

Model 6517B

Reference Manual

6517B-901-01 Rev. B / June 2009

WARRANTY

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

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

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

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

LIMITATION OF WARRANTY

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

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KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

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Model 6517B Electrometer Reference Manual

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

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty 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 user documentation. 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, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments 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 user documentation.

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 1000V, 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, ensure that 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 the 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 means caution, risk of danger. The user should refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means caution, risk of danger. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation 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 the user documentation 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., a 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

Section	Topic	Page
1	Introduction	1-1
	Introduction.....	1-2
	Capabilities and features overview.....	1-2
	Available options and accessories.....	1-3
	Manual addenda.....	1-5
	Specifications.....	1-5
	Warranty information.....	1-5
	Unpacking and inspection.....	1-5
	Inspection for damage.....	1-5
	Shipment contents.....	1-6
	Repacking for shipment.....	1-6
2	Getting Started	2-1
	Introduction.....	2-2
	Front and rear panel familiarization.....	2-2
	Front panel summary.....	2-2
	Rear panel summary.....	2-4
	Power-up.....	2-6
	Line power connection.....	2-6
	Line fuse replacement.....	2-6
	Power-up sequence.....	2-7
	Display.....	2-8
	Exponent mode (Engineering or Scientific).....	2-8
	Information messages.....	2-9
	Range messages.....	2-9
	Status and error messages.....	2-11
	Multiple displays.....	2-15
	Navigating menus.....	2-17
	Menu types.....	2-17
	Navigation rules.....	2-17
	Menu.....	2-18
	SAVESETUP.....	2-19
	TEST.....	2-26
LIMITS.....	2-26	
STATUS-MSG.....	2-26	
GENERAL.....	2-26	
3	Connections	3-1
	Introduction.....	3-2
	Electrometer input connector.....	3-2
	Input configurations.....	3-2
	Maximum input levels.....	3-3
	Input protection.....	3-4
	Connection methods.....	3-4
	High-resistance meter connections.....	3-4
	Voltage source output connections.....	3-5
	V-source probes and cables.....	3-6
	Low noise cables, shielding, and guarding.....	3-6
	Low noise input cables.....	3-6
	Shielding and guarding.....	3-7
	Floating circuits.....	3-9

	Floating measurements	3-9
	Floating voltage source	3-10
	Test fixtures	3-11
	Keithley Instruments Model 8009 test fixture	3-11
	Custom built test fixtures	3-11
4	Basic Measurements	4-1
	Introduction	4-2
	Voltage measurements	4-2
	Basic measurement procedure	4-2
	Volts configuration	4-5
	Voltage measurement considerations	4-6
	Current measurements	4-9
	Basic measurement procedure	4-9
	Amps configuration	4-11
	Current measurement considerations	4-13
	Resistance and resistivity measurements	4-18
	Overview	4-18
	Resistance measurements	4-19
	Resistivity measurements	4-22
	Ohms configuration	4-27
	Ohms measurement considerations	4-30
	Charge measurements (Q)	4-31
	Basic measurement procedure	4-31
	Coulombs configuration	4-33
	Charge measurement considerations	4-34
	Other measurement considerations	4-35
	Ground loops	4-35
	Triboelectric effects	4-36
	Piezoelectric and stored charge effects	4-36
	Electrochemical effects	4-36
	Humidity	4-36
	Light	4-37
	Electrostatic interference	4-37
	Magnetic fields	4-37
	Electromagnetic interference (EMI)	4-38
	Relative humidity and external temperature readings	4-38
5	Measurement Options	5-1
	Introduction	5-2
	Voltage source	5-2
	V-Source configuration	5-2
	Sourcing options	5-3
	Setting voltage source value	5-6
	Voltage and current limit	5-7
	Interlock and test fixtures	5-7
	Operate	5-8
	Analog outputs	5-8
	2 V analog output	5-9
	Preamp out	5-11
	Using external feedback	5-12
	Electrometer input circuitry	5-12
	Shielded fixture construction	5-13
	External feedback procedure	5-14
	Non-standard coulombs ranges	5-15
	Logarithmic currents	5-15
	Non-decade current gains	5-16
	Range and resolution	5-17
	Measurement range	5-17
	Display resolution	5-17
	Zero check, relative, and zero correct	5-18
	Zero check	5-18
	Relative (REL)	5-19
	Zero correct	5-20

