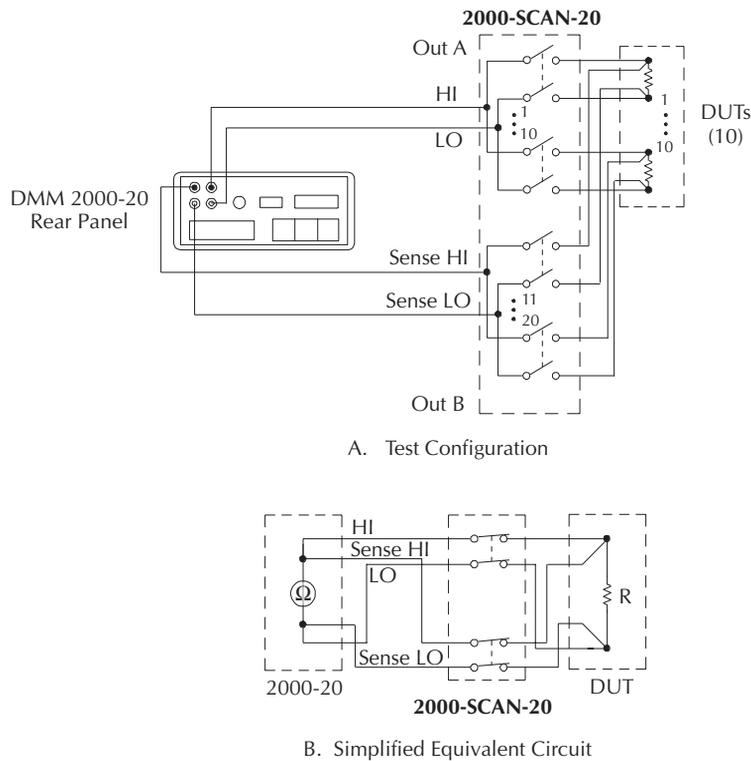
Figure 3-1
2-wire resistance test connections



4-wire resistance tests

More precise measurements over a wider range of system and DUT conditions can be obtained using the 4-wire measurement scheme shown in [Figure 3-2](#). Here, separate sense leads from the Model 2000-20 Multimeter are routed through the scanner to the resistor under test. The extra set of sense leads minimizes the effects of voltage drops across the test leads, greatly reducing measurement errors with lower DUT resistances. Note, however, that an extra two poles of switching are required for each resistor tested. For this reason, only ten resistors can be tested using this configuration.

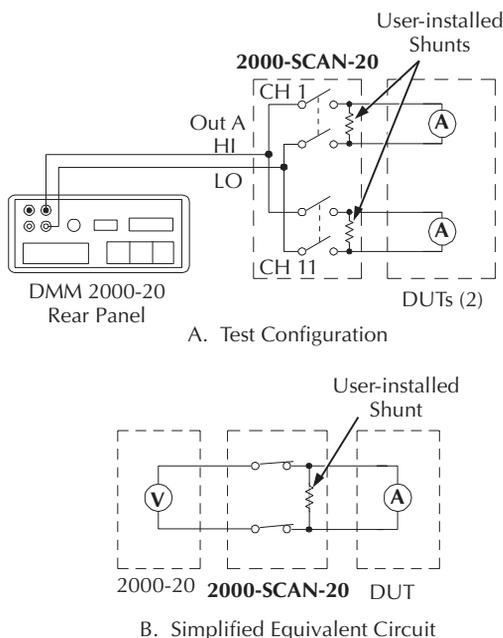
Figure 3-2
4-wire resistance test connections



Current measurements

Although the Model 2000-SCAN-20 is not intended for direct current measurements, on-card shunt resistors can be installed for channels 1 and 11 to allow for indirect current measurements. [Figure 3-3](#) shows the typical configuration for current measurements. Refer to [Section 2](#) of this manual for specific information on recommended shunt resistors and their installation.

Figure 3-3
Connections for current measurements



The current through each shunt resistor can be calculated as follows:

$$I = V/R$$

Where: I = current being determined

V = voltage measured by multimeter

R = shunt resistance value

Instead of manually calculating current, set up a Model 2000-20 $mX + b$ math calculation function. (Here, $m = 1/R$ and $b = 0$). The multimeter will then display the actual current value. Refer to the multimeter manual for details on using math functions.

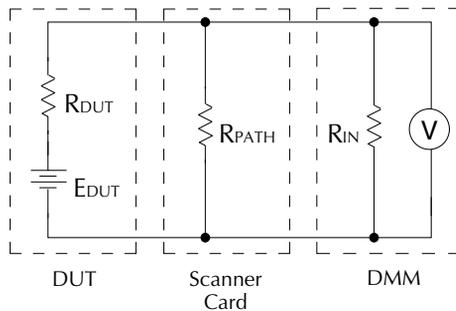
Measurement considerations

Many measurements made with the Model 2000-SCAN-20 are subject to various effects that can seriously affect low-level measurement accuracy. The following paragraphs discuss these effects and ways to minimize them.

Path isolation

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

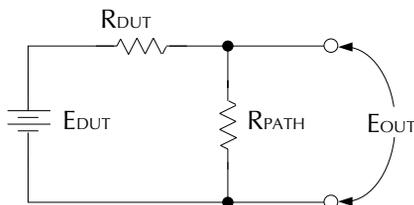
Figure 3-4
Path isolation resistance



- R_{DUT} = Source Resistance of DUT
- E_{DUT} = Source EMF of DUT
- R_{PATH} = Path Isolation Resistance
- R_{IN} = Input Resistance of Multimeter

Path isolation resistance forms a signal path that is in parallel with the equivalent resistance of the DUT, as shown in [Figure 3-4](#). For low-to-medium device resistance values, path isolation resistance is seldom a consideration; however, it can seriously degrade measurement accuracy when testing high-impedance devices. The voltage measured across such a device, for example, can be substantially attenuated by the voltage divider action of the device source resistance and path isolation resistance, as shown in [Figure 3-5](#). Also, leakage currents can be generated through these resistances by voltage sources in the system.

Figure 3-5
Voltage attenuation by path isolation resistance



$$E_{OUT} = \frac{E_{DUT} R_{PATH}}{R_{DUT} + R_{PATH}}$$

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 scanning system. If the conductor has sufficient length, even weak magnetic fields like those of the earth can create sufficient signals to affect low-level measurements. Two ways to reduce these effects are: (1) reduce the lengths of the test leads, and (2) minimize the exposed circuit area. In extreme cases, magnetic shielding may be required. Special metal with high permeability at low flux densities (such as mu metal) is 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.

Electromagnetic interference (EMI)

The electromagnetic interference characteristics of the Model 2000-20 Multimeter comply with the electromagnetic compatibility (EMC) requirements of the European Union (EU) directives as denoted by the CE mark. However, it is still possible for sensitive measurements to be affected by external sources. In these instances, special precautions may be required in the test setup.

Sources of EMI include:

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

The instrument, measurement leads, and other cables should be kept as far away as possible from any EMI sources. Shielding measurement leads and the multimeter may reduce EMI to acceptable levels. In extreme cases, a specially constructed screen room may be required to sufficiently attenuate troublesome signals.

Many instruments incorporate internal filtering that may help reduce EMI effects. In some cases, additional external filtering may be required. Keep in mind, however, that filtering may have detrimental effects on the measurement.

