

KEITHLEY

Model 6521 Low Current
Model 6522 Voltage/Current
Scanner Cards
Instruction Manual

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Model 6521 Low Current Scanner Card
Model 6522 Voltage/Current Scanner Card
Instruction Manual

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Manual Print History

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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.

Model 6521 Low Current Scanner

CHANNELS PER CARD: 10.

FUNCTIONS: Amps.

CONTACT CONFIGURATION:

Current Mode: Single pole break-before-make for signal HI input. Signal LO is common for all 10 channels and output. When a channel is off, signal HI is connected to signal LO via a relay. All channels connect to signal LO, in a make-before-break configuration between channel closures so that the current path is never interrupted.

All relays open when power is off.

SCAN SPEED:

1.5 channels/second with default settings.^{1,2}

43 channels/second maximum speed.^{1,2,3}

¹ When used with 6517 Electrometer.

² Scan speeds are for fixed range readings for 200V and 20mA 6517 ranges, into data buffer.

³ 6517 Filter off, speed fast, settling time 0 seconds.

CONNECTOR TYPE: Inputs BNC, Outputs Triaxial.

SIGNAL LEVEL: 30V, 500mA, 10VA (resistive load).

CONTACT LIFE: $>10^6$ closures at maximum signal level; $>10^7$ closures at low signal levels.

CONTACT RESISTANCE: $<1\Omega$.

CONTACT POTENTIAL: $<200\mu\text{V}$.

OFFSET CURRENT: $<1\text{pA}$ ($<30\text{fA}$ typical at 23°C, $<60\%$ RH).

ACTUATION TIME: 2ms.

COMMON MODE VOLTAGE: $<30\text{V}$ peak.

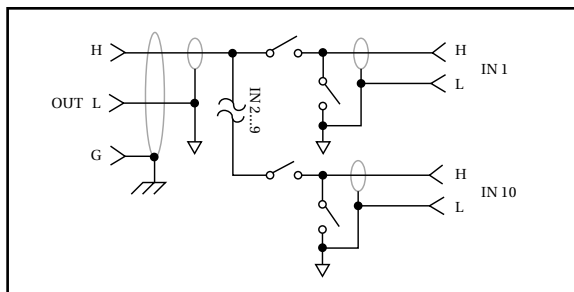
ENVIRONMENT:

Operating: 0°C to 50°C up to 35°C at 70% RH.

Storage: -25°C to 65°C.

DIMENSIONS, WEIGHT: 38mm high \times 70mm wide \times 242mm deep (1.5 in \times 2.75 in \times 9.5 in). Net weight 623g (22 oz).

Specifications are subject to change without notice.



Model 6522 Low Current/Voltage Scanner

CHANNELS PER CARD: 10.

FUNCTIONS: Volts, Amps.

CONTACT CONFIGURATION:

Voltage Mode: Single pole break-before-make for signal HI input. Guard is common for all 10 channels and output.

Current Mode: Single pole break-before-make for signal HI input. Signal LO is common for all 10 channels and output. When a channel is off, signal HI input is connected to signal LO via a relay. All channels connect to signal LO in a make-before-break configuration between channel closures so that the current path is never interrupted.

All relays open when power is off.

SCAN SPEED:

1.5 channels/second with default settings.^{1,2}

43 channels/second maximum speed.^{1,2,3}

¹ When used with 6517 Electrometer.

² Scan speeds are for fixed range readings for 200V and 20mA 6517 ranges, into data buffer.

³ 6517 Filter off, speed fast, settling time 0 seconds.

CONNECTOR TYPE: Inputs: Triaxial. Outputs: Triaxial.

SIGNAL LEVEL: 200V, 500mA, 10VA (resistive load).

CONTACT LIFE: $>10^6$ closures at maximum signal level; $>10^7$ closures at low signal levels.

CONTACT RESISTANCE: $<1\Omega$.

CONTACT POTENTIAL: $<200\mu\text{V}$.

OFFSET CURRENT: $<1\text{pA}$ ($<30\text{fA}$ typical at 23°C, $<60\%$ RH).

CHANNEL ISOLATION: $>10^{13}\Omega$, $<0.3\text{pF}$.

INPUT ISOLATION: $>10^{10}\Omega$, $<125\text{pF}$ (Input HI to Input LO).

ACTUATION TIME: 2ms.

COMMON MODE VOLTAGE: $<250\text{V}$ peak.

ENVIRONMENT:

Operating: 0°C to 50°C up to 35°C at 70% RH.

Storage: -25°C to 65°C.

DIMENSIONS, WEIGHT: 38mm high \times 70mm wide \times 242mm deep (1.5 \times 2.75 in \times 9.5 in). Net weight 623g (22 oz).

Specifications are subject to change without notice.

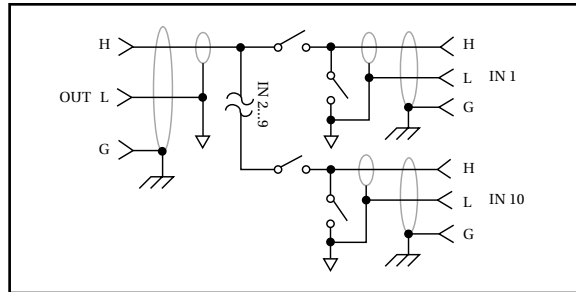


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General Information

1.1 Introduction

This section contains general information about the Models 6521 and 6522 scanner card options for the Model 6517 Electrometer. Both cards provide 10 channels of single-pole switching. The Model 6521 is intended for use primarily with the amps function, while the Model 6522 can be used with the volts, amps, ohms, and charge functions. Both cards have very low offset current and are designed for installation in the Model 6517 rear panel OPTION SLOT.

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 Specification
- 1.7 Unpacking and inspection
- 1.8 Repacking for shipment
- 1.9 Optional accessories

1.2 Features

1.2.1 Model 6521 features

Key Model 6521 features include:

- 10 channels of single-pole switching designed for amps.
- Input HI is connected to input LO when a channel is off for true current switching.

- BNC input cables and a triax output cable to maintain signal integrity.
- Low offset current (<1pA; <30fA typical).

1.2.2 Model 6522 features

Key Model 6522 features include:

- 10 channels of single-pole switching designed for volts, ohms, amps and coulombs functions.
- When configured for current operation, input HI is connected to input LO when a channel is off for true current switching.
- Triax input cables and a triax output cable to maintain signal integrity.
- Low offset current (<1pA; <30fA typical).
- High channel isolation and input isolation.
- Fully guarded operation is supported to maintain signal integrity under high-impedance voltage measurement conditions.

1.3 Warranty information


Warranty information is located on the inside front cover of this instruction manual. Should your Model 6521/22 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the scanner 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 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.


1.5 Safety symbols and terms

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

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

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

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

The  symbol indicates a safety earth ground. The ground screw must be secured to assure that the scanner card is properly grounded.

1.6 Specifications

Model 6521/22 specifications are found at the front of this manual. These specifications are exclusive of the Model 6517 Electrometer specifications.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

The Model 6521/22 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 precautions on handling discussed below.

1.7.2 Handling precautions

- Always grasp the card by the side edges and covers. Do not touch the board surfaces or components.

- 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.
- When the card is not installed in a Model 6517 Electrometer, keep the card in the anti-static bag, and store it in the original packing carton.

1.7.3 Shipment contents

The following items are included with every Model 6521/22 order:

- Model 6521/22 Scanner Card
- Model 6521/22 Instruction Manual
- Input/output cables (factory connected to card)
- Additional accessories as ordered

1.7.4 Instruction manual

If an additional Model 6521/22 Instruction Manual is required, order the manual package, Keithley part number 6521-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 Repacking for shipment

Should it become necessary to return the Model 6521/22 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.

1.9 Optional accessories

The following optional accessories are recommended for use for the Model 6521/22.

1.9.1 Model 6521 accessories

Model 4801 Coax Cable: Low-noise coax cable, 1.2m (48 in) in length with male BNC connectors on each end. Recommended for extending Model 6521 input connections.

Model 4802-10 Coax Cable: 3m (10 ft.) of low-noise coax cable with a male BNC connector on one end and unterminated at the other end. Recommended for extending Model 6521 input connections.

Model 4803 Low-Noise Cable Kit: Includes 15m (50 ft.) of low-noise coax cable, 10 male BNC connectors, and five female BNC, chassis-mount connectors. Recommended for extending Model 6521 input connections.

Model CAP-18 2-Slot Cap: Protective shield/cap for Model 6521 input jacks.

SC-9 Coax Cable: Low-noise coax cable without connectors (sold by the foot).

1.9.2 Model 6522 accessories

Model 237-ALG Triax Cable: 2m (6.6 ft.) of low-noise triax cable terminated with a 3-slot male triax connector on one end, and three alligator clips on the other end. Recommended for extending Model 6522 input connections.

Model 6171 Adapter: 3-slot male to 2-lug female triax adapter. Recommended for adapting 2-slot triax cables to Model 6522 input connectors.

Model 7078-TRX-3 Triax Cable: 0.9m (3 ft.) low-noise triax cable terminated at both ends with 3-slot male triax connectors. Also available in 3m (10 ft.) and 6m (20 ft.) lengths (Models 7078-TRX-10 and 7078-TRX-20 respectively). Recommended for extending Model 6522 input connections.

Model 7078-TRX-BNC Adapter: 3-slot male triax to BNC adapter useful for adapting BNC coax cables to Model 6522 input jacks.

Model 7078-TRX-TBC Triax Bulkhead Connector: 3-lug female triax bulkhead connector with cap for assembly of custom panels and interface connections.

Model CAP-31 3-Slot Cap: Protective shield/cap for Model 6522 input jacks.

SC-22 Triax Cable: Low-noise triax cable without connectors (sold by the foot).

2

Card Connections and Installation

2.1 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 6521/22 and on installing the card in the Model 6517 Electrometer. This section is arranged as follows:

- 2.2 **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.
- 2.3 **Connections:** Covers the basics for connecting external circuitry to the scanner card.
- 2.4 **Card installation and removal:** Summarizes the procedure to install the scanner card assembly in the Model 6517 Electrometer, outlines scanner card output connections, and describes how to remove the card.

2.2 Handling precautions

To maintain high impedance isolation between channels, care should be taken when handling the scanner card to avoid contamination from such foreign materials as body oils. Such contamination can substantially lower leakage resistances and increase offset currents, degrading card performance. To avoid possible contamination, always grasp the

scanner card by the side edges or covers. Do not touch board surfaces, components, or input/output connector insulators.

Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the electrometer and scanner card in a clean environment. If the card becomes contaminated, it should be thoroughly cleaned as explained in paragraph 4.2.

2.3 Connections

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

2.3.1 Model 6521 scanner card configuration

Model 6521 simplified schematic

Figure 2-1 shows a simplified schematic diagram of the Model 6521. The scanner card has 10 input channels and a single output. Note that each channel utilizes single-pole switching with only the HI signal path switched. Input connections include H (HI), L (LO), while output connections include H, L, and G (chassis ground).

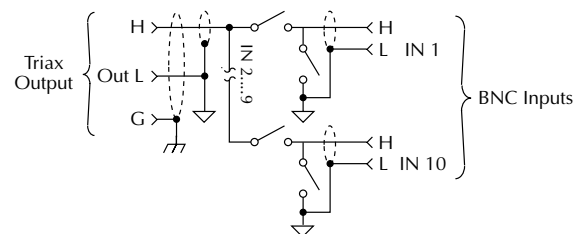


Figure 2-1
Model 6521 simplified schematic

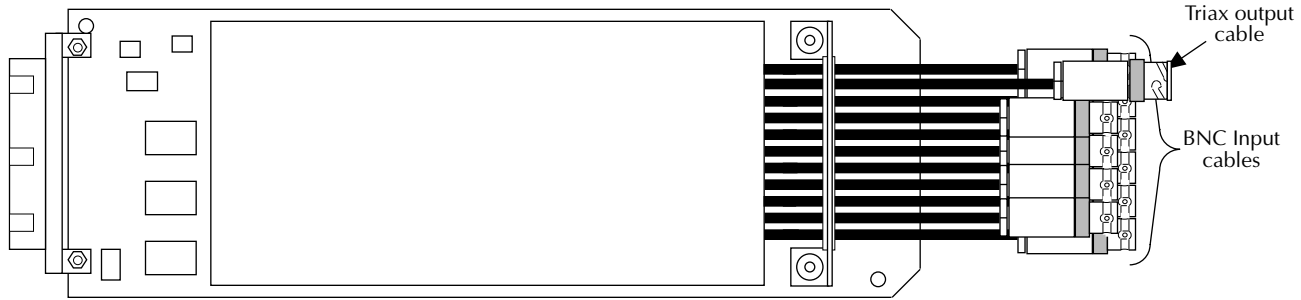


Figure 2-2
Model 6521 connecting cables

Model 6521 connecting cables

Figure 2-2 shows the input/output connecting cables for the Model 6521 card. Card connections include:

- INPUT 1-10 (channels 1-10): Each input is equipped with a BNC coaxial cable, which is terminated with a female BNC connector. The center conductor is HI, while the outer shell is LO.
- OUTPUT: The triax output cable is equipped with a 3-slot male triax connector. The center conductor is HI, the inner ring is LO, and the outer shell is connected to chassis ground.