6	Test Sequences	6-1
	Introduction	6-2
	Test sequences	6-2
	Test descriptions	6-2
	Diode leakage current test	6-2
	Capacitor leakage current test	6-4
	Cable insulation resistance test	6-4
	Resistor voltage coefficient test	6-5
	Standard method resistivity tests	6-6
	Alternating polarity resistance/resistivity test	6-7
	Surface insulation resistance (SIR) test	6-8
	Sweep tests (square wave and staircase)	6-9
	Configuring test sequences	6-11
	Configure sequence menu	6-11
	Menu sections	6-12
	Running the selected test	6-14
7	Triggering	7-1
	Introduction	7-2
	Trigger configuration menu	7-2
	Trigger models	7-4
	Basic trigger model	7-4
	Advanced trigger model	7-5
	Trigger model layers	7-7
	Trigger configuration	7-8
	Basic trigger configuration	7-8
	Advanced trigger configuration	7-9
	External triggering	7-14
	Trigger link connector	7-14
	Asynchronous operation	7-14
	Semi-synchronous operation	7-18
8	Buffer (Data Store)	8-1
	Introduction	8-2
	Buffer overview	8-2
	Maximum readings	8-2
	Data elements	8-2
	Configuring data storage	8-3
	Data store configuration menu	8-4
	Storing and recalling readings	8-6
	Buffer multiple displays	8-7
9	Filters and Math	9-1
	Introduction	9-2
	Filters	9-2
	Digital filters	9-2
	Median filter	9-3
	Configuring the filters	9-5
	Math	9-7
	Polynomial	9-7
	Percent	9-7
	Percent deviation	9-8
	Deviation	9-8
	Ratio	9-8
	Logarithmic	9-8
	Selecting and configuring math	9-9
	Math multiple display	9-10
10	Limits, Digital I/O, and Scanning	10-1
	Introduction	10-2
	Limits	10-2
	Setting limits	10-2
	Strobe control	10-4
	Pass pattern	10-4

	Limits example.....	10-4
	Digital I/O	10-5
	Digital I/O menu.....	10-5
	Digital I/O port.....	10-6
	Scanning	10-9
	Internal scanning	10-9
	External scanning	10-9
11	Remote Operations	11-1
	Introduction	11-2
	Standards.....	11-2
	RS-232 serial port.....	11-2
	Connections	11-2
	IEEE-488 bus connections	11-2
	RS-232 interface connections	11-4
	Selecting interface parameters	11-4
	Communication menu	11-4
	GPIB primary address selection	11-5
	General bus commands	11-6
	REN (remote enable).....	11-6
	IFC (interface clear).....	11-6
	LLO (local lockout).....	11-7
	GTL (go to local).....	11-7
	DCL (device clear).....	11-7
	SDC (selective device clear).....	11-7
	GET (group execute trigger).....	11-7
	SPE, SPD (serial polling).....	11-7
	IEEE-488 front panel operation.....	11-7
	Error and status messages.....	11-8
	IEEE-488 status indicators	11-8
	LOCAL key	11-8
	Programming syntax	11-8
	Command words	11-8
	Program messages	11-11
	Response messages	11-13
	Message exchange protocol.....	11-13
	IEEE-488 trigger model.....	11-14
	Idle and initiate	11-14
	Trigger model layers	11-14
	RS-232 serial interface.....	11-17
	RS-232 Interface configuration.....	11-17
	RS-232 operating considerations	11-18
	Error messages	11-19
12	Common Commands	12-1
	Introduction	12-2
	Common command summary	12-2
	Common command descriptions.....	12-2
13	Status Structure	13-1
	Introduction	13-2
	Status register sets.....	13-2
	Condition registers.....	13-9
	Transition filters	13-9
	Event registers.....	13-10
	Enable registers.....	13-10
	Queues.....	13-11
	Output queue	13-11
	Error queue	13-11
	Status byte and service request (SRQ).....	13-11
	Status byte register	13-11
	Service request enable register	13-13
	Serial poll and SRQ	13-13