Ground loops

When two or more instruments are connected together, care must be taken to avoid unwanted signals caused by ground loops. Ground loops usually occur when sensitive instrumentation is connected to other instrumentation with more than one signal return path such as power line ground. As shown in [Figure 3-6](#), 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 3-6
Power line ground loops

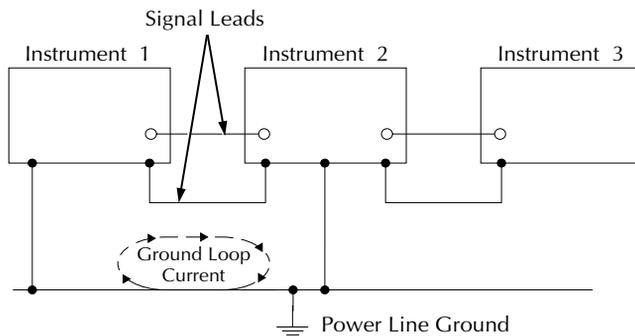
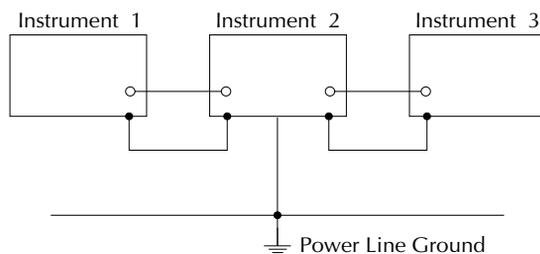


Figure 3-7 shows how to connect several instruments together to eliminate this type of ground loop problem. Here, only one instrument is connected to power line ground. Ground loops are not normally a problem with instruments having isolated LO terminals. However, all instruments in the test setup may not be designed in this manner. When in doubt, consult the manual for all instrumentation in the test setup.

Figure 3-7
Eliminating ground loops



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 connector insulation becomes contaminated, the insulation resistance will be substantially reduced, affecting high-impedance measurement paths. Oils and salts from the skin can contaminate connector insulators, reducing their resistance. Also, contaminants present in the air can be deposited on the insulator surface. To avoid these problems, never touch the connector insulating material. In addition, only use the scanner card in clean, dry environments to avoid contamination.

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

4 Service Information

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

Introduction

This section contains information necessary to service the Model 2000-SCAN-20 scanner card and is arranged as follows:

- **Handling and cleaning precautions** — Discusses handling precautions and methods to clean the card should it become contaminated.
- **Performance verification** — Covers the procedures necessary to determine if the scanner card meets stated specifications.
- **Special handling of static-sensitive devices** — Reviews precautions necessary when handling static-sensitive devices.
- **Principles of operation** — Briefly discusses circuit operation.

Handling and cleaning precautions

Because of the high-impedance areas on the Model 2000-SCAN-20, take care when handling or servicing the card to prevent possible contamination. The following precautions should be observed when servicing the card.

Handling precautions

- Handle the card only by the side edges.
- Do not touch any board surfaces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- When servicing the card, wear clean cotton gloves.
- 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.

Soldering precautions

Should it become necessary to use solder on the circuit board, observe the following precautions:

- Use an OA-based (organic activated) flux and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean cotton swabs or a clean, soft brush to remove the flux.
- Once the flux has been removed, swab only the repaired area with methanol and then blow dry the board with dry nitrogen gas.
- After cleaning, allow the card to dry in a 50°C low-humidity environment for several hours before use.

Performance verification

The following paragraphs discuss performance verification procedures for the Model 2000-SCAN-20, including path resistance, contact potential, and isolation.

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

Failure of any performance verification test may indicate that the scanner card is contaminated. See “Handling and cleaning precautions” in this section for information on cleaning the card.

Environmental conditions

Make all verification measurements at an ambient temperature between 18° and 28°C and at a relative humidity of less than 70%.

Recommended equipment

Table 4-1 summarizes the equipment necessary for performance verification and the application for each item.

Table 4-1
Recommended verification equipment

Description	Model/part	Specifications	Application
Multimeter	Keithley 2000-20	100Ω; 100ppm of reading; 40ppm of range	Control card, measure path resistance
Electrometer with voltage source	Keithley 6517A	20pA, 200pA; 1.0% 100V source; 0.15%	Path isolation
Sensitive Digital Voltmeter	Keithley 182	3mV; 60ppm	Contact potential
Triax cable (unterminated)	Keithley 7025	—	Path isolation
Low-thermal cable	Keithley 1484	—	Contact potential
#22AWG solid copper wire	—	—	Path resistance
#22AWG Teflon-insulated stranded wire	—	—	Path isolation
Triax adapter (3-slot male to 2-lug female)	Keithley 6171	—	Path isolation

Path resistance tests

Perform the following steps to verify that the path resistance of each channel is within the specified values.

NOTE *To perform this test, you must custom-wire a cable to connect to the scanner card connections.*

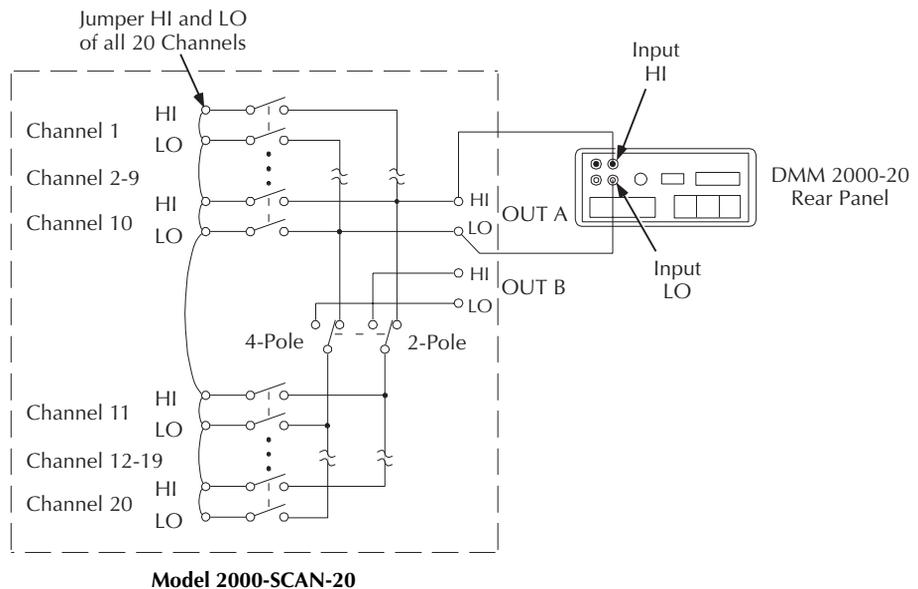
1. Connect the HI and LO inputs of all 20 channels together to make one common input using #22AWG solid copper jumper wires (Figure 4-1).

NOTE *Make sure all jumper wires are clean and free of oxides.*

2. Connect the output cables to OUT A HI and LO as shown in Figure 4-1.
3. With the power off, install the scanner card in a Model 2000-20 Multimeter.