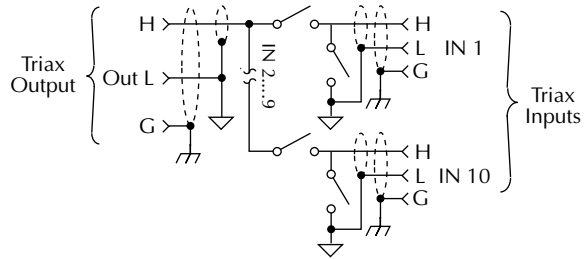


Figure 2-3
Model 6522 simplified schematic

Model 6522 connecting cables

Figure 2-4 shows the input/output connecting cables for the Model 6522 card. Card connections include:

- INPUT 1-10 (channels 1-10): Each input is equipped with a triax cable terminated with a 3-lug female triax connector. The center conductor is HI, the inner ring is LO, and the outer shell is connected to chassis ground.
- OUTPUT: The output cable is terminated with a 3-slot male triax connector. The center conductor is HI, the inner ring is LO, and the outer shell is connected to chassis ground.

2.3.2 Model 6522 scanner card configuration

Model 6522 simplified schematic

Figure 2-3 shows a simplified schematic diagram of the Model 6522. As with the Model 6521, the Model 6522 scanner card has 10 input channels and a single output. Note that each channel utilizes single-pole switching with only the HI signal path switched. Input connections include H (HI), L (LO), and G (chassis ground), while output connections include H, L, and G, which is connected to chassis ground.

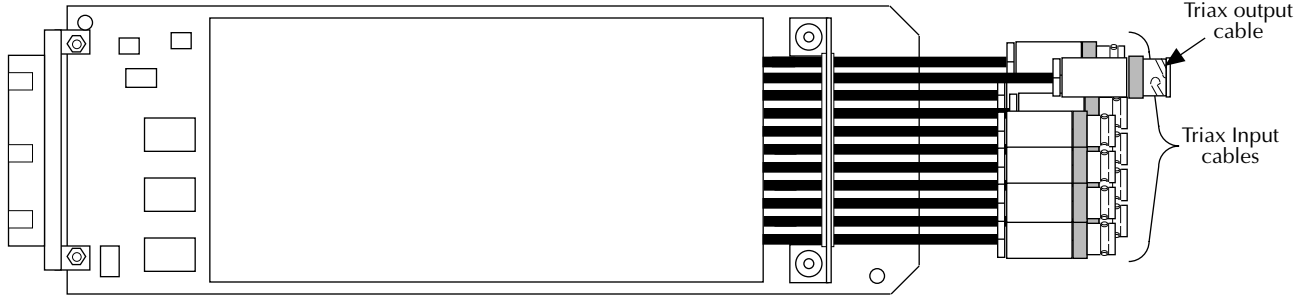


Figure 2-4
Model 6522 connecting cables

2.3.3 Input connections

All connections to the scanner card input jacks should be made using appropriate low-noise coax (Model 6521) or triax (Model 6522) cables. See paragraph 1.9 in Section 1 for cable recommendations.

WARNING

Make sure all power is off and any stored energy in external circuitry is discharged before connecting or disconnecting cables.

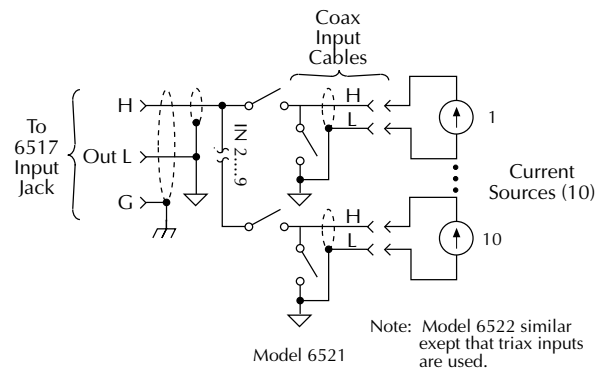


Figure 2-5
Typical amps function connections

2.3.4 Output connections

The supplied triax output cable should be connected to the Model 6517 INPUT jack.

2.3.5 Typical connecting schemes

Figure 2-5 through Figure 2-8 show typical connecting schemes for using the scanner card for amps, volts, ohms, and coulombs measurements.

NOTE

The Model 6521 is intended for current measurements. The Model 6522 is designed for all Model 6517 measurement functions. The Model 6517 should be programmed for the voltage or current scan mode as appropriate. (See paragraph 3.4.4.)

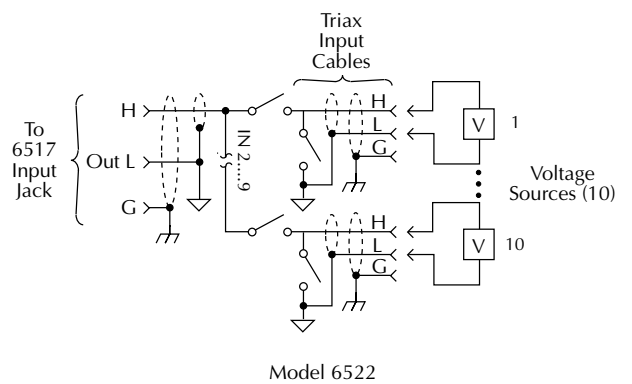


Figure 2-6
Typical volts function connections

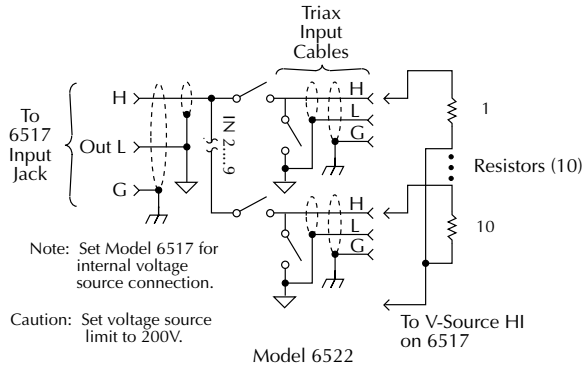


Figure 2-7
Typical ohms function connections

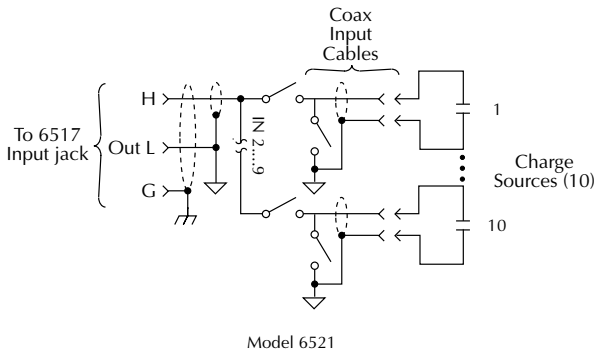


Figure 2-8
Typical coulombs function connections

2.3.6 Guarded operation

The Model 6522 supports guarded voltage measurements. (The Model 6517 cannot be operated in the guarded mode when the Model 6521 is installed.) When using guarding, the inner shield routes the guard signal, while the outer shield remains at chassis ground. Thus, signal LO must be routed using a path external to the scanner card. Figure 2-9 shows typical guarded connections.

In order to use guarding, the Model 6517 Electrometer must be placed in the guarded mode. Refer to the Model 6517 User's Manual for more details on guarded operation.

2.4 Card installation and removal

This paragraph explains how to install and remove the Model 6521/22 card assembly from the Model 6517 Electrometer.

WARNING

Installation or removal of the Model 6521/22 should be performed only by qualified service personnel. Failure to recognize and observe standard safety precautions could result in personal injury or death.

CAUTION

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

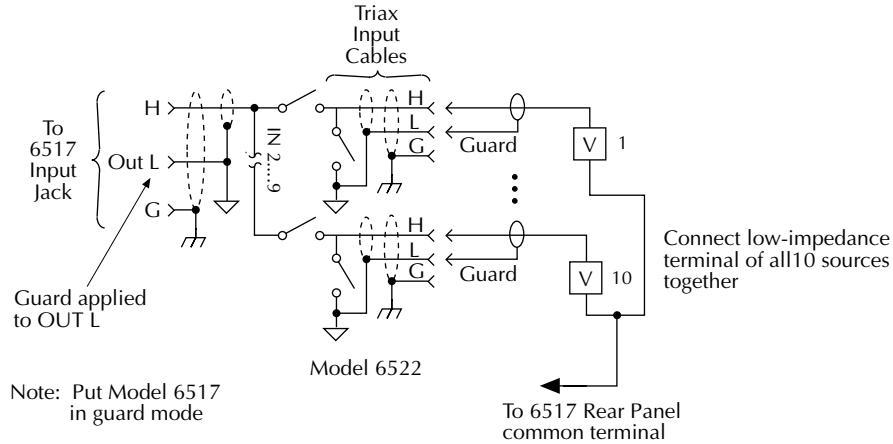


Figure 2-9
 Typical guarded volts connections (Model 6522 only)

2.4.1 Scanner card installation

Perform the following steps, and refer to Figure 2-10 to install the card assembly in the Model 6517 Electrometer:

WARNING

Turn off power to all instrumentation (including the Model 6517 Electrometer), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Remove the cover plate from the OPTION SLOT on the rear panel of the Model 6517 Electrometer. To do so, pry out the two fasteners, then remove the cover plate.

2. Slide the card edges into the guide rails inside the electrometer.
3. Carefully push the card all the way forward until it seats in the internal connector.
4. After the card is fully seated, tighten the mounting screw.

WARNING

The mounting screw must be securely fastened to ensure a proper ground connection to avoid possible shock hazards.