14	SCPI Command Reference	14-1
	Introduction	14-2
	Signal-oriented measurement commands	14-2
	SCPI command summary	14-4
	SCPI command subsystems	14-25
15	Calibration Procedure	15-1
	Introduction	15-2
	Calibration procedure	15-2
	Environmental conditions	15-2
	Warm-up period	15-2
	Recommended calibration equipment	15-2
	Comprehensive calibration procedure	15-2
	Restoring factory defaults	15-3
	Unlocking calibration	15-3
	Voltage offset calibration	15-3
	Current offset calibration	15-5
	Current ranges calibration	15-6
	Coulombs ranges calibration	15-8
	Voltage measurement ranges calibration	15-9
	Voltage source calibration	15-10
	Humidity calibration	15-11
	Temperature calibration	15-11
	Set calibration dates	15-11
	Save calibration	15-11
	Lock calibration	15-12
	Partial calibration	15-12
	Calibration command reference	15-14
	Voltage offset calibration commands	15-14
	Current offset calibration commands	15-14
	Charge calibration commands	15-15
	Current calibration commands	15-16
	Voltage measurement calibration commands	15-17
	Voltage source calibration commands	15-18
	Humidity calibration commands	15-18
	Temperature calibration commands	15-19
	Error codes	15-20
16	Verification Procedure	16-1
	Introduction	16-2
	Equipment needed for verification	16-2
	Warm up time and environment	16-3
	Considerations	16-3
	Verification Procedures	16-3
	DC voltage verification	16-4
	DC amps verification	16-5
	Coulombs verification	16-7
	Voltage source verification	16-8
	Temperature verification	16-9
	Humidity verification	16-10
	.....	16-12
A	Specifications	A-1
	Specifications	A-2
	Volts	A-2
	Amps	A-2
	Coulombs	A-3
	Ohms (normal method)	A-3
	Ohms (alternating polarity method)	A-4
	Voltage source	A-4
	Temperature (thermocouple)	A-4
	Humidity	A-5
	General	A-5

B	Accuracy Calculations	B-1
	Introduction	B-2
	Calculating volts accuracy	B-2
	Calculating amps accuracy	B-2
	Calculating ohms accuracy	B-2
	Calculating coulombs accuracy	B-3
	Calculating resistance/resistivity accuracy	B-3
C	Interface Function Codes	C-1
	Interface function codes	C-2
	Code summary	C-2
	Code descriptions	C-2
D	ASCII Character Codes	D-1
	Introduction	D-2
	Code summary	D-2
E	IEEE-488 Bus Overview	E-1
	Introduction	E-2
	Bus description	E-2
	Bus lines	E-4
	Data lines	E-4
	Bus management lines	E-4
	Handshake lines	E-4
	Bus commands	E-5
	Uniline commands	E-6
	Universal multiline commands	E-6
	Addressed multiline commands	E-7
	Addressed commands	E-7
	Unaddress commands	E-7
	Common commands	E-7
	SCPI commands	E-8
	Command codes	E-8
	Typical command sequences	E-9
	IEEE command groups	E-10
F	IEEE-488 Conformance	F-1
	Information	F-2
G	SCPI Conformance	G-1
	Introduction	G-2
Index	.....	I-1

In this section:

Topic	Page
Introduction	1-2
Capabilities and features overview	1-2
Available options and accessories	1-3
Manual addenda	1-5
Specifications	1-5
Warranty information	1-5
Unpacking and inspection	1-5
Inspection for damage	1-5
Shipment contents	1-6
Repacking for shipment	1-6

Introduction

This Reference Manual is provided on the supplied product information CD in PDF format. The User's Manual, also provided on the supplied product information CD in PDF format, is an abbreviated version of the operation sections of this Reference Manual.

This section contains general information about the Keithley Instruments Model 6517B Electrometer.

If you have any questions after reviewing this information, please contact your local Keithley Instruments representative or call one of our applications engineers at 1-888-KEITHLEY (1-888-534-8453) within the U.S. and Canada. You can also visit the Keithley Instruments website to contact the applications engineering department online, at www.keithley.com, or for updated worldwide contact information.