4. Turn on the multimeter and allow it to warm up for one hour before proceeding.
5. Select the $\Omega 2W$ function and the 100Ω range on the multimeter.
6. Temporarily connect a second set of output leads, identical in length and type to the leads connected to the scanner card output, to the multimeter rear panel HI and LO INPUT jacks. Be sure to select the rear panel terminals with the front panel INPUT switch.
7. Short the free ends of the temporary leads together and allow the reading to settle. Enable the multimeter REL mode after settling, and leave REL enabled for the remainder of the path resistance tests.
8. Disconnect the temporary leads from the multimeter, and connect the output leads from the scanner card to the rear panel HI and LO INPUT jacks (Figure 4-1).
9. Program the multimeter to close channel 1.
10. Note the resistance reading on the multimeter. Verify that the reading is $<2\Omega$.
11. Repeat steps 9 and 10 for channels 2 through 20. Verify that the path resistance for each channel is $<2\Omega$.
12. After completing the tests, turn off the multimeter power, remove the scanner card, and remove all jumper wires. (Leave HI and LO shorted for each channel if you intend to perform contact potential tests.)

Figure 4-1
Connections for path resistance checks



Contact potential tests

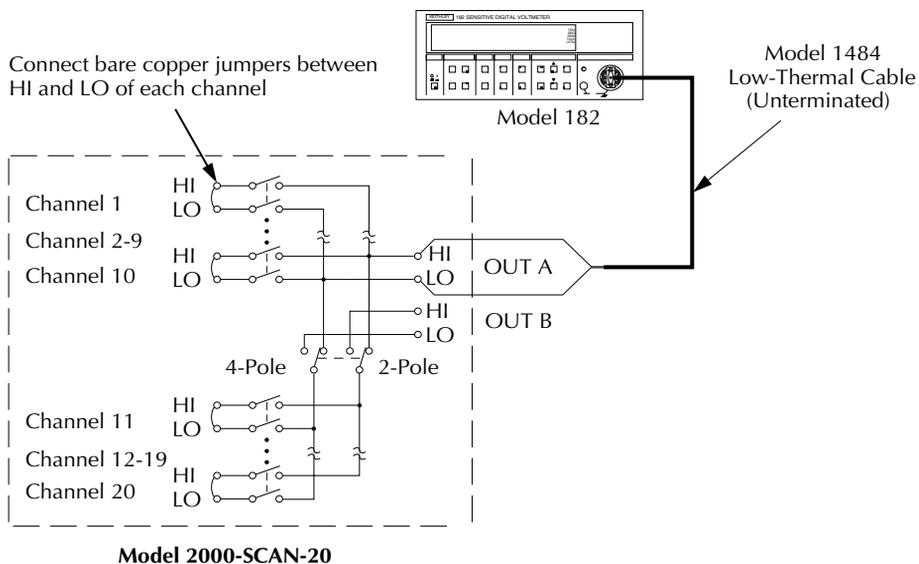
These tests check the EMF (contact potential) generated by each relay contact pair (HI and LO) for each channel. The tests use a sensitive digital voltmeter (Model 182) to measure the contact potential.

Perform the following procedure to check contact potential of each channel.

NOTE To perform this test, you must custom-wire a cable to connect to the scanner card connections.

1. Connect 1 in. #22AWG bare copper jumper wires between the HI and LO inputs of each channel (Figure 4-2).
2. Connect the Model 182 Sensitive Digital Voltmeter to OUT A HI and LO using the low-thermal cable (Figure 4-2).
3. With the power off, install the scanner card in the Model 2000-20 Multimeter.
4. Turn on the multimeter and the voltmeter. Allow the voltmeter to warm up for two hours before taking measurements.
5. Select the 3mV range on the voltmeter.
6. Select the DCV function on the multimeter.
7. Program the multimeter to close channel 1.
8. Verify that the voltmeter reading is $<2\mu\text{V}$.
9. Repeat steps 7 and 8 for all 20 channels.
10. After completing all measurements, turn off the multimeter power, remove the scanner card, and disconnect all jumpers and test leads.

Figure 4-2
Connections for contact potential tests



Isolation tests

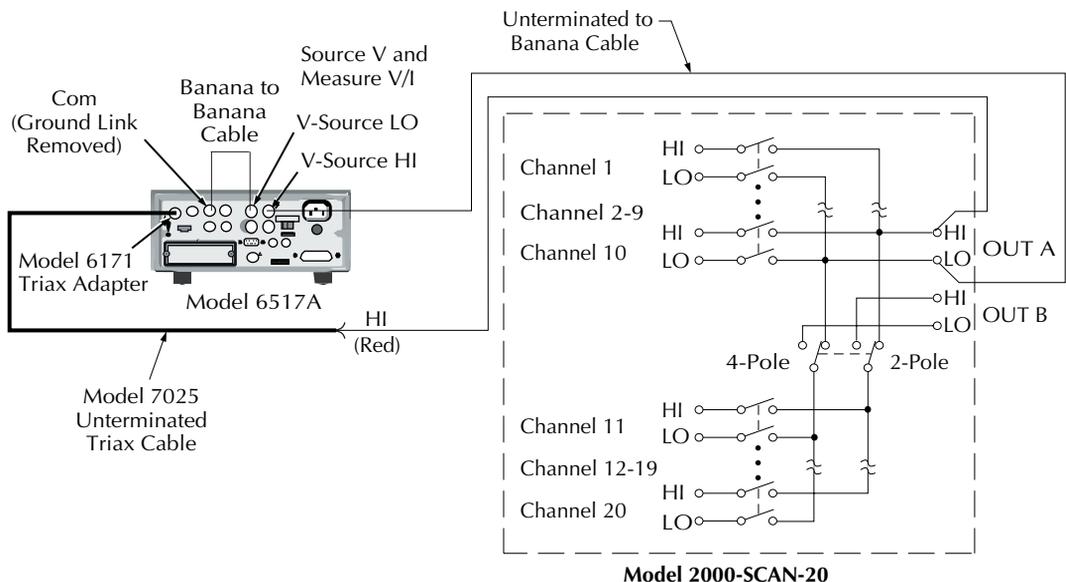
These tests check the leakage resistance (isolation) between all HI and LO inputs for each channel and from the HI and LO inputs to chassis ground. In general, the test is performed by applying a voltage (60V) across the connections and then measuring the leakage current. The isolation resistance is then calculated as $R = V/I$. In the following procedure, the Model 6517A Electrometer functions as a voltage source and as an ammeter. In the R function, the electrometer internally calculates the resistance from the known voltage and current levels and displays the resistance value.

Perform the following steps to check isolation:

NOTE To perform this test, you must custom-wire a cable to connect to the scanner card connections.

1. Turn off the Model 2000-20 Multimeter if it is on and remove the scanner card.
2. Remove any jumpers or test leads connected to the card.
3. Turn on the Model 6517A Electrometer and allow the unit to warm up for two hours before testing.
4. Connect a 4 in. length of Teflon-insulated #22AWG stranded wire to every HI and LO input and output on the scanner card (connectors J1035 and J1036). Mark the free end of each wire so you can identify the wires when the scanner card is installed.
5. With the power off, install the scanner card in the multimeter.
6. Connect the electrometer to OUT A HI and LO of the scanner card as shown in Figure 4-3.