5. After installation, connect the output cable to the electrometer as discussed below.

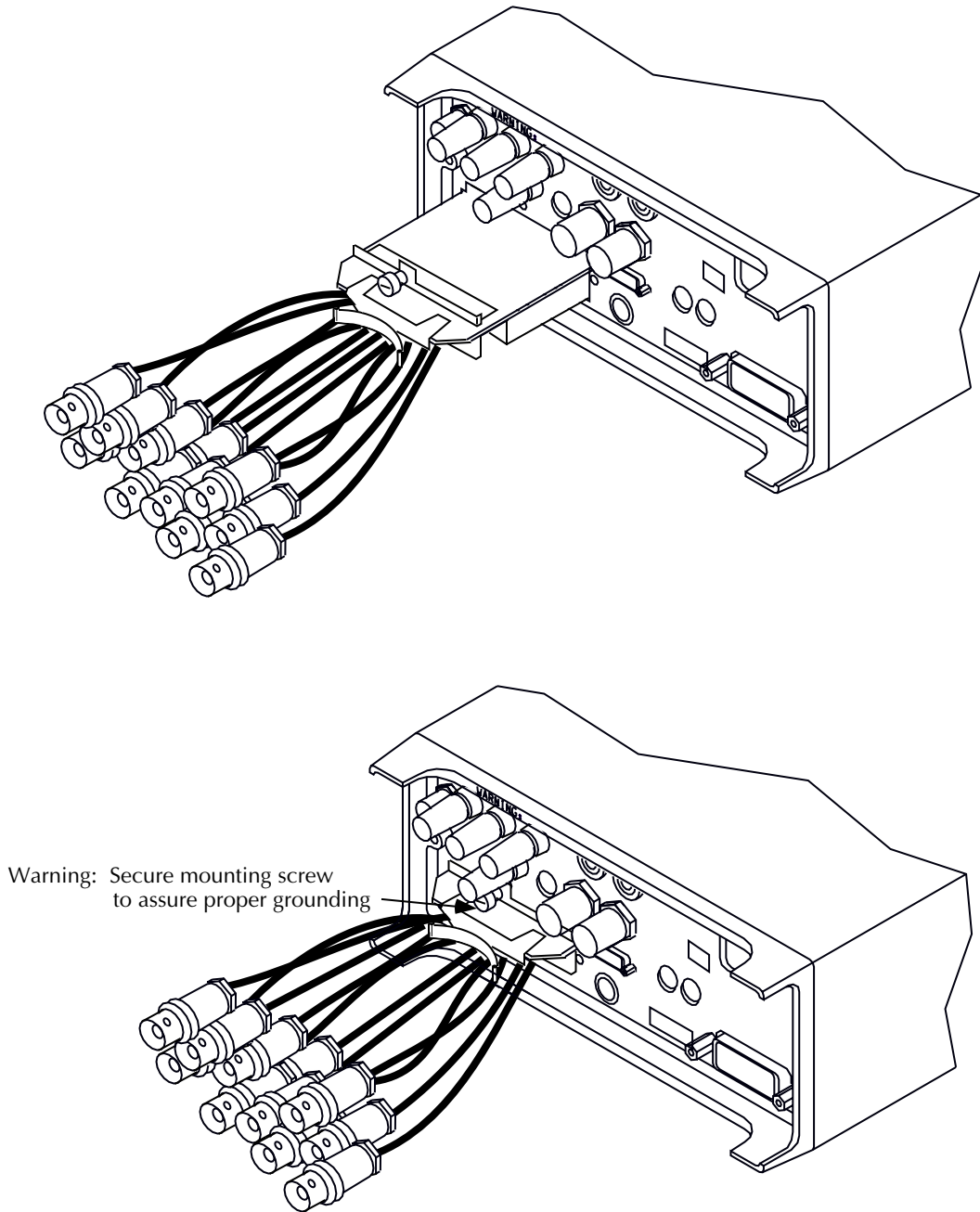


Figure 2-10
Scanner card installation

2.4.2 Output connections to electrometer

After installation, be sure to connect the scanner card triax output cable to the Model 6517 INPUT jack. Figure 2-11 shows typical output connections.

2.4.3 Scanner card removal

Follow the steps below to remove the scanner card from the multimeter:

sure all power is removed and any stored energy in external circuitry is discharged.

1. Loosen the mounting screw.
2. Carefully slide the card out of the electrometer.
3. If the electrometer is to be operated without the scanner card installed, install the cover plate over the OPTION SLOT.

WARNING

Turn off power to all instrumentation (including the Model 6517 Electrometer), and disconnect all line cords. Make

NOTE

The Model 6517 should not be operated without the OPTION SLOT cover in place because internal temperature changes could affect accuracy.

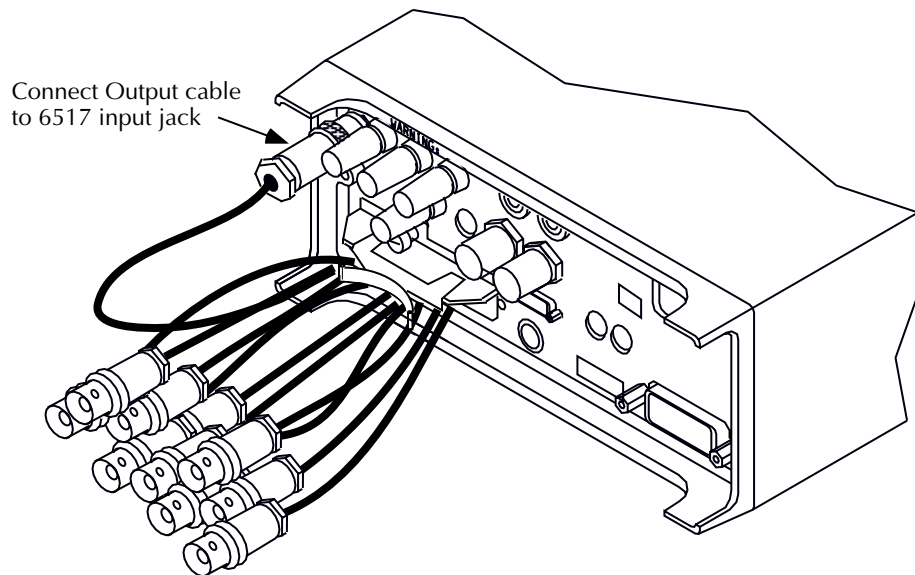


Figure 2-11
Output connections

3

Operation

3.1 Introduction

This section contains detailed information on front panel and IEEE-488 bus operation of the Model 6521/22. The information in this section is organized as follows:

- 3.2 Signal limitations:** Summarizes the maximum signals that can be applied to the Model 6521/22.
- 3.3 Scanner card detection:** Discusses how the scanner card is detected and how to determine whether or not the card is installed with a bus command.
- 3.4 Front panel operation:** Gives an overview of the Model 6517 Electrometer front panel scanner controls and discusses how to open and close channels and perform basic scanning.
- 3.5 IEEE-488 bus operation:** Summarizes bus commands necessary to control the scanner card and gives an overview of general bus scanner operation.
- 3.6 Measurement considerations:** Discusses a number of measurement considerations that should be taken into account when using the scanner card with the Model 6517.
- 3.7 Typical applications:** Discusses typical applications for the Model 6521/22.

NOTE

Before using the Model 6521/22 scanner card, you should be thoroughly familiar with the operation of the Model 6517 Electrometer. See the Model 6517 User's Manual for details.

3.2 Signal limitations

CAUTION

To prevent damage to the Model 6521/22, do not exceed the maximum signal level specifications of the card.

3.2.1 Model 6521 signal limitations

To prevent over-heating or damage to the relays, never exceed the following maximum signal levels when using the Model 6521:

- Maximum signal level (HI to LO): 30V, 500mA, 10VA (resistive load)
- Maximum common-mode voltage (LO to chassis ground): <30V peak

WARNING

Applying >30V peak common-mode voltage will result in a shock hazard.

3.2.2 Model 6522 signal limitations

To prevent over-heating or damage to the relays, never exceed the following maximum signal levels when using the Model 6522:

- Maximum signal level (HI to LO): 200V, 500mA, 10VA (resistive load)
- Maximum common-mode voltage (LO to chassis ground): <250V peak

CAUTION

Use special caution when using the Model 6517 voltage source with the Model 6522. Although the voltage source has a maximum output voltage of 1000V, the maximum signal level that can be switched by the Model 6522 is 200V. It is recommended that you program the Model 6517 voltage source limit to 200V when using the Model 6522. (See paragraphs 3.4 and 3.5 for details.)

3.2.3 Relay operation

Relays are normally opened and closed when the Model 6517 is programmed to do so, and when scanning is in progress. Note, however, that all relays will open when Model 6517 power is turned off.

3.3 Scanner card detection

3.3.1 Power-up detection

The scanner card is detected only at power-on. If the card is plugged into the Model 6517 after the power is turned on, the card will not be recognized as being present by the Model 6517.

CAUTION

Plugging in the scanner card with power turned on may result in damage to both the Model 6521/22 and the Model 6517 Electrometer. To avoid damage, never install or remove the scanner card from the electrometer with the power turned on.

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

3.3.2 Scanner option bus query

*OPT? is an IEEE 488.2 common query which will allow you determine whether or not the Model 6521/22 card is installed. The response to this query indicates whether or not the scanner is present with an appropriate message. Refer to the Model 6517 User’s manual for more details on using the *OPT? query.

3.4 Front panel operation

The following paragraphs give an overview of the various Model 6517 Electrometer menu items used with the scanner and also discuss opening and closing channels and scanning operation.

3.4.1 Scanning controls

The following controls are used for scanning:

CARD: This key accesses the scanning menu (discussed in paragraph 3.4.2 below) to control most scanning operations.

CONFIG CARD: Pressing these two keys in succession will display the card configuration menu. This menu lets you select current or voltage scanning, settling time, and voltage source limit.

EXIT: Pressing this key during a scan sequence will abort the scan and return the instrument to normal operation.

Function Keys: As with normal operation, the function keys control the measurement function to be used during scanning.

3.4.2 Scan control and configuration menus

To access the scan control menu, simply press the Model 6517 OPTION CARD key. You can then access the various levels of the scan control menu, which is outlined in Table 3-1.

To access the card configuration menu, press CONFIG then CARD. The card configuration menu is summarized in Table 3-2.

Table 3-1
Scan control menu

Menu item*	Description
CHANNEL CLOSURES CLOSE-CHANNEL OPEN-ALL-CHANNELS PERFORM-SCAN EXTERNAL INTERNAL	Close channel manually. Close selected channel. Open all closed channels. Perform internal or external scanning. Scan with external scanner. Scan with 6521/22.

* Access scan control menu with OPTION CARD key.

Table 3-2
Card configuration menu

Menu item*	Description
CONFIGURE SCANNER INTERNAL CHANNELS SCAN-MODE VSRC-LIMIT SETTLING-TIME EXTERNAL	Set up scanning operation. Configure internal scanner. Select channels in scan list. Select voltage or current mode. Select voltage source limit. Set settling time. Configure external scan.

* Access card configuration menu by pressing CONFIG then CARD

3.4.3 Closing and opening channels

Closing channels

1. Press the CARD button. The instrument will display the following:
SCANNER OPTION
CHANNEL-CLOSURES PERFORM-SCAN
2. Select CHANNEL-CLOSURES, then press ENTER. The following will be displayed:
CHANNEL SELECTION
CLOSE-CHANNEL OPEN-ALL-CHANNELS
3. Choose CLOSE-CHANNEL, then press ENTER, and note the unit prompts you for the channel to close:
ENTER CHAN#01 (1-10)
4. Using the range keys, choose the channel to close, then press the ENTER key.
5. The selected channel will close, and the instrument will return to normal measurement display.

Opening channels

1. Press the CARD button. The instrument will display the following:
SCANNER OPTION
CHANNEL-CLOSURES PERFORM-SCAN
2. Select CHANNEL-CLOSURES, then press ENTER. The following will be displayed:
CHANNEL SELECTION
CLOSE-CHANNEL OPEN-ALL-CHANNELS
3. Choose OPEN-ALL-CHANNELS, then press ENTER.
4. The closed channel will open, and the instrument will return to normal measurement display.

NOTE

Any closed relays will open if the Model 6517 power is turned off.

3.4.4 Card configuration

Selecting scan list channels

To choose the channels to include in the scan list, perform the following steps:

1. Press CONFIG then CARD, and note that the following is displayed:

```
CONFIGURE SCANNER
INTERNAL  EXTERNAL
```

2. Select INTERNAL, press ENTER, and note that the instrument displays the following:

```
INTERNAL SCANNER
CHANNELS  SCAN-MODE  VSRC-LIMIT ►
◀ SETTling-TIME
```

3. Select CHANNELS, then press ENTER, and note that the instrument displays the following:

```
CONFIGURE CHANNELS
INTERNAL-CHANS  EXTERNAL-INPUTS
```

4. Select INTERNAL-CHANS, then press ENTER. The following will then be displayed:

```
SET INTERNAL CHANS
1=ON 2=ON 3=ON 4=ON 5=ON ►
◀ 6=ON 7=ON 8=ON 9=ON 10=ON
```

5. Using the range and cursor keys, select the channels you wish to include in the scan list. (ON = include channel; OFF = exclude channel.)
6. Press the ENTER key to complete programming, then press EXIT twice to return to normal display.

Scan mode

The scanner card can be configured for either voltage or current operation. When in the voltage mode, the card is configured for break-before-make operation. (The relay for the presently closed channel opens before the next channel relay closes.) When in the current mode, the HI and LO terminals of each input channel remain shorted together when the channels are open.

Program the scan mode as follows:

1. Press CONFIG then CARD, and note that the following is displayed:

```
CONFIGURE SCANNER
INTERNAL  EXTERNAL
```

2. Select INTERNAL, press ENTER, and note that the instrument displays the following message:

```
INTERNAL SCANNER
CHANNELS  SCAN-MODE  VSRC-LIMIT ►
◀ SETTling-TIME
```

3. Select SCAN-MODE, then press ENTER. The instrument will display the following:

```
SCAN MODE
VOLTAGE  CURRENT
```

4. Select VOLTAGE or CURRENT as desired, then press ENTER.
5. Press EXIT twice to return to normal display.

Setting the voltage source limit

The maximum recommended voltage for the Model 6522 card is 200V, while the Model 6521 is limited to 30V for safety reasons. Use the following procedure to program the voltage limit up to a maximum of 200V.