Capabilities and features overview

The Model 6517B is a 6½-digit Electrometer/high-resistance system with the following measurement capabilities:

- DC voltage measurements from 1 μV to 210 V
- DC current measurements from 10 nA to 21 mA
- Charge measurements from 10 fC to 2.1 μC
- Resistance measurements from 10 Ω to 210 P Ω
- Surface resistivity measurements
- Volume resistivity measurements
- External temperature measurements from -25°C to 150°C using the supplied Model 6517-TP thermocouple
- Relative humidity measurements (0 to 100%) using the optional Model 6517-RH probe

Some additional capabilities of the Model 6517B include:

- Built-in V-Source: The 100 V range provides up to $\pm 100\text{V}$ at 10 mA, while the 1000 V range provides up to $\pm 1000\text{V}$ at 1 mA.
- Data storage (50,000 points)
- Single button zeroing (REL)
- Built-in math functions
- Filtering: averaging and median
- Built-in test sequences
- Remote operation using the IEEE-488 (GPIB) bus or the RS-232 interface
- Scan (measure) channels of an external scanner
- Scan (measure) channels of an internal scanner card (for example, Model 6521 or Model 6522) installed in the option slot

Available options and accessories

NOTE Check the Keithley Instruments website (www.keithley.com) for additional options and accessories that may have been added to the Keithley Instruments product line for use with the Model 6517B Electrometer.

The following options and accessories are available from Keithley Instruments for use with the Model 6517B Electrometer:

Cables and adapters

Model 237-ALG-2 Triax Cable: This is a 2 m (6.6 ft) low noise triax cable terminated with a 3-slot male triax connector on one end and three alligator clips on the other.

Model 237-BNC-TRX Adapter: This is a male BNC to 3-lug female triax adapter (guard disconnected). It is used to terminate a triax cable with a BNC plug. Suitable for use with the Model 6517B V-Source in high voltage applications.

Model 237-TRX-T Adapter: This is a 3-slot male to dual 3-lug female triax tee adapter for use with Model 7078-TRX triax cables. Suitable for use with the Model 6517B V-source in high voltage applications.

Model 237-TRX-TBC Connector: This is a 3-lug female triax bulkhead connector with cap for assembly of custom panels and interface connections. Suitable for use with the Model 6517B V-source in high voltage applications.

Model 6517B-ILC-3 Interlock Cable: This is a 3 m (9.8 ft) cable terminated with a 4-pin Phoenix Connector on one end and a 4-pin Switchcraft connector on the other end.

Model 7078-TRX-BNC Adapter: This is a 3-slot male triax to female BNC adapter. This adapter lets you connect a BNC cable to the triax input of the Model 6517B. Suitable for use with the Model 6517B in high voltage applications.

Models 7078-TRX-3, 7078-TRX-10 and 7078-TRX-20 Triax Cables: These are low noise triax cables terminated at both ends with 3-slot male triax connectors.

Table 1-1

Triax cable lengths

Model	Metric length	Imperial length
Model 7078-TRX-3	0.9 m	3 ft
Model 7078-TRX-10	3 m	10 ft
Model 7078-TRX-20	6 m	20 ft

Model 7078-TRX-TBC Connector: This is a 3-lug female triax bulkhead connector with cap for assembly of custom panels and interface connections. Suitable for use with the Model 6517B V-source in high voltage applications.

Models 7007-1 and 7007-2 Shielded IEEE-488 Cables: Connect the Model 6517B to the IEEE-488 bus using shielded cables and connectors to reduce electromagnetic interference (EMI). The Model 7007-1 is 1 m in length; the Model 7007-2 has a length of 2 m.

Models 8501-1 and 8501-2 Trigger Link Cables: Connect the Model 6517B to other instruments with trigger link connectors (for example, Model 7001 Switch System). The Model 8501-1 is 1 m long; the Model 8501-2 is 2 m long.

Model 8502 Trigger Link Adapter: Allows you to connect the trigger link of the Model 6517B to instruments that use the standard BNC (in/out) external triggering technique.

Model 8606 High Performance Probe Tip Kit: Consists of two spade lugs, two alligator clips, and two spring hook test probes. (The spade lugs and alligator clips are rated at 30 V RMS, 42.4 V peak; the test probes are rated at 1000 V.) These components are designed to be used with high performance test leads terminated with banana plugs, such as the Model 8607 High Performance Banana Cables.

Model 8607 High Performance Banana Cables: Consists of two high voltage (1000 V) banana cables. The cables are terminated with banana plugs that have retractable sheaths.