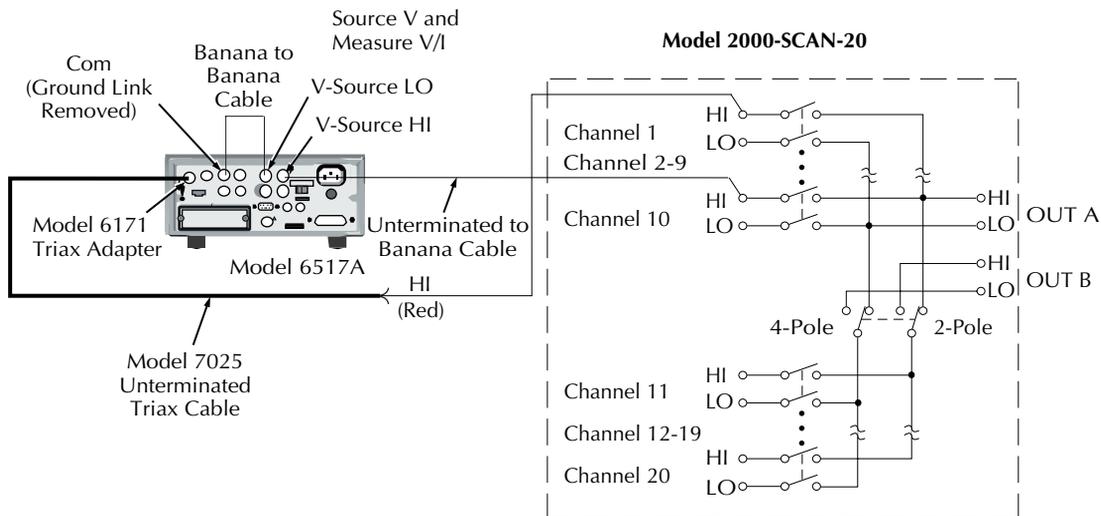
Figure 4-3
Connections for same-channel isolation tests



WARNING The following steps use a 60V. Be sure to remove power from the circuit before making connection changes.

7. Place the electrometer in the R measurement function.
8. Turn on the multimeter power.
9. Program the multimeter to close channel 1.
10. On the electrometer, source 60V.
11. After allowing the reading on the electrometer to settle, verify that the reading is $>100\text{M}\Omega$ ($10^8\Omega$). This measurement represents the isolation resistance between channel 1 HI and LO.
12. Turn off the electrometer voltage source.
13. Repeat steps 9 through 12 for channels 2 through 20. Be sure the channel under test is closed.
14. Turn off the multimeter power.
15. With the Model 6517A Electrometer voltage source off, connect the electrometer to channel 1 HI and channel 2 HI as shown in Figure 4-4.

Figure 4-4
Connections for channel-to-channel isolation tests



16. Turn on the Model 2000-20 Multimeter power.
17. Program the multimeter to close channel 1.
18. On the electrometer, source 60V.
19. After allowing the reading on the electrometer to settle, verify that the reading is $>100\text{M}\Omega$ ($10^8\Omega$). This measurement represents the isolation resistance between channel 1 HI and channel 2 HI.
20. Turn off the electrometer voltage source.

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 To prevent damage, assume all parts are static-sensitive.

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

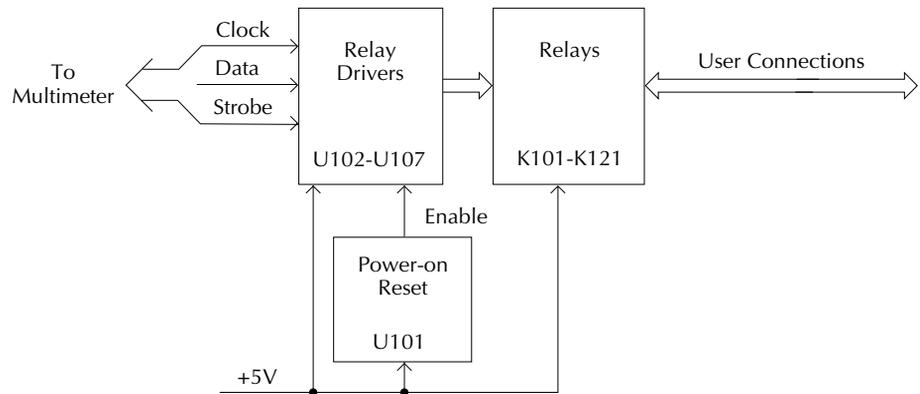
Principles of operation

The following paragraphs discuss the basic operating principles for the Model 2000-SCAN-20 and can be used as an aid in troubleshooting the card. The schematic drawing of the card is shown on drawing number 2000-186 located at the end of [Section 5](#).

Block diagram

[Figure 4-6](#) shows a simplified block diagram of the Model 2000-SCAN-20. Key elements include the relay drivers, relays, and power-up reset circuit. These various elements are discussed in the following paragraphs.

Figure 4-6
Block diagram



Relay control

Card relays are controlled by serial data transmitted via the relay DATA line. A total of six bytes are shifted in serial fashion into latches located in the card relay driver ICs. The serial data is clocked in by the CLOCK line. As data overflows one register, it is fed out the Q's line of the register down the chain.

Once all six bytes have shifted into the card, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate relays are energized (assuming the driver outputs are enabled as discussed below). Note that a relay driver output goes low to energize the corresponding relay.

Switching circuits

Relays K101 through K105 and K107 to K121 perform input switching, while K106 configures the card for 2-pole or 4-pole operation.

Power-on safeguard

A power-on safeguard circuit, made up of U101 and associated components, ensures that relays do not change state on power-up and power-down. This circuit disables all relay actuation during power-up and power-down periods by holding the OE (output enable lines) high during these periods.



5 Replaceable Parts

Introduction

This section contains replacement parts information, schematic diagram, and component layout drawing for the Model 2000-SCAN-20.

Parts list

A parts list for the scanner card is included in a table integrated with a schematic diagram and component layout drawing for the board. Parts are listed alphabetically in order of circuit designation.

Ordering information

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

- Card model number (2000-SCAN-20)
- Card serial number
- Part description
- Circuit description, if applicable
- Keithley part number

Factory service

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

- Call the Instruments Division Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual and include it with the card.
- Carefully pack the card in the original packing carton.
- Write ATTENTION REPAIR DEPT and the RMA number on the shipping label.

NOTE *It is not necessary to return the Model 2000-20 Multimeter with the card.*

Component layout and schematic diagram

A component layout drawing and schematic diagram are included on the following pages integrated with the parts list (Table 5-1) for the Model 2000-SCAN-20.