1. Press CONFIG then CARD, and note that the following is displayed:

```
CONFIGURE SCANNER
INTERNAL  EXTERNAL
```

2. Select INTERNAL, press ENTER, and note that the instrument displays the following:

```
INTERNAL SCANNER
CHANNELS  SCAN-MODE  VSRC-LIMIT ►
◀ SETTling-TIME
```

3. Select VSRC-LIMIT, then press ENTER. The instrument will display the following:

```
LIMIT VSRC TO 200V
YES  NO
```

4. To limit the voltage source to 200V, select YES, then press ENTER.
5. Press EXIT twice to return to normal display.

Settling time

The setting time parameter allows you to program a delay time to allow circuit settling. The settling time between channels can be set to any value in the range of 0sec to 999.999sec. Program the settling time as follows:

1. Press CONFIG then CARD, and note that the following is displayed:

```
CONFIGURE SCANNER
INTERNAL  EXTERNAL
```

2. Select INTERNAL, press ENTER, and note that the instrument displays the following:

```
INTERNAL SCANNER
CHANNELS  SCAN-MODE  VSRC-LIMIT ►
◀ SETTling-TIME
```

3. Select SETTling-TIME, then press ENTER, and note that the instrument displays the following:

```
SETTLE-t: 000.000sec
```


4. Set the settling time as desired, then press ENTER.
5. Press EXIT to return to normal display.

3.4.5 Scanning procedure

NOTE

Before scanning, you should configure the card as covered in paragraph 3.4.4.

1. Press the CARD key, and note that the instrument displays the following:

```
SCANNER OPTION
CHANNEL-CLOSURES  PERFORM-SCAN
```

2. Select PERFORM-SCAN, then press ENTER. The Model 6517 will prompt you as to the type of scan:

```
CHOOSE SCAN TYPE
EXTERNAL INTERNAL
```

3. Select INTERNAL, then press ENTER. You will then be prompted to set the scan count (number of scans):

```
SCAN COUNT = 00010
```

4. Set the scan count to the desired value, then press the ENTER key. The instrument will then prompt you as to whether or not you wish to use the scan timer:

```
USE SCAN TIMER?
YES  NO
```

5. If you wish to use the timer to control the length of the scan, select YES; otherwise choose NO, then press ENTER.

6. If you are using the scan timer, the unit will prompt you for the scan interval (length of scan):

```
INTRVL = 00002.500
```

7. Set the scan interval to the desired value, then press ENTER. The instrument will then display the following asking whether or not you intend to store measurement data in memory:

```
DATA TO MEMORY?
YES  NO
```

8. If you desire to store measurement data in the Model 6517 buffer, select YES; otherwise choose no, then press ENTER.

9. Assuming that you chose to store readings in the buffer, the instrument will display the following:

```
00100 RDGS TO BUFFER
Press ENTER to continue
```

10. Press ENTER to continue, and the unit will display one last prompt before starting the scan:

Press ENTER to begin

11. Press the ENTER key to start scanning. During scanning, the unit will display the current reading being processed. For example:

Storing reading 010 of 100

NOTE

To abort scanning at any time, press the EXIT key. The unit will then display the following message to indicate that scanning has been aborted:

```
SCANNING DISABLED
```

12. After the scan process has completed normally, the instrument will display the following:

```
SCAN COMPLETE
RECALL-DATA  SCAN-AGAIN  EXIT
```

13. Choose the desired option as follows:

RECALL-DATA: Choose this option if you wish to recall data stored in the buffer. Use the range keys to scroll through readings.

SCAN-AGAIN: Select this option to scan again.

EXIT: Choose this option to exit scanning and return to normal operation.

3.5 IEEE-488 bus operation

The following paragraphs summarize bus scanner commands and also cover such aspects as closing and opening channels, card configuration, and scanning over the bus.

3.5.1 IEEE-488 bus scanner commands

Table 3-3 summarizes commands that control basic scanning operations over the IEEE-488 bus. For information on other bus commands, refer to the Model 6517 Electrometer User's Manual.

Table 3-3
Summary of IEEE-488 bus scanner commands

Command	Description
:ROUte :CLOSe <channel list> :STATe? :CLOSe? <channel list> :OPEN <channel list> :OPEN:ALL :OPEN? <channel list> :SCAN [:INteRnal] <scan list> [:INteRnal]? :EXteRnal <n channels> :EXteRnal? :LSElect INTERNAL EXteRnal NONE :LSElect? :STIME <n> :STIME? :SMETHod VOLTage CURRent :SMETHod? :VSLimit :VSLimit?	Route subsystem. Close channels. Query channel state. Query closed channels. Open channels. Open all channels. Query open channels. Scanning commands. Program internal scan list. Query internal scan list. Program external scan number of channels (1 <=n <=400). Query external scan number of channels. Select scan list. Query selected scan list. Program settling time (0.000 <= n <= 999.999 sec). Query settling time. Select scan method (voltage=break before make). Query scan method. Set voltage source limit (1 = 200V) Query voltage source limit.

NOTES:

1. When querying specific channel states, 1 = closed, 0 = open
2. Internal scan list = 2 to 10 channels.
3. Internal channel list = 1 to 10.
4. Selecting internal scan (LSEL INT) requires that a Model 6521 or 6522 be installed.
5. Sending the STIME, SMETHod, or VSLimit commands without a 6521/22 installed will generate a "Hardware Missing" error.

3.5.2 Closing and opening channels

Closing channels

Use the CLOSe command to close any of the ten channels on the scanner card. For example, to close channel 3, you would send the following command over the bus:

```
:ROUte:CLOSe (@3)
```

Similarly, the following command would be used to close channel 7:

```
:ROUte:CLOSe (@7)
```

Note that closing a specific channel will automatically open any other closed channel.

Opening channels

Send the OPEN command to open any close channels. For example, to open channel 3, send the following command.

```
:ROUte:OPEN (@3)
```

Alternatively, you can send the following command to open any closed channel:

```
:ROUte:OPEN:ALL
```

NOTE

Turning off Model 6517 power will also open any closed channel.

3.5.3 Card configuration

Settling time

Use the STIME command to program the channel settling time, which can be programmed in the range of 0sec to 999.999sec. For example, to program a 50msec settling time, send the following command:

```
:ROUTe:SCAN:STIME 50E-3
```

Scan method

The scanner card can be configured for either voltage or current operation. When in the voltage mode, the card is configured for break-before-make operation. When in the current mode, the HI and LO terminals of each input channel remain shorted together when the channels are open.

Scan method is programmed with the SMETHod command. For example, to configure the card for current operation, send the following command:

```
:ROUT:SCAN:SMET CURR
```

Similarly, send the following command to configure the card for voltage operation:

```
:ROUT:SCAN:SMET VOLT
```

Setting the voltage source limit

The maximum recommended voltage for the Model 6522 card is 200V, while the Model 6521 is limited to 30V for safety reasons. Use the VSLimit command to program the voltage limit to 200V. For example, the following command sets the voltage limit to 200V:

```
:ROUTe:SCAN:VSLimit 1
```

3.5.4 Bus scanning

Follow the steps below to perform scanning over the bus.

Step 1: Program internal scan list

Use the :ROUT:SCAN:INT command to program a scan list (channels you wish to scan). For example, assume that you wish to scan channels 1, 3, and 5. This scan list would be programmed by sending the following command:

```
:ROUT:SCAN:INT (@ 1,3,5)
```

Step 2: Configure scanner card

Configure the scanner card as outlined previously. For example, the following commands will program the card for a set-

tlng time of 100msec, current operation, and a voltage source limit of 200V:

```
:ROUT:SCAN:STIM 0.1
:ROUT:SCAN:SMET CURR
:ROUT:SCAN:VSL 1
```

Step 3: Enable scan

After programming the scan list and functions, use the :ROUT:SCAN:LSET INT command to enable scanning as follows:

```
:ROUT:SCAN:LSET INT
```

The scanning sequence will then begin using the scan list and other scan parameters previously programmed.

To disable a scan sequence in progress, send the following command:

```
:ROUT:SCAN:LSET NONE
```

3.6 Measurement considerations

Many measurements made with the aid of the Model 6521/22 Scanner Cards are subject to various effects that can seriously affect low-level measurement accuracy. The following paragraphs discuss some of these effects and ways to minimize them.

For further information on making accurate low-level measurements, refer to the *Low Level Measurements* handbook available from Keithley Instruments. Contact the Keithley Instruments Applications Department for more information.

3.6.1 Generated currents

Any extraneous generated currents in a test system will add to the desired measured current, degrading sensitive current measurements. The following paragraphs discuss the more commonly encountered generated currents and methods to minimize their effects when using the Model 6521/22 Scanner Card.

Offset currents

Offset currents can be generated from a variety of internal or external sources. Internal offsets can be generated within the meter or scanner card itself, while external offsets can be present in connecting cables, connectors, or test fixtures

Regardless of the source of the offsets, they can be nulled using the electrometer REL feature. See the Model 6517 User's Manual for more information on using relative.

Triboelectric effects

Triboelectric currents are generated by charges created between a conductor and insulator by friction. In this situation, free electrons rub off the conductor and create a charge imbalance that causes the current to flow. A typical example would be the electrical currents generated in a coax or triax cable by flexing that cable or otherwise subjecting it to stress.

Low-noise cables are constructed with a special graphite coating under the shield(s) to minimize friction and provide a conducting path to minimize charge generation. Keithley triax cables and special low-noise coax cables are constructed in this manner; such cables should be used for any low-level measurements made using the Model 6521/22 Scanner Card. Note the conventional cable such as RG-58 is not recommended for use with the Model 6521 because of high noise currents.

Even low-noise cables generate some currents when subjected to stress. For that reason, the following precautions should be taken to minimize unwanted currents that might be generated by cables:

- Keep all cables as short as possible.
- Keep cable temperature variations to a minimum.
- Tie down or tape all connection cables to a rigid pole or fixture
- Do not bend or flex cables during sensitive measurements.
- Keep vibration sources such as motors and pumps well away from connecting cables.

Dielectric absorption

Dielectric absorption in a triax or coax connector insulator can occur when a voltage applied to the insulator causes positive and negative charges within that insulator to separate. When the voltage is removed, the separated charges generate a decaying current through circuitry connected to the scanner card.

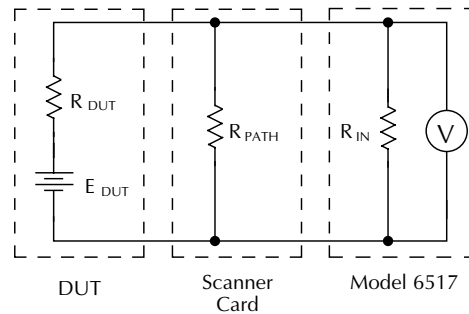
To minimize the effects of dielectric absorption, avoid applying more than a few volts to the input or output connectors of a scanner card to be used for sensitive current measurements. In cases where this practice is unavoidable, it may take minutes or even hours in some cases for currents caused by dielectric absorption to dissipate.

3.6.2 Path isolation

The path isolation is simply the equivalent impedance between any two test paths in a measurement system. Ideally, the path isolation should be infinite, but the actual resistance and distributed capacitance of cables and connectors results in less than infinite path isolation values for these devices. The capacitive component of path isolation impedance is generally fixed by design, but the resistive component can be reduced by environmental and other factors, as we will now discuss.

Path isolation resistance forms a signal path that is in parallel with the equivalent resistance of the DUT, as shown in Figure 3-1. 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 3-2.

Another phenomenon negatively affected by lower path resistance values are leakage currents that can be generated through these resistances by voltage sources in the system. Such leakage currents can, of course, seriously affect low-level current measurement accuracy. Thus, it is imperative that the path isolation resistance be as high as possible in order to minimize these effects.



- R_{DUT} = Source Resistance of DUT
- E_{DUT} = Source EMF of DUT
- R_{PATH} = Path Isolation Resistance
- R_{IN} = Input Resistance of Model 6517

Figure 3-1
Path isolation resistance

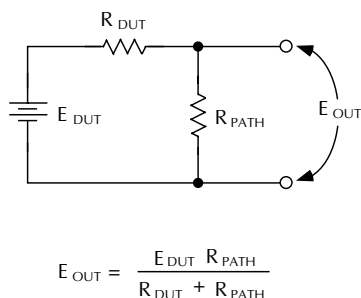


Figure 3-2
Voltage attenuation by path isolation resistance

3.6.3 Noise

Noise induced into a switching system can have serious detrimental effects on measurements made with the system. Chief among noise considerations are magnetic fields, radio frequency interference, and ground loops.

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 6517 Electrometer/High Resistance System 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 TV 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 3-3, 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.