CS-751 Barrel Adapter: This is a barrel adapter that allows you to connect two triax cables together. Both ends of the adapter are terminated with 3-lug female triax connectors.

Case and rack mount kits

Model 1050 Padded Carrying Case: A carrying case for a Model 6517B. Includes handles and shoulder strap.

Model 4299-1 Single Fixed Rack Mount Kit: Mounts a single Model 6517B in a standard 19 inch rack.

Model 4299-2 Side-by-side Rack Mount Kit: Mounts two instruments side by side in a standard 19 inch rack.

Model 4288-4 Side-by-side Rack Mount Kit: Mounts a Model 6517B and a 5¹/₄ inch instrument side-by-side in a standard 19 inch rack.

Probes

Model 6517-RH Humidity Probe with Cable: This sensor allows the Model 6517B to make relative humidity measurements (0% to 100%). Also included is an extension cable (part number CA-129-1).

Model 6517-TP Thermocouple with Leads: This type K thermocouple sensor allows the Model 6517B to make external temperature measurements from –190° C to 1350° C.

Scanner cards

Model 6521 Low Current Scanner Card: This 10-channel low current scanner card is terminated with BNC connectors and plugs into the option slot of the Model 6517B.

Model 6522 Low Current/Low Voltage Scanner Card: This 10-channel low current/low voltage scanner card is terminated with triax connectors and plugs into the option slot of the Model 6517B.

Test fixture

Model 8009 Resistivity test Fixture: This is a guarded test fixture for measuring volume and surface resistivities. It can accommodate sheet samples 64 mm to 102 mm (2½ to 4 inches) in diameter and up to 3.175 mm (1/8 inches) thick.

Software

Model 6524 Hi-R Software Package: Designed to aid in making more repeatable high resistance/resistivity measurements. Four windows-driven programs increase measurement precision, ease download and analysis of Hi-R data, and allow cross-correlation of environmental factors.

Manual addenda

Any improvements or changes concerning the Model 6517B or manuals will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

Specifications

Full Model 6517B specifications are included in [Appendix B](#). Check the Keithley Instruments website at www.keithley.com for the latest updates to the specifications.

Warranty information

Warranty information is located at the front of this manual. Should your Model 6517B Electrometer require warranty service, contact the Keithley Instruments representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with the necessary information.

Unpacking and inspection

Inspection for damage

The Model 6517B was carefully inspected electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. There may be a protective film over the display lens, which can be removed. Report any damage to the shipping agent immediately. Save the original packing carton for possible future shipment. Before removing the Model 6517B from the anti-static bag, observe the following handling precautions.

Handling precautions

- Always grasp the Model 6517B by the covers.
- After removing the Model 6517B 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 Model 6517B is not installed and connected, keep the unit in its anti-static bag and store it in the original packing carton.

Shipment contents

The following items are included with every Model 6517B order:

- Model 6517B Electrometer with line cord
- Protective Triax Shield/Cap (CAP-28-1)
- 237-ALG-2 Triax Cable terminated with alligator clips on one end
- Accessories as ordered
- Certificate of calibration

Always check the Keithley Instruments website at www.keithley.com for the latest revision of the instruction manuals, which can be downloaded (in PDF format) from the website.

Repacking for shipment

Should it become necessary to return the Model 6517B for repair, carefully pack the unit in the original packing carton or the equivalent, and follow these instructions:

- Call the repair department toll-free at 1-888-KEITHLEY (1-888-534-8453), within the U.S. and Canada, to obtain a Return Material Authorization (RMA) number.
- Advise as to the warranty status of the Model 6517B.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

In this section:

Topic	Page
Introduction	2-2
Front and rear panel familiarization.....	2-2
Front panel summary	2-2
Rear panel summary.....	2-4
Power-up.....	2-6
Line power connection	2-6
Line fuse replacement.....	2-6
Power-up sequence	2-7
Display	2-8
Exponent mode (Engineering or Scientific).....	2-8
Information messages.....	2-9
Range messages	2-9
Status and error messages	2-11
Multiple displays.....	2-15
Navigating menus	2-17
Menu types	2-17
Navigation rules	2-17
Menu	2-18
SAVESETUP	2-19
TEST	2-26
LIMITS	2-26
STATUS-MSG	2-26
GENERAL	2-26