Table 5-1

Model 2000-SCAN-20 parts list

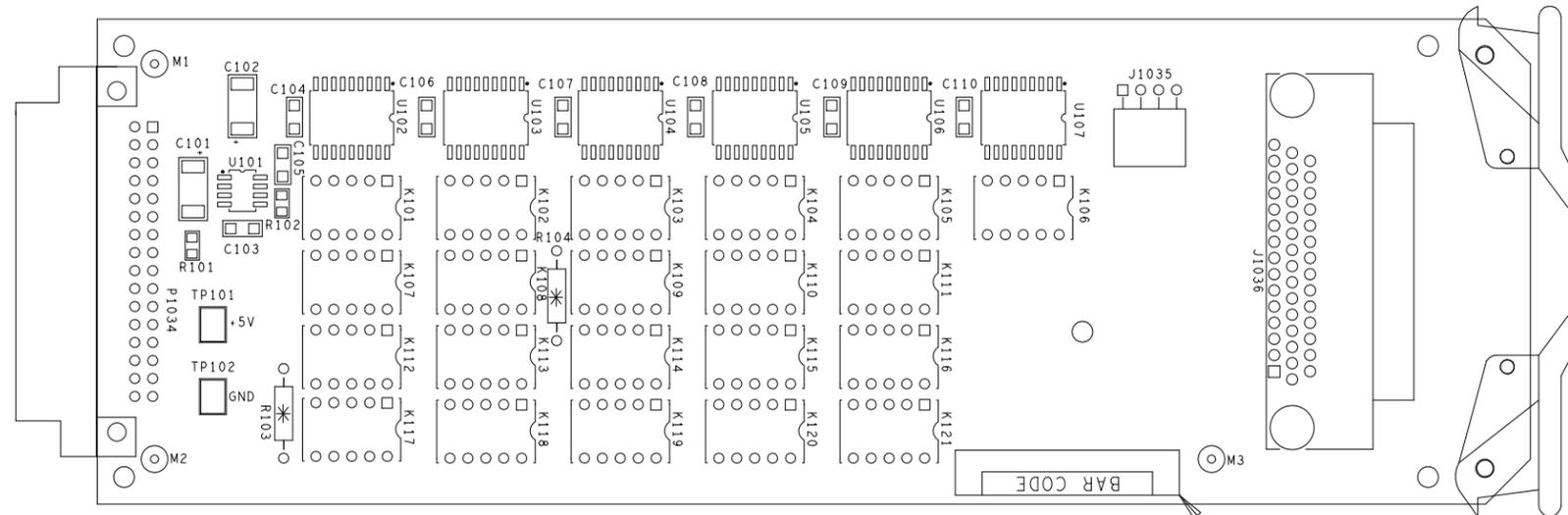
Circuit desig.	Description	Keithley part no.
	4-40 Pem Nut	FA-131
	4-40 x 5/16 Phillips Pan Head Screw	4-40x5/16PPH
	Card Ejector	FA-237
	Crimp Housing	CS-1018-1
	Crimp Terminal, Female	CS-1019-1
	Latching Block	FA-304
	Sleeved Banana Plug Test Lead	CA-109A
C101	CAP, 100 μ F, 20%, 16V, TANTALUM (7243)	C-504-100
C102	CAP, 10 μ F, 20%, 25V, TANTALUM (D7243)	C-440-10
C103-110	CAP, .1 μ F, 20%, 50V, CERAMIC (1206)	C-418-.1
J1035	CONN, RT ANGLE HEADER	CS-1017-1
J1036	CONN, RT ANGLE	CS-967-2
K101-121	RELAY, MINIATURE (DPDT) TQ2E-L2-5V	RL-155
P1034	CONN, FEMALE DUAL 16-PIN	CS-455
R101	RES, 4.75K, 1%, 100MW, THICK FILM (0805)	R-418-4.75K
R102	RES, 1K, 1%, 100MW, THICK FILM (0805)	R-418-1K
U101	IC, SUPPLY VOLT SUPERVISOR, TL7705A (SOIC)	IC-860
U102-107	IC, 8 STG/SHFT/STR REG, UCN5841LW (SOLIC)	IC-857

081-0002

ON

LTR.	ECA NO.	REVISION	ENG.	DATE
A	20792R	RELEASED	SZ	11/26/97
B	21455	DEL. .5X.325 ROUTE; ADD .125 DIA.; HOLE; DEL. (2) .125NP HOLES	SZ	12/10/98
B1	26875	ADDED MC-285	MAH	2/19/02

PRIMARY SIDE COMPONENTS (SIDE -02)

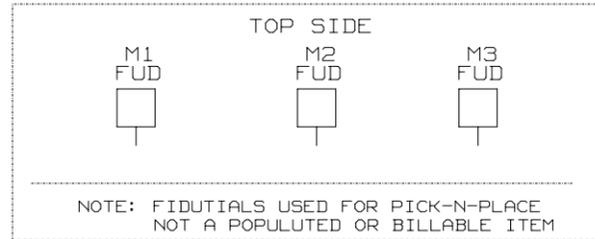
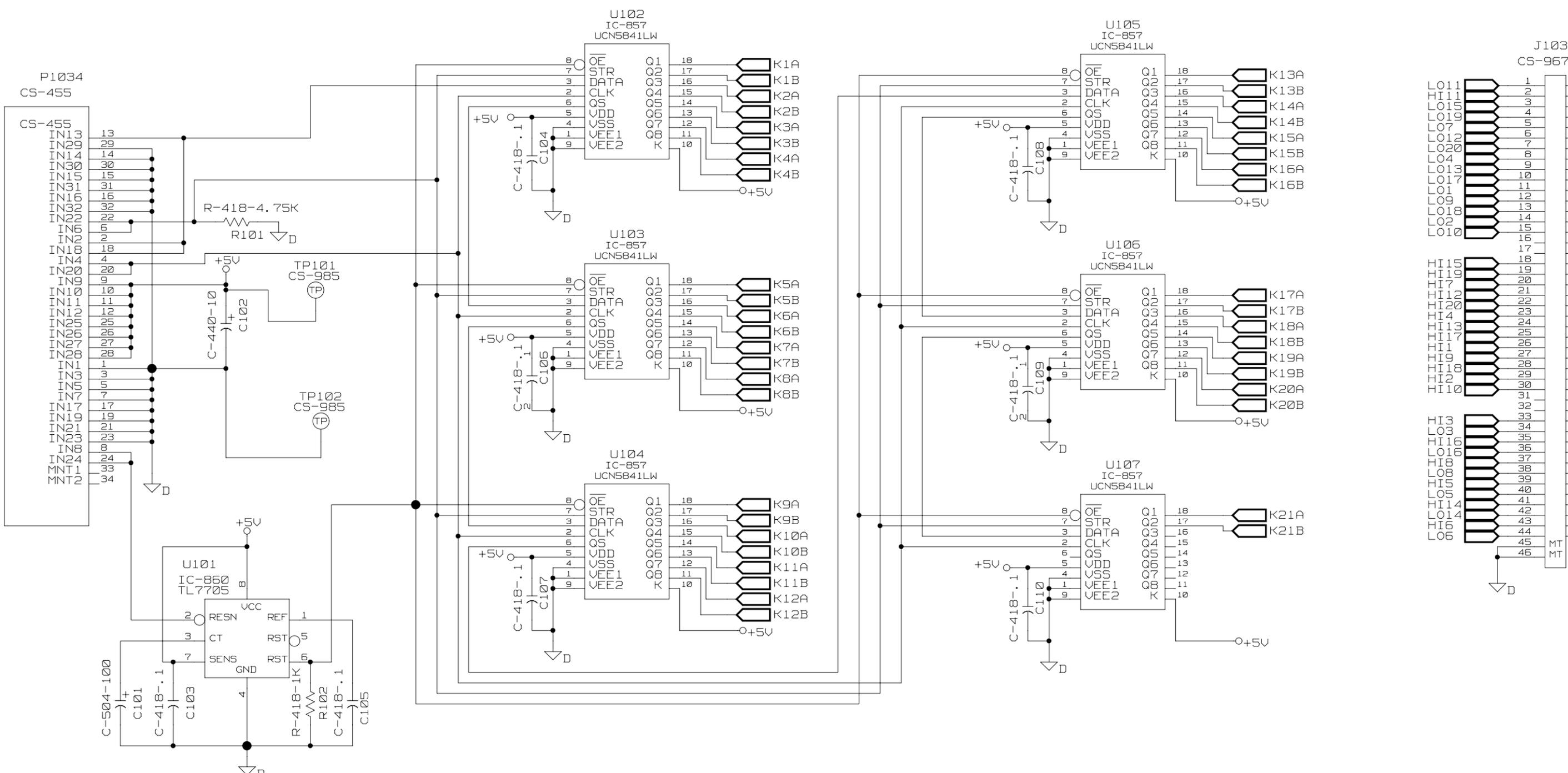


*DO NOT POPULATE: PTH: R103, R104.