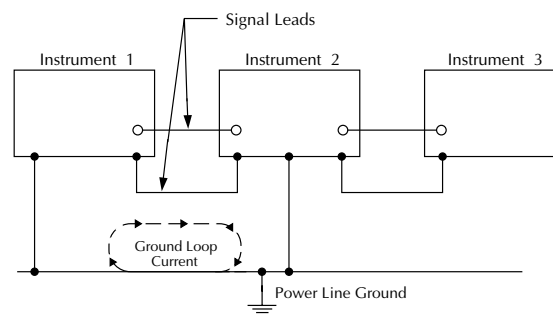


Figure 3-3
Power line ground loops

Figure 3-4 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.

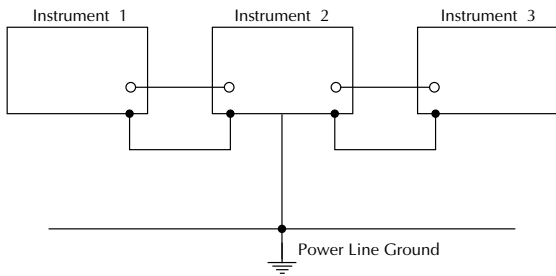


Figure 3-4
Eliminating ground loops

3.6.4 Keeping connectors clean

As is the case with any high-resistance device, the integrity of the triax and BNC connectors used on the Model 6521/22 can be compromised if they are not handled properly. If connector insulators become 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 BNC or triax connector insulating materials. In addition, the scanner card should be used only in clean, dry environments to avoid contamination.

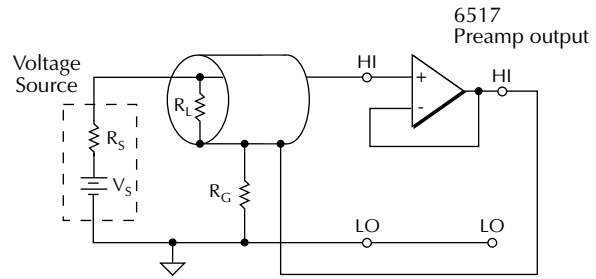
If the connector insulators should become contaminated, either by inadvertent touching, or from air-borne deposits, they can be cleaned with a cotton swab dipped in clean methanol. After thorough cleaning, they should be allowed to dry for several hours in a low-humidity environment before use, or they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

See Section 4 for additional information on cleaning scanner card connectors.

3.6.5 Guarded operation

Guarding is useful when making measurements from voltage sources that have high internal source resistances. As shown in Figure 3-5, guarding consists of surrounding a signal-carrying lead with a guard signal that is driven by the low-impedance electrometer preamp output. Since the guard shield is at the same potential as the HI signal lead, no leakage cur-

rent is supplied by the high-impedance source being measured, and no loading occurs. Leakage between the guard shield and the outer (chassis ground shield) may be considerable, but that leakage current is of no consequence since it is supplied by the low-impedance preamp rather than by the high-impedance source itself.



R_S = Source resistance
 R_L = Leakage resistance
 R_G = Guard-to-ground resistance

Figure 3-5
Guarded operation

In order to use guarding with the Model 6522 Scanner Card, be sure to make appropriate signal connections, and place the Model 6517 in the guarded mode (see the Model 6517 User's Manual for details).

NOTE

The Model 6521 Scanner Card is designed for current measurements and cannot be used for guarded voltage measurements. The Model 6517 Electrometer cannot be placed in the guarded mode when the Model 6521 is installed.

3.6.6 Voltage/current scan mode

The Model 6517 Electrometer can be programmed for the voltage or current scan mode. When in the voltage scan mode, the relays are operated under a break-before-make basis, which means that the relay for the present channel opens before the relay for the next channel closes. Thus, to avoid possible damage to the Model 6521/6522 or external circuits, you should always program the Model 6517 for the voltage scan mode when switching voltages. The voltage scan mode is also recommended for resistance or charge function switching.

When the Model 6517 is programmed for the current scan mode, a ground relay contact shorts the HI and LO terminals of each off channel, maintaining a true current path at all times. For that reason, you should program the Model 6517 to operate in the current scan mode when switching currents.

See paragraphs 3.4.4 and 3.5.3 for more information on selecting the voltage or current scan modes.

3.7 Typical applications

Typical applications for the Model 6521/22 are discussed in the following paragraphs. For more information on these and other scanner card applications, contact the Keithley Applications Department.

3.7.1 Capacitor leakage measurements

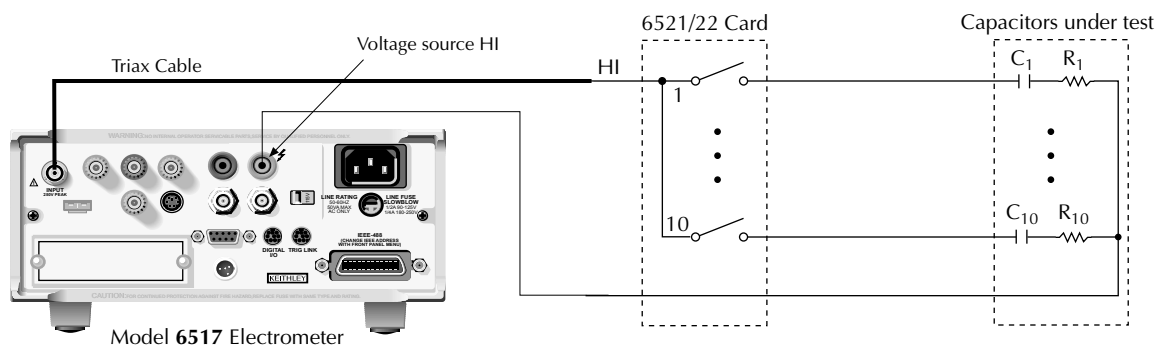
One of the more important test parameters associated with capacitors is their leakage characteristics. Such leakage may be specified as the “IR” (Insulation Resistance), or it may be expressed as leakage current at a given voltage, usually the operating voltage.

Since capacitor leakage characteristics are largely dependent on the applied voltage, an ordinary ohmmeter is of little

value in making such tests. Instead a fixed voltage is applied to the capacitor, and the resulting leakage current is measured. Leakage resistance can then be determined by simple computation.

In many cases, a number of capacitors of a given type are tested in order to obtain useful statistical data. In those cases, an automated test system like the one shown in Figure 3-6 may be used to test a number of capacitors. The system includes a Model 6517 Electrometer to apply test voltages and measure leakage currents, while the Model 6521/22 Scanner card provides the necessary switching functions. The electrometer ohms function can be used, of course, to measure the leakage resistance directly. Resistors are connected in series with the capacitors under test to limit current and reduce noise.

The test configuration shown in Figure 3-6 can be used only where test speed is unimportant because of the capacitor charging time caused by large RC time constants, particularly with larger value capacitors. If shorter test times are required, external switching can be added to allow a voltage to be applied to each capacitor for a “bias” time before each test. (The bias time is the period required for the capacitor to charge fully, or about five RC time constants.)



Note: Electrometer must be configured for internal voltage source connection

Figure 3-6
Capacitor leakage test system

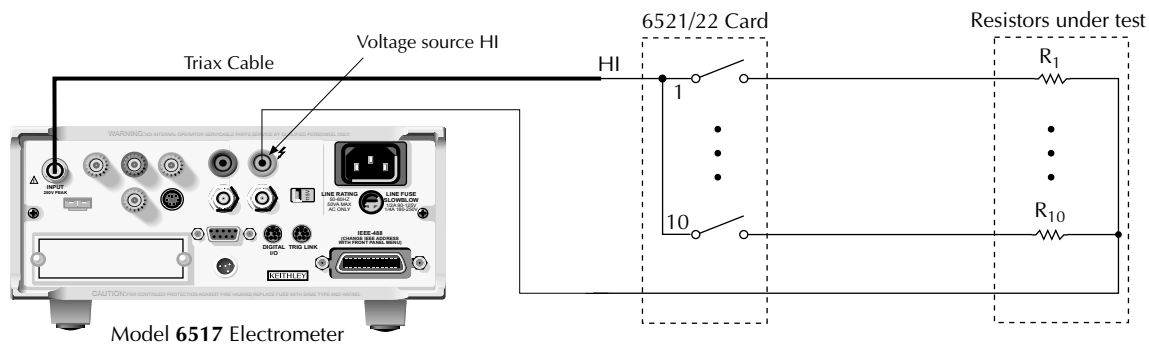
3.7.2 High-resistance measurements

Resistors with values of $1\text{G}\Omega$ or more are often referred to as high-megohm resistors. Such resistors often exhibit unusual characteristics such as changes in resistance with applied voltage. (Such change in resistance is known as the voltage coefficient, which is given in percent/volt, or ppm/volt.)

As with many other component evaluation tests, high-megohm resistance tests are often best performed on an automated basis since testing usually involves multiple devices. Figure 3-7 demonstrates a test system using the Model 6517 Electrometer along with a Model 6521/22 Scanner Card to perform automated high-resistance testing on up to 10 resistors simultaneously. The test voltage is, of course, supplied by the Model 6517 voltage source, while the electrometer section measures the current through each resistor. The instrument then computes and displays the value of each resistor automatically.

Since the resistance of such devices varies with applied voltage, all testing should be done at the same voltage for comparative analysis to be valid. Alternatively, the voltage coefficient may be determined by measuring the resistance at two different voltages and then computing the voltage coefficient as follows:

$$\text{Voltage Coefficient (\%)} = \frac{R_2 - R_1}{R_1(V_2 - V_1)} \times 100$$



Note: Electrometer must be configured for internal voltage source connection

Figure 3-7
High-resistance test system

Where: V_1 = first applied voltage
 V_2 = second applied voltage
 R_1 = resistance with V_1 applied
 R_2 = resistance with V_2 applied

Since high resistance values are involved, it is imperative that only the highest-quality components be used for the test fixture. All insulators throughout should be made of a material with very high resistance such as Teflon. Any residual leakage current can be nulled out by suppressing the measured current.

3.7.3 Low-current measurements

Both the Models 6521 and 6522 are ideal for low-current measurements because of their low offset currents. Also, when the Model 6517 is programmed for the current scan mode, the HI and LO terminals of all off channels are shorted together, an important requirement when switching current sources. (See paragraph 3.4.4 for information on programming the Model 6517 for the current scan mode.)

Figure 3-8 demonstrates an application using low-current switching, with the current sources connected to the channel inputs as usual. In this example, channel 1 is closed so that current from the source flows into the electrometer INPUT jack. All other channels are open, but their ground relays remain closed so that the current paths are not broken.

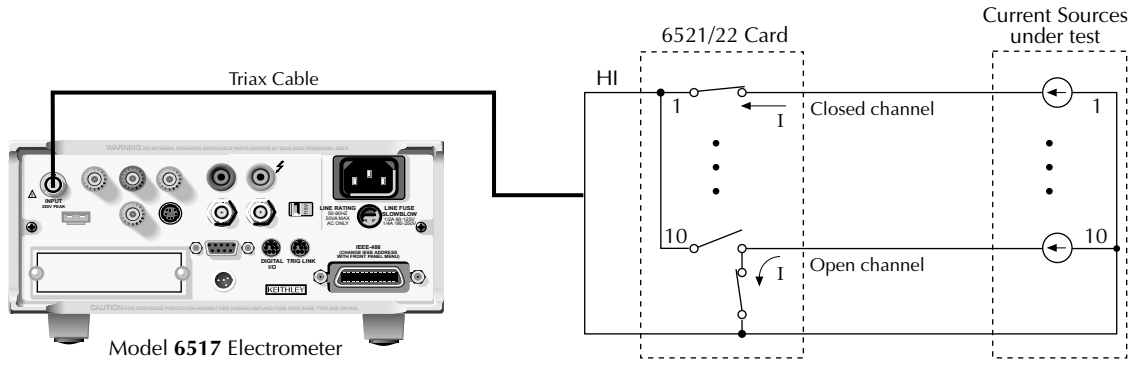


Figure 3-8
Low-current test system

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.

4.1 Introduction

This section contains information necessary to service the Model 6521/22 scanner card and is arranged as follows:

- 4.2 **Handling and cleaning precautions:** Discusses handling precautions and methods to clean the card should it become contaminated.
- 4.3 **Performance verification:** Covers the procedures necessary to determine if the scanner card meets stated specifications
- 4.4 **Special handling of static-sensitive devices:** Reviews precautions necessary when handling static-sensitive devices.
- 4.5 **Principles of operation:** Briefly discusses circuit operation.
- 4.6 **Troubleshooting:** Presents some troubleshooting tips for the Model 6521/22 including relay replacement precautions.