NOTE: FOR COMPONENT INFORMATION, SEE PRODUCT STRUCTURE.

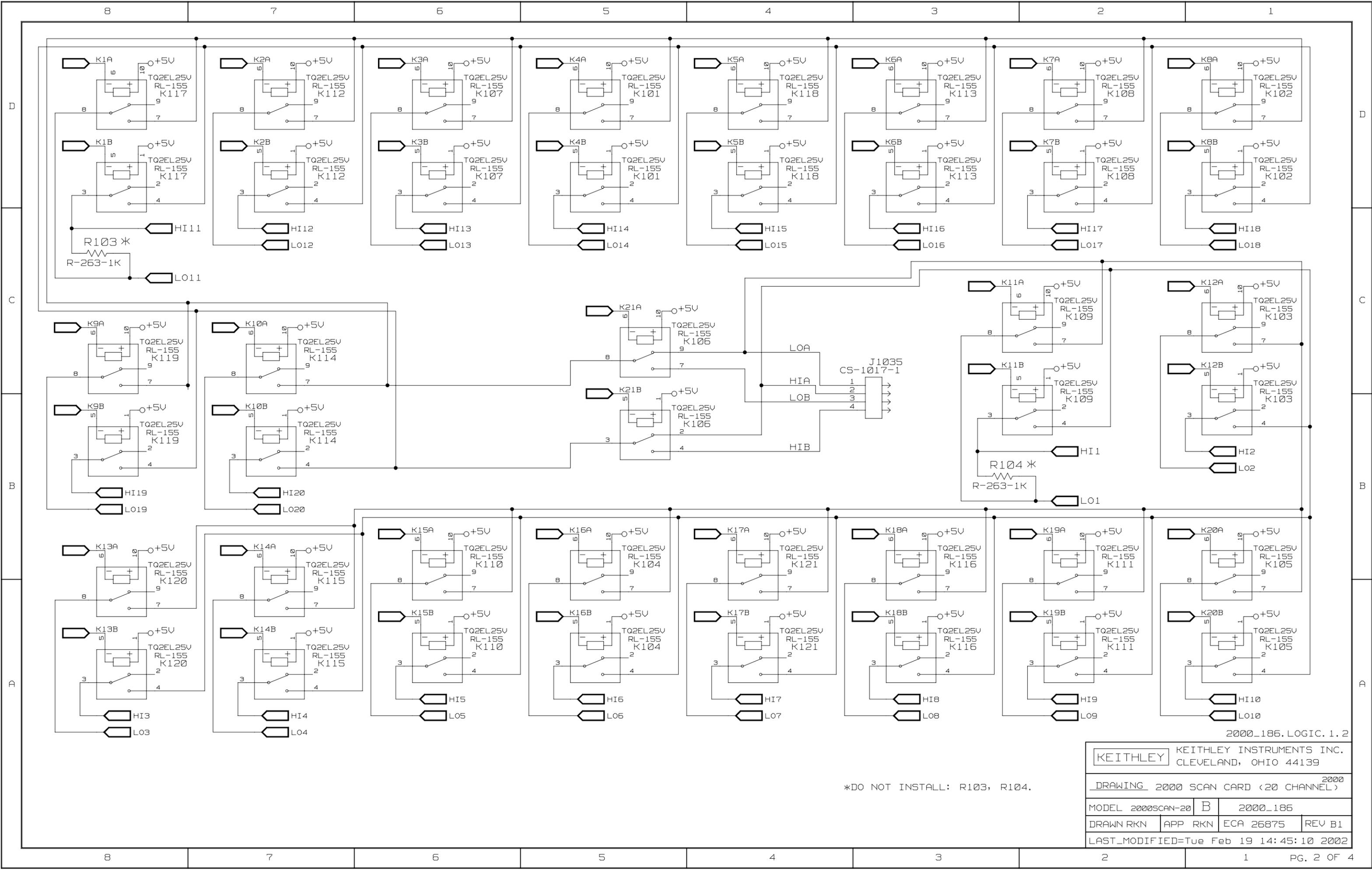
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	DIM ARE IN IN. UNLESS OTHERWISE NOTED	DATE 9/04/97	SCALE 1:1	TITLE COMPONENT LAYOUT
	DIM. TOL. UNLESS OTHERWISE SPECIFIED	DRN MRS	APPR. RKN/PS	2000 (20 CHANNEL) SCAN CARD
	XX=+.01 XXX=+.005	ANG.=+1 FRAC.=+1/64	DO NOT SCALE THIS DRAWING	B NO.



2000_186.LOGIC.1.1

KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
DRAWING 2000 SCAN CARD (20 CHANNEL) 2000			
MODEL 2000SCAN-20	B	2000_186	
DRAWN RKN	APP RKN	ECA 26875	REV B1
LAST_MODIFIED=Tue Feb 19 14:46:37 2002			



2000_186.LOGIC.1.2

KEITHLEY KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

*DO NOT INSTALL: R103, R104.

DRAWING 2000 SCAN CARD (20 CHANNEL)			
MODEL 2000SCAN-20	B	2000_186	
DRAWN RKN	APP RKN	ECA 26875	REV B1
LAST_MODIFIED= Tue Feb 19 14:45:10 2002			

*** Signal Cross-Reference ***
 --- for the entire design ---

K20B	1B2 2A1
K21A	1B2 2C5
K21B	1B2 2C5
L01	1C1 2B2
L02	1C1 2B1
L03	1B1 2A8
L04	1C1 2A7
L05	1B1 2A6
L06	1B1 2A5
L07	1D1 2A4
L08	1B1 2A3
L09	1C1 2A2
L010	1C1 2A1
L011	1D1 2C8
L012	1D1 2C7
L013	1C1 2C6
L014	1B1 2C5
L015	1D1 2C4
L016	1B1 2C3
L017	1C1 2C2
L018	1C1 2C1
L019	1D1 2B8
L020	1D1 2B7
L0A	2C4
L0B	2B4