4.2 Handling and cleaning precautions

Because of the high-impedance areas on the Model 6521/22, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be observed when servicing the card.

4.2.1 Handling precautions

- Handle the card only by the edges and shields.
- Do not touch connector insulators.
- 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.

4.2.2 Soldering considerations

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, then blow dry the board with dry nitrogen gas.
- After cleaning, the card should be allowed to dry in a 50°C low-humidity environment for several hours before use.

4.3 Performance verification

The following paragraphs discuss performance verification procedures for the Model 6521/22, including offset current, channel and input isolation, contact resistance, and contact potential.

CAUTION

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.

NOTE

Failure of any performance verification test may indicate that the scanner card or its input/output connectors are contaminated. See paragraph 4.2 for information on cleaning the card.

4.3.1 Environmental conditions

All performance verification measurements should be made under the following environmental conditions:

- Offset current and isolation measurements: 23°C, <60% relative humidity.
- All other measurements: 18°C to 28°C, <70% relative humidity.

4.3.2 Recommended verification equipment

Table 4-1 summarizes the equipment necessary for performance verification, along with an application for each item

NOTE

Various coax/triax cables, adapters, and wires (not shown) are also required. Use only high-quality low-noise coax/triax cables and adapters, and Teflon-insulated wires where required. (See paragraph 1.9 in Section 1 for cable recommendations.) Make sure that connector and adapter insulators are clean and free of contamination.

4.3.3 Scanner card connections

Various cables should be connected to the input/output jacks before the card is installed in the electrometer. Also, a number of triax/BNC adapters are required. See the pertinent drawings for each procedure and the detailed connection information provided in Section 2.

Table 4-1
Recommended verification equipment

Description	Manufacturer/Model	Specifications ¹	Application
Electrometer	Keithley 6517	20pA, 1% 20GΩ, 20TΩ, 1%	Control card, measure offset current, isolation
Digital Multimeter	Keithley 2001	20Ω, 79ppm 200mV, 44ppm	Contact resistance

¹ Full-range input specifications

² Various coax/triax cables, adapters, and wires (not shown) are also required. Use only high-quality low-noise coax/triax cables and adapters, and Teflon insulated wires where required. make sure that connector and adapter insulators are clean and free of contamination.

4.3.4 Offset current tests

Offset current tests are performed by measuring the residual current of each Model 6521/22 channel by closing each channel in succession and then measuring the offset current using the Model 6517 Electrometer.

Proceed as follows:

1. With the power off, install the Model 6521/22 Scanner Card in the Model 6517 OPTION SLOT.
2. Connect the scanner card triax output cable to the Model 6517 INPUT jack. (See Figure 4-1.) Also install the BNC (Model 6521) or triax (Model 6522) shielding cap on each channel 1 input cable connector.
3. Program the Model 6517 for the current scan mode (see paragraph 3.4.4).
4. Turn on the electrometer, and allow a one-hour warm-up period before performing the offset current tests.
5. Select the electrometer amps function and the 20pA range. Leave zero check enabled for the time being.
6. Press the OPTION CARD button, then use the CHANNEL-CLOSURES menu to close channel 1 on the scanner card.
7. Disable zero check, and allow the reading to settle.
8. Verify that the Model 6517 current reading, which represents the scanner card offset current, is $<1\text{pA}$.
9. Enable zero check, then open channel 1.
10. Repeat steps 6 through 9 for channels 2 through 10. For each channel, be sure to connect the shielding cap to the input cable, close the appropriate channel, then verify that the offset current is $<1\text{pA}$.

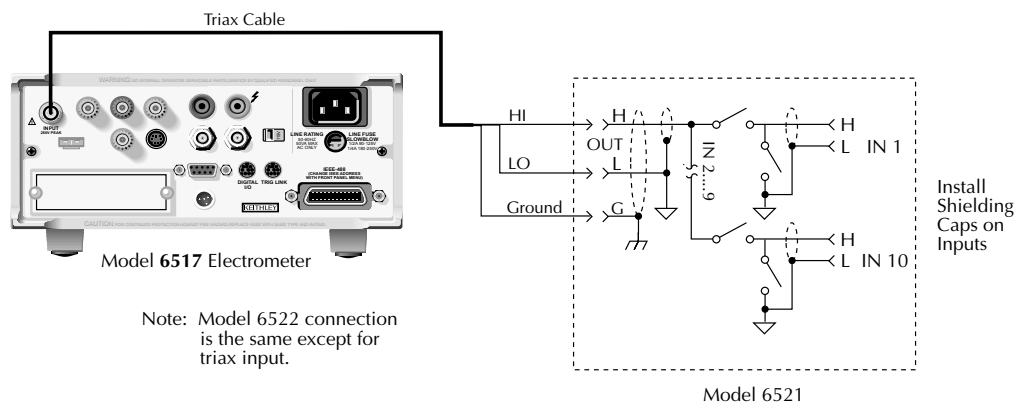


Figure 4-1
Connections for offset current verification

4.3.5 Signal path contact resistance tests

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

1. Connect an alligator clip lead to the HI and LO input jacks of the DMM to be used for the test. (See Figure 4-2.)
2. Turn on the DMM, and allow it to warm up for one hour before making the tests.
3. Select the ohms function and the 20Ω range on the DMM.
4. Temporarily short the ends of the DMM leads together, then enable the DMM REL mode to null out any residual test lead resistance. Leave REL enabled for the remainder of the contact resistance tests.
5. With the power off, install the scanner card in the Model 6517 Electrometer OPTION SLOT.
6. Connect the DMM LO input lead to the HI terminal of the channel 1 input cable using bare wire or a suitable adapter, and connect the DMM HI input lead to the HI terminal of the scanner card output jack with a similar adapter. (Again, refer to Figure 4-2.)
7. Turn on the Model 6517 power.
8. Press the OPTION CARD button, then use the CHANNEL-CLOSURES menu to close channel 1 on the scanner card.
9. Note the resistance reading on the DMM. Verify that the reading is $<1\Omega$.
10. Repeat steps 8 and 9 for channels 2-10. When testing each channel, be sure to:
 - Connect the DMM to the HI input terminal of the channel being tested.
 - Close the channel being tested.

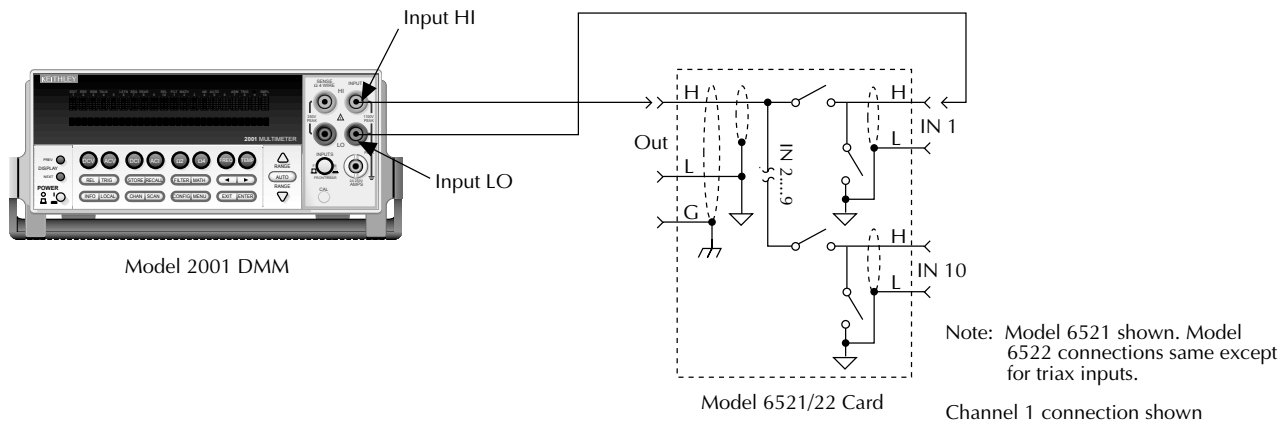


Figure 4-2
Connections for signal path contact resistance tests

4.3.6 Ground relay contact resistance tests

Perform the following steps to verify that the contact resistance of the ground relay for each channel is within specific limits.

1. Connect an alligator clip lead to the HI and LO input jacks of the DMM to be used for the test. (See Figure 4-3.)
2. Turn on the DMM, and allow it to warm up for one hour before making the tests.
3. Select the ohms function and the 20Ω range on the DMM.
4. Temporarily short the ends of the DMM leads together, then enable the DMM REL mode to null out any residual test lead resistance. Leave REL enabled for the remainder of the contact resistance tests.
5. With the power off, install the scanner card in the Model 6517 Electrometer OPTION SLOT.
6. Turn on the Model 6517 power.
7. Press CONFIG then CARD, and program the Model 6517 for the current scan mode. (See paragraph 3.4.4 for details.)
8. Press the OPTION CARD button, then select OPEN-ALL-CHANNELS in the CHANNEL SELECTION menu to make certain that all channels are open.
9. Connect the DMM to the HI and LO terminals of the channel 1 input jack, as shown in Figure 4-3.
10. Note the resistance reading on the DMM. Verify that the reading is $<1\Omega$.
11. Repeat steps 9 and 10 for channels 2-10. Be sure to connect the DMM to the HI and LO input terminals of the channel being tested. Also, the channel being tested must be open so that the ground relay is closed.

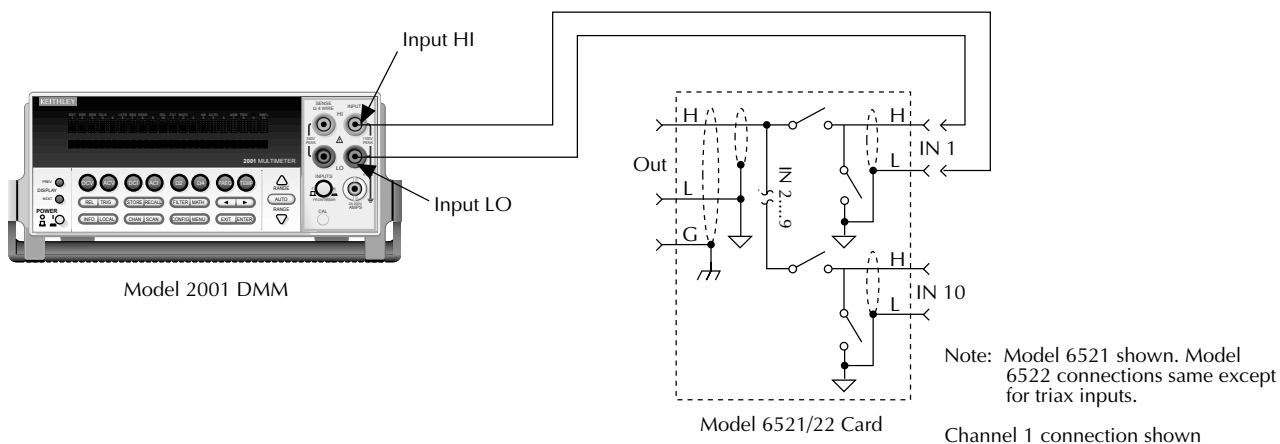


Figure 4-3
Connections for ground relay contact resistance tests

4.3.7 Isolation tests

These tests check the leakage resistance (isolation) between all Model 6522 channel input HI and LO terminals, and the input isolation between the HI and LO terminals of each channel. In general, the test is performed by applying a voltage from the Model 6517 voltage source across the terminals and then measuring the isolation resistance using the ohms function of the electrometer.

NOTE

The isolation tests covered here should be performed only on the Model 6522 Scanner Card. Isolation values for the Model 6521 Scanner card are not specified

Channel isolation

Perform the following steps to check channel isolation:

1. With the power off, install the scanner card in the electrometer OPTION SLOT.
2. Turn on the Model 6517 power, and allow the unit to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.

WARNING

The following steps use high voltage. Be sure to turn off the Model 6517 voltage source before making connection changes.

3. Select the Model 6517 ohms function, choose the 20T Ω range, and make certain zero check is disabled.
4. Connect the Model 6517 to the channels 1 and 2 HI input terminals, as shown in Figure 4-4.
5. Press the OPTION CARD button, use the CHANNEL-CLOSURES menu to close channel 1. Program the voltage source for 200V, and then turn on the Model 6517 voltage source.

6. Verify that the Model 6517 resistance reading is $>10T\Omega$.
7. Turn off the voltage source, and open channel 1.
8. Repeat steps 6 through 8 for channels 2 through 10. (Measure resistance between each channel in succession and all other channels.)
9. Repeat the entire procedure for channel LO input terminals.

Input isolation

Perform the following steps to check input isolation:

1. With the power off, install the scanner card in the electrometer OPTION SLOT.
2. Turn on the Model 6517 power, and allow the unit to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.

WARNING

The following steps use high voltage. Be sure to turn off the Model 6517 voltage source before making connection changes.

3. Select the Model 6517 ohms function, choose the 20G Ω range, and make certain zero check is disabled.
4. Connect the Model 6517 to the channel 1 HI and LO input terminals, as shown in Figure 4-5.
5. Press the OPTION CARD button, use the CHANNEL-CLOSURES menu to close channel 1. Program the voltage source for 200V output, and then turn on the Model 6517 voltage source.
6. Verify that the Model 6517 resistance reading is $>10G\Omega$.
7. Turn off the voltage source, and open channel 1.
8. Repeat steps 5 through 7 for channels 2 through 10. (Measure resistance between HI and LO of each channel with that channel closed.)

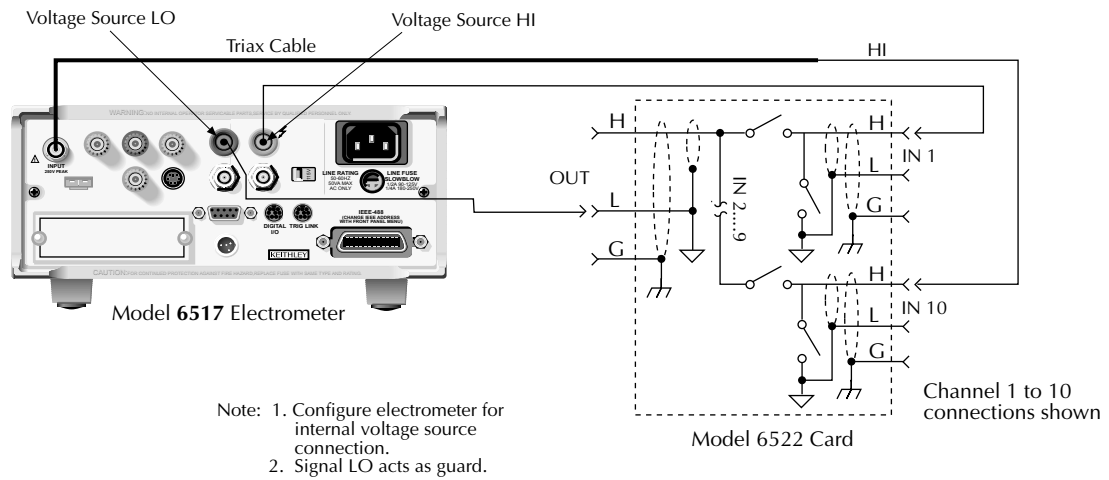


Figure 4-4
Connections for channel isolation

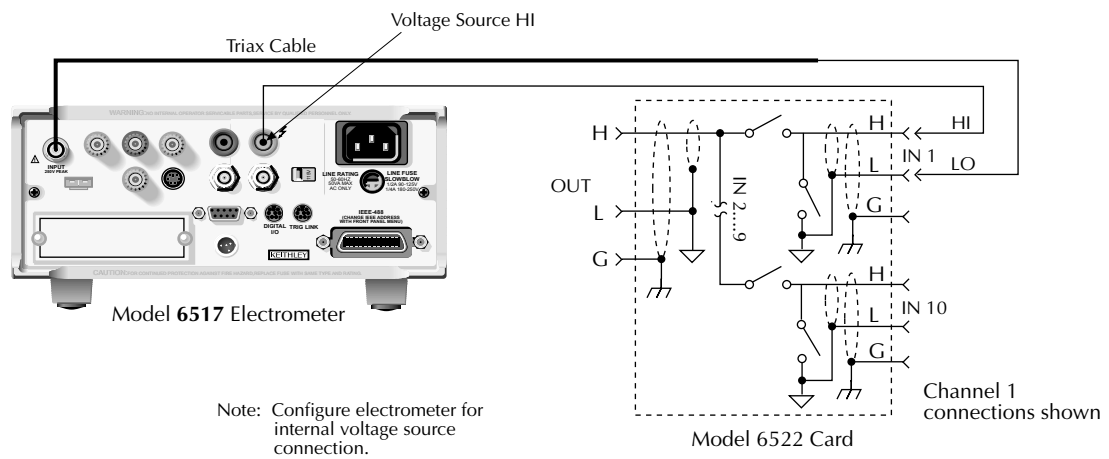


Figure 4-5
Connections for input isolation

4.4 Special handling of static-sensitive devices

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

NOTE

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

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

4.5 Principles of operation

The following paragraphs discuss the basic operating principles for the Model 6521/22, and can be used as an aid in troubleshooting the card. The schematic drawings of the scanner cards are located at the end of Section 5.

4.5.1 Block diagram

Figure 4-6 shows a simplified block diagram of the Model 6521/22. Key elements include the relay data control circuits, the relay drivers and relays, and the power-up reset circuit. These various elements are discussed in the following paragraphs.

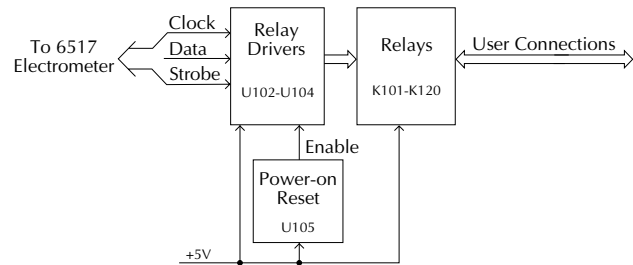


Figure 4-6
Block diagram

4.5.2 Relay control

Card relays are controlled by serial data transmitted from the host electrometer via the relay DATA line. A total of three bytes are shifted in serial fashion into latches located in the card relay driver ICs (U102- U104). The serial data is clocked in by the CLK (clock) line. As data overflows one register, it is fed out the QS line of the register down the chain.

Once all three bytes have shifted into the card, the STR 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.

4.5.3 Switching circuits

Signal switching is performed by relays K101 through K120. Even-numbered relays (K102 through K120) perform the actual signal switching, while odd-numbered relays (K101 through K119) maintain a common path for current switching by maintaining a current path to common when a channel is open.

4.5.4 Power-on/power-off safeguard

A power-on/power-off safeguard circuit, made up of U105 and associated components ensures that relays do not randomly energize on power-up and power-down. This circuit disables all relays (all relays are open) during power-up and power-down periods by holding the OE (output enable) lines high during these periods.

4.6 Troubleshooting

4.6.1 Troubleshooting equipment

Table 4-2 summarizes recommended equipment for troubleshooting the Model 6521/6522.

Table 4-2
Recommended troubleshooting equipment

Description	Manufacturer/ Model	Application
Multimeter	Keithley 2001	DCV checks
Oscilloscope	TEK 2243	View logic waveforms

4.6.2 Troubleshooting access

In order to gain access to the scanner card circuit board to measure voltages under actual operation conditions, perform the following steps:

1. Turn off the Model 6517 power, and disconnect the line cord and all other equipment.

WARNING

Disconnect the line core and all other equipment from the Model 6517 and the scanner card before removing the cover.

2. If cables are connected to the scanner card, remove the scanner card from the electrometer.
3. Remove the Model 6517 cover.
4. Install the scanner card in the electrometer.
5. Disconnect any cables connected to the scanner card input/output jacks.
6. Connect the line cord, and turn on the power to measure voltages (see following paragraph).

4.6.3 Troubleshooting procedure

Table 4-3 summarizes scanner card troubleshooting steps. Refer to the schematic diagrams and component layout drawings at the end of Section 5 for component locations.

WARNING

Lethal voltages are present within the Model 6517. Some of the procedures may expose you to hazardous voltages. Observe standard safety precautions for dealing with live circuits. Failure to do so could result in personal injury or death.

CAUTION

Observe the following precautions when troubleshooting or repairing the switch card:

- To avoid contamination, which could degrade card performance, always handle the card only by the side edges. Do not touch edge connectors, board surfaces, or components on the card. Also, do not touch areas adjacent to electrical contacts on connectors.
- Use care when removing relays from the PC board to avoid pulling traces away from the circuit board. Before attempting to remove a relay, use an appropriate de-soldering tool to clear each mounting hole completely free of solder. Each relay pin must be free to move in its mounting hole before removal. Also, make certain that no burrs are present on the ends of the relay pins.

Table 4-3
Troubleshooting procedure

Step	Item/component	Required condition	Comments
1	Digital ground P1034, pin 1, 3, 5		All voltages referenced to digital ground.
2	P1034, pin 9	+5VDC	Card power supply voltage.
3	U102, pin 2	CLK pulses	During relay update sequence only.
4	U102, pin 3	DATA pulses	During relay update sequence only.
5	U102, pin 7	STR pulse	End of relay update sequence.
6	U102-U104, pins 10-18	Low with relay	Relay driver outputs. Low with relay energized, high with relay de-energized.

5

Replaceable Parts

5.1 Introduction

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 6521/22.

5.2 Parts lists

Parts lists for the scanner cards are included in tables integrated with schematic diagrams and component layout drawings for the boards. Parts are listed alphabetically in order of circuit designation.

5.3 Ordering information

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

- Card model number (6521/22)
- Card serial number
- Part description
- Circuit description, if applicable
- Keithley part number

5.4 Factory service

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

- Call the 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 6517 Electrometer with the card.

5.5 Component layouts and schematic diagrams

Component layout drawings and schematic diagrams are included on the following pages integrated with the parts lists for the Model 6521 and Model 6522 Scanner Card.

Model 6521 Parts List

Circuit Desig.	Description	Keithley Part No.
	BNC JACK	CS-832
	CABLE ASSEMBLY	6521-SCAN-1
	CAP (OUTPUT)	CAP-28-1
	CAP, PROTECTIVE (INPUT 1)	CAP-18
	CAP, PROTECTIVE (INPUT 2-10)	CAP-30-1
	CONNECTOR (FOR SC-22)	CS-810
	EPROM PROGRAM	6521-800A01
	GROMMET, POLYETHYLENE	GR-34
	HANDLE	HH-38
	LOW NOISE COAXIAL CABLE	SC-110
	REAR BRACKET	6522-304-1A
	REAR PANEL	6522-302A
	SHIELD	6522-305-1A
	TERMINAL, COAX SHIELD (FOR SC-22 AND SC-36)	TE-114
	TRIAx CABLE (IN1-10)	SC-22
	TRIAx 3 SLOT CABLE PLUG (FOR OUTPUT)	CS-631
	4-40X5/16 PHILLIPS PAN HD SEMS	4-40X5/16PPHSEM
C101-106	CAP, .1UF, 20%, 50V, CERAMIC(1206)	C-418-1
C107	CAP, 10UF, 20%, 25V, TANTALUM (D7243)	C-440-10
C108	CAP, 100UF, 20%, 16V, TANTALUM (7243)	C-504-100
K101-120	RELAY, 1FORMA, COTO 1203-0147	RL-181
P1034	CONNECTOR, FEMALE 48 PIN	CS-826-2
R101, 102	RES 4.7K, 5%, 125MW, METAL FILM (1206)	R-375-4.7K
R103	RES, 1K, 5%, 125MW, METAL FILE (1206)	R-375-1K
U101	EPROM PROGRAM	6521-800*
U102-104	IC, 8 STG/SHFT/STR REG, UCN5841LW(SOLIC)	IC-857
U105	IC, SUPPLY VOLT SUPERVISOR, TL7705A(SOIC)	IC-860
W101	SHIELDED COAX TEFLON	SC-36

* Order current firm are revision level.