HI1	1C1 2B2
HI2	1C1 2B1
HI3	1B1 2A8
HI4	1C1 2A7
HI5	1B1 2A6
HI6	1B1 2A5
HI7	1C1 2A4
HI8	1B1 2A3
HI9	1C1 2A2
HI10	1C1 2A1
HI11	1D1 2C8
HI12	1C1 2C7
HI13	1C1 2C6
HI14	1B1 2C5
HI15	1C1 2C4
HI16	1B1 2C3
HI17	1C1 2C2
HI18	1C1 2C1
HI19	1C1 2B8
HI20	1C1 2B7
HIA	2C4
HIB	2B5
K1A	1D5 2D8
K1B	1D5 2D8
K2A	1D5 2D7
K2B	1D5 2D7
K3A	1D5 2D6
K3B	1D5 2D6
K4A	1C5 2D5
K4B	1C5 2D5
K5A	1C5 2D4
K5B	1C5 2D4
K6A	1C5 2D3
K6B	1C5 2D3
K7A	1C5 2D2
K7B	1C5 2D2
K8A	1C5 2D1
K8B	1B5 2D1
K9A	1B5 2C8
K9B	1B5 2B8
K10A	1B5 2C7
K10B	1B5 2B7
K11A	1B5 2C3
K11B	1B5 2C3
K12A	1B5 2C1
K12B	1B5 2C1
K13A	1D2 2B8
K13B	1D2 2A8
K14A	1D2 2B7
K14B	1D2 2A7
K15A	1D2 2B6
K15B	1C2 2A6
K16A	1C2 2B5
K16B	1C2 2A5
K17A	1C2 2B4
K17B	1C2 2A4
K18A	1C2 2B3
K18B	1C2 2A3
K19A	1C2 2B2
K19B	1C2 2A2
K20A	1C2 2B1

CREFOUT.LOGIC. 1. 3

KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
DRAWING 2000 SCAN CARD (20 CHANNEL) CREF			
MODEL 2000SCAN-20	B	2000_186	
DRAWN RKN	APP RKN	ECA 26875	REV B1
LAST_MODIFIED= Tue Feb 19 14:47:38 2002			

*** Unit Cross-Reference ***
--- for the entire design ---

C101 ELCAP 1A8
C102 ELCAP 1C7
C103 CAPACITOR 1A7
C104 CAPACITOR 1C6
C105 CAPACITOR 1A6
C106 CAPACITOR 1C6
C107 CAPACITOR 1B6
C108 CAPACITOR 1C3
C109 CAPACITOR 1B3
C110 CAPACITOR 1B3
J1035 CS-1017-1 2C3
J1036 CS-967-2 1D1
K101 RL-155 2D5 2D5
K102 RL-155 2D1 2D1
K103 RL-155 2B1 2C1
K104 RL-155 2A5 2B5
K105 RL-155 2A1 2B1
K106 RL-155 2B4 2C4
K107 RL-155 2D6 2D6
K108 RL-155 2D2 2D2
K109 RL-155 2B2 2C2
K110 RL-155 2A6 2B6
K111 RL-155 2A2 2B2
K112 RL-155 2D7 2D7
K113 RL-155 2D3 2D3
K114 RL-155 2B7 2C7
K115 RL-155 2A7 2B7
K116 RL-155 2A3 2B3
K117 RL-155 2D8 2D8
K118 RL-155 2D4 2D4
K119 RL-155 2B8 2C8
K120 RL-155 2A8 2B8
K121 RL-155 2A4 2B4
M1 FUD 1A4
M2 FUD 1A3
M3 FUD 1A3
P1034 CS-455 1D8
R101 RESISTOR 1C7
R102 RESISTOR 1A7
R103 RESISTOR 2C8
R104 RESISTOR 2B3
TP101 CS-985 1C7
TP102 CS-985 1B7
U101 IC-850 1B7
U102 IC-857 1D5
U103 IC-857 1C5
U104 IC-857 1B5
U105 IC-857 1D3
U106 IC-857 1C3
U107 IC-857 1B3

CREFOUT.LOGIC. 1. 4

KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
DRAWING		2000 SCAN CARD (20 CHANNEL)	
MODEL	2000SCAN-20	B	2000_186
DRAWN RKN	APP RKN	ECA 26875	REV B1
LAST_MODIFIED= Tue Feb 19 14:48:57 2002			

A Specifications

GENERAL:

20 Channels: 20 channels of 2-pole relay input. All channels configurable to 4-pole.

Relay Type: Latching electromechanical.

Actuation Time: <3.5ms.

Safety: Conforms with European Union Directive 73/23/EEC.

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

CAPABILITIES: Multiplex one of twenty 2-pole or one of ten 4-pole signals into DMM.

INPUTS

Maximum Signal Level:

DC Signals: 60V DC CAT I, 0.5A switched, 30VA maximum (resistive load).

AC Signals: 30V AC rms CAT I or 42.4V AC peak, 100kHz maximum, 0.5A switched, 15VA maximum (resistive load).

Contact Life: >10⁵ operations at maximum signal level; >10⁸ operations cold switching.

Contact Resistance: <1Ω at end of contact life.

Contact Potential: <±1μV typical per contact, 2μV max. <±1μV typical per contact pair, 2μV max.

Connector Type: 44 pin male D-subminiature.

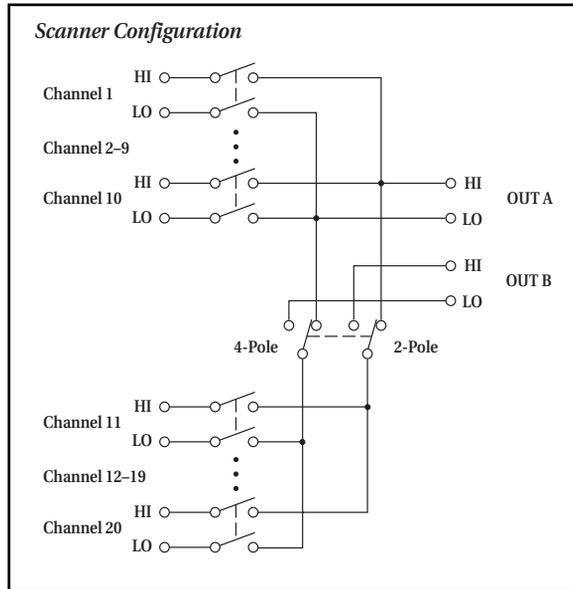
Isolation Between Any Two Terminals: >10⁸Ω, <75pF

Isolation Between Any Terminal and Earth: >10⁸Ω, <150pF

Common Mode Voltage: 42.4VAC peak; 60VDC between any terminal and earth.

Maximum Voltage Between Any Two Terminals: 42.4VAC peak, 60VDC.

Maximum Voltage Between Any Terminal and Model 2000 Input LO: 42.4VAC peak, 60VDC.



Internal Scanner Speed

MAXIMUM INTERNAL SCANNER RATES

RANGE: Channels/s¹

TRIGGER DELAY = 0

DCV ²	ACV ^{2,3}	2 WIRE OHMS ²	4 WIRE OHMS ²	TEMPERATURE ²
All : 100	All : 90	All : 95	<10MΩ : 31	All : 60

TRIGGER DELAY = AUTO

DCV ²	ACV ^{2,3}	2 WIRE OHMS ²	4 WIRE OHMS ²	TEMPERATURE ²
0.1 V : 95	All : 1.8	100 Ω : 81	100 Ω : 28	All : 60
1 V : 100		1 kΩ : 81	1 kΩ : 28	
10 V : 101		10 kΩ : 42	10 kΩ : 21	
100 V : 70		100 kΩ : 28	100 kΩ : 17	
1000 V : 70		1 MΩ : 8	1 MΩ : 7	
		10 MΩ : 5	10 MΩ : 5	
		100 MΩ : 3	100 MΩ : 3	

Internal Scanner Speed Notes

1. Speeds are for 60Hz operation using factory default operating conditions (*RST). Auto Zero off, Auto Range off, Display off, sample count = 1024.
2. NPLC = 0.01.
3. DETector: BANDwidth 300.