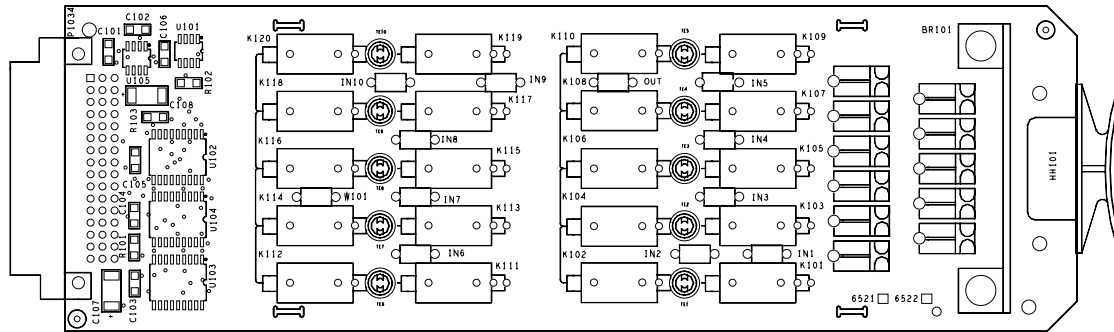
Model 6522 Parts List

Circuit Desig.	Description	Keithley Part No.
	CAP (OUTPUT)	CAP-28-1
	CAP, PROTECTIVE (INPUT 2-10)	CAP-30-1
	CAP, PROTECTIVE (INPUT 1)	CAP-31
	CABLE ASSEMBLY	6522-SCAN-1
	CONNECTOR	CS-829
	CONNECTOR (FOR SC-22)	CS-810
	GROMMET, POLYETHYLENE	GR-34
	HANDLE	HH-38
	REAR BRACKET	6522-304-2A
	REAR PANEL	6522-302A
	SHIELD	6522-305-2A
	TERMINAL, COAX SHIELD (FOR SC-22 AND SC-36)	TE-114
	TRIAx CABLE (IN1-10)	SC-22
	TRIAx 3 SLOT CABLE PLUG (FOR OUTPUT)	CS-631
	4-40X5/16 PHILLIPS PAN HD SEMS	4-40X5/16PPHSEM
C101-106	CAP, .1UF, 20%, 50V, CERAMIC(1206)	C-418-1
C107	CAP, 10UF, 20%, 25V, TANTALUM (D7243)	C-440-10
C108	CAP, 100UF, 20%, 16V, TANTALUM (7243)	C-504-100
K101-120	RELAY, 1FORMA, COTO 1203-0147	RL-181
P1034	CONNECTOR, FEMALE 48 PIN	CS-826-2
R101, 102	RES 4.7K, 5%, 125MW, METAL FILM (1206)	R-375-4.7K
R103	RES, 1K, 5%, 125MW, METAL FILM (1206)	R-375-1K
U101	EPROM PROGRAM	6522-800*
U102-104	IC, 8 STG/SHFT/STR REG, UCN5841LW(SOLIC)	IC-857
U105	IC, SUPPLY VOLT SUPERVISOR, TL7705A(SOIC)	IC-860
W101	SHIELDED COAX TEFLON	SC-36

* Order current firm are revision level.

001-1259

LTR.	ECA NO.	REVISION	ENG.	DATE
B				



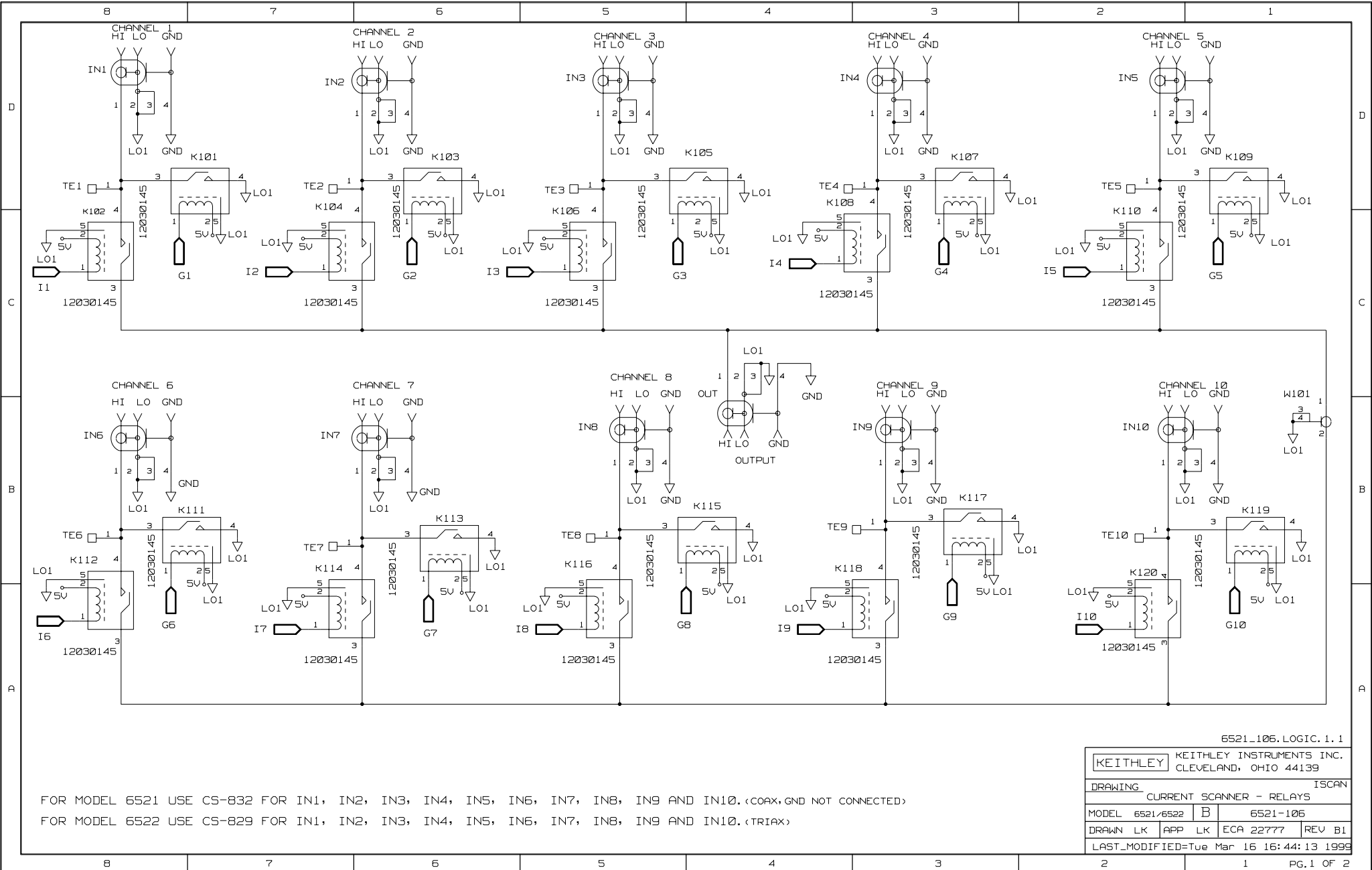
NOTE: FOR COMPONENT INFORMATION, SEE PRODUCT STRUCTURE.

NOTES:

- ARTWORK: 6521-103-04_03_02 & 01B
- SOLDER PASTE STENCIL: 6521-108-04B
- GLUE STENCIL: NA

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

 KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	DIM ARE IN IN. UNLESS OTHERWISE NOTED	DATE 6/4/94	SCALE 1:1	TITLE COMPONENT LAYOUT, LOW CURRENT SCANNER CARD
	DIM. TOL. UNLESS OTHERWISE SPECIFIED	DRN CB	APPR.	
XX = .01 ANG. = +1 XXX = .005 FRAC. = +1/64	DO NOT SCALE THIS DRAWING	B NO. 6521-100		

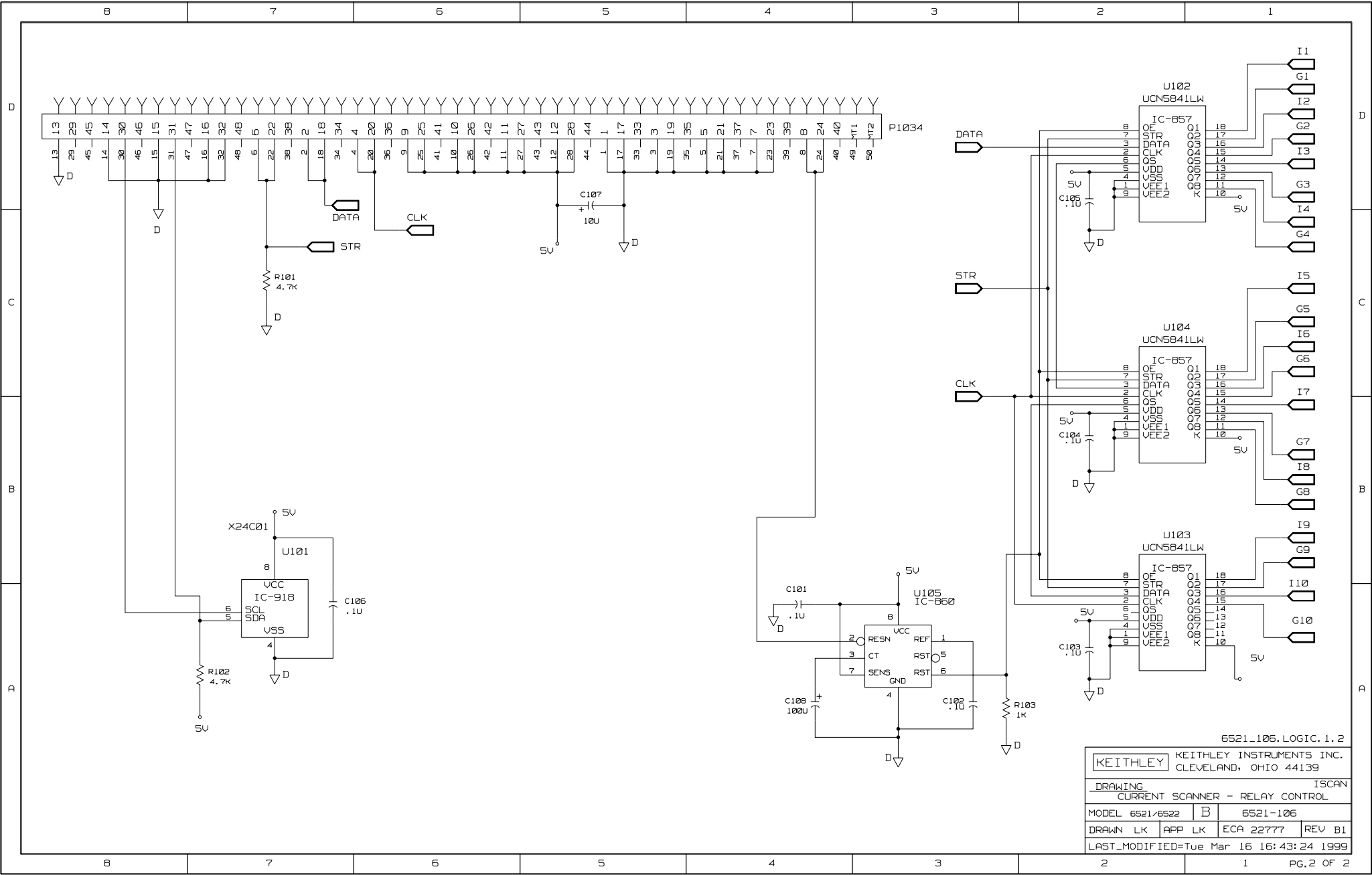


6521-106. LOGIC. 1. 1

KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
DRAWING		ISCAN	
CURRENT SCANNER - RELAYS			
MODEL 6521/6522	B	6521-106	
DRAWN LK	APP LK	ECA 22777	REV B1
LAST_MODIFIED=Tue Mar 16 16:44:13 1999			

FOR MODEL 6521 USE CS-832 FOR IN1, IN2, IN3, IN4, IN5, IN6, IN7, IN8, IN9 AND IN10. (COAX, GND NOT CONNECTED)

FOR MODEL 6522 USE CS-829 FOR IN1, IN2, IN3, IN4, IN5, IN6, IN7, IN8, IN9 AND IN10. (TRIAx)



6521_106. LOGIC. 1.2

KEITHLEY		KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	
DRAWING		ISCAN	
CURRENT SCANNER - RELAY CONTROL			
MODEL 6521/6522	B	6521-106	
DRAWN LK	APP LK	ECA 22777	REV B1
LAST_MODIFIED=Tue Mar 16 16:43:24 1999			

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Service Form

Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

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

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

Display or output (check one)

- | | |
|-----------------------------------|--|
| <input type="checkbox"/> Drifts | <input type="checkbox"/> Unable to zero |
| <input type="checkbox"/> Unstable | <input type="checkbox"/> Will not read applied input |
| <input type="checkbox"/> Overload | |

- | | |
|---|--|
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of calibration required |
| <input type="checkbox"/> Data required | |

(attach any additional sheets as necessary)

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

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

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

Relative humidity? _____ Other? _____

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

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

Specifications are subject to change without notice.

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