ENVIRONMENTAL:

Operating Environment: Specified for 0°C to 50°C. Specified to 80% R.H. at 35°C.

Storage Environment: -40°C to 70°C.

DIMENSIONS, WEIGHT: 21mm high × 72mm wide × 221mm deep (0.83 in. × 2.83 in. × 8.7 in.). Adds 0.3kg (7 oz.).

Specifications are subject to change without notice.

Index

Numerics

- 2-pole output connections 2-16
- 2-wire resistance test connections 3-9
- 4-pole output connections 2-17
- 4-wire resistance test connections 3-10

B

- Block diagram 4-11

C

- Card Connections and Installation 2-1
- Card connectors 2-5
- Card installation 2-14, 2-15
- Card installation and removal 2-14
 - Output connections to multimeter 2-16
 - Scanner card installation 2-14
 - Scanner card removal 2-17
- Card removal 2-14
- Component layout and schematic diagram 5-3
- Connections 2-3
 - Card configuration 2-4
 - Card connectors 2-5
 - Connection precautions 2-3
- Connections for channel-to-channel isolation tests 4-8
- Connections for contact potential tests 4-6
- Connections for current measurements 3-11
- Connections for HI and LO input-to-chassis ground isolation tests 4-9
- Connections for path resistance checks 4-5
- Connections for same-channel isolation tests 4-7
- Connections for voltage scanning 2-8
- Current connections 2-13
- Current shunt locations 2-11

E

- Eliminating ground loops 3-15

F

- Factory service 5-2
- Features 1-2

G

- General Information 1-1

H

- Handling and cleaning precautions 4-2
 - Handling precautions 4-2
 - Soldering precautions 4-3
- Handling precautions 2-2

I

- Input and output connector terminal identification 2-6
- Input connector J1036 pin designations 2-7
- Introduction 1-2, 2-2, 3-2, 4-2, 5-2

M

- Manual addenda 1-3
- Measurement considerations 3-12
 - Electromagnetic interference (EMI) 3-13
 - Ground loops 3-14
 - Keeping connectors clean 3-15
 - Magnetic fields 3-13
 - Path isolation 3-12
- Model 2000-20 multimeter front panel scanner controls and SCPI scanner commands 3-4
 - Closing channels 3-4
 - Front panel 3-4
 - Remote interface 3-4
 - Configuring scan parameters 3-6
 - Front Panel 3-6
 - Remote interface 3-7
 - Opening channels 3-5
 - Front panel 3-5
 - Remote interface 3-5
 - Selecting measurement function 3-5
- Model 2000-SCAN-20 parts list 5-3
- Model 2000-SCAN-20 simplified schematic 2-4

O

- Operation 3-1
- Optional accessories 1-5
- Ordering information 5-2
- Output connector J1035 pin designations 2-7
- Output connector terminal identification 2-6

P

- Parts list 5-2
- Path isolation resistance 3-12
- Performance verification 4-3
 - Contact potential tests 4-6
 - Environmental conditions 4-3
 - Isolation tests 4-7
 - Path resistance tests 4-4
 - Recommended equipment 4-4
- Power line ground loops 3-14
- Principles of operation 4-10
 - Block diagram 4-10
 - Power-on safeguard 4-11
 - Relay control 4-11
 - Switching circuits 4-11

R

- Recommended verification equipment 4-4
- Repacking for shipment 1-4
- Replaceable Parts 5-1

S

- Safety symbols and terms 1-3
- Scanner card detection 3-3
 - Power-up detection 3-3
 - Scanner option bus query 3-3
- SCPI scanner commands 3-8
- Service Information 4-1
- Signal limitations 3-2
 - Relay input signal limitations 3-2
- Special handling of static-sensitive devices 4-10
- Specifications 1-3, A-1
- Summary of SCPI scanner commands 3-8

T

- Typical applications 3-9
 - Current measurements 3-11
 - Resistor testing 3-9
 - 2-wire resistance tests 3-9
 - 4-wire resistance tests 3-10
- Typical connecting schemes 2-8
 - Current measurements 2-11, 2-12
 - Board soldering and cleaning precautions 2-12
 - Current connections 2-13
 - Current shunt locations 2-11
 - Recommended current shunt values 2-11
 - Resistance connections 2-9
 - 2-Pole connections 2-9
 - 4-Pole connections 2-10
 - Voltage connections 2-8
- Typical connections for 2-wire resistance scanning 2-9
- Typical connections for 4-wire resistance scanning 2-10

U

- Unpacking and inspection 1-3
 - Handling precautions 1-4
 - Inspection for damage 1-3
 - Instruction manual 1-4
 - Shipment contents 1-4

V

- Voltage attenuation by path isolation resistance 3-13

Service Form

Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

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

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

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

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

Display or output (check one)

Drifts Unable to zero Unstable

Overload Will not read applied input

Calibration only Certificate of calibration required Data required

(attach any additional sheets as necessary)

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

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

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

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

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

Specifications are subject to change without notice.

All Keithley trademarks and trade names are the property of Keithley Instruments, Inc.

All other trademarks and trade names are the property of their respective companies.

KEITHLEY

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

Sales Offices:

BELGIUM:	Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02-363 00 40 • Fax: 02-363 00 64
CHINA:	Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-82251886 • Fax: 8610-82251892
FINLAND:	Halsuantie 2 • 00420 Helsinki, Finland • 09-53 06 65 60 • Fax: 09-53 06 65 65
FRANCE:	3, allée des Garays • 91127 Palaiseau Cédex • 01-64 53 20 20 • Fax: 01-60 11 77 26
GERMANY:	Landsberger Strasse 65 • 82110 Germering • 089-84 93 07-40 • Fax: 089-84 93 07-34
GREAT BRITAIN:	Unit 2 Commerce Park, Brunel Road • Theale, Berkshire RG7 4AB • 0118 -929 75 00 • Fax: 0118- 929 75 19
INDIA:	1/5, Eagles Street • Langford Town • Bangalore 560 025 • 080 212 80-27 • Fax: 080 212 80 05
ITALY:	Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
JAPAN:	New Pier Takeshiba North Tower 13F • 11-1, Kaigan 1-chome • Minato-ku, Tokyo 105-0022 • 81-3-5733-7555 • Fax: 81-3-5733-7556
KOREA:	2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-888 • 82-2-574-7778 • Fax: 82-2-574-7838
NETHERLANDS:	Postbus 559 • 4200 AN Gorinchem • 0183-63 53 33 • Fax: 0183-63 08 21
SWEDEN:	c/o Regus Business Centre • Frosundaviks Allé 15, 4tr • 16970 Solna • 08-50 90 46 00 • Fax: 08-655 26 10
TAIWAN:	13F-3, NO. 6, Lane 99, Pu-Ding Road, Hsinchu, Taiwan, ROC. • 886-3-572-9077 • Fax: 886-3-572-9031

© Copyright 2003 Keithley Instruments, Inc.

Printed in the U.S.A.

5/03