Introduction

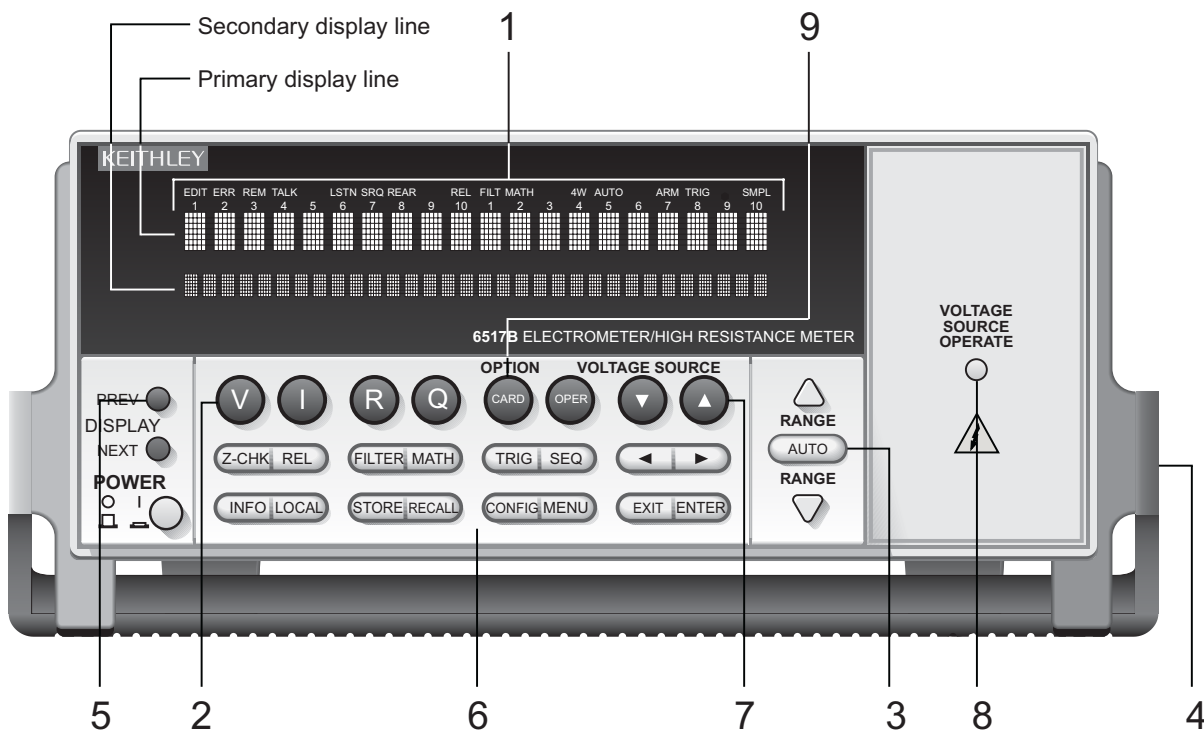
This section contains identification and descriptions of controls and components of the Keithley Instruments Model 6517B Electrometer and detailed information for powering up the Model 6517B.

Front and rear panel familiarization

Front panel summary

The front panel of the Model 6517B is shown in *Figure 2-1*. The descriptions of the front panel controls follow *Figure 2-1*.

Figure 2-1
Model 6517B front panel



1 ANNUNCIATORS

EDIT	Editing voltage source values
ERR	Questionable reading
REM	In remote
TALK	Addressed to talk
LSTN	Addressed to listen
SRQ	Service Request
REL	Relative reading displayed
FILT	Digital filter enabled
MATH	Math calculation enabled
AUTO	Autoranging enabled
ARM	Trigger armed; not in idle
*(asterisk)	Reading being stored

2 FUNCTION KEYS

Select measurement function; volts (V), amps (I), resistivity (R) or coulombs (Q).

3 RANGE KEYS

△ Moves to higher range; increments digit.
 ▽ Moves to lower range; decrements digit.
 AUTO Enables/disables autorange.

4 HANDLE

Pull out and rotate to desired position.

5 DISPLAY KEYS

PREV/NEXT Scroll through multiple displays of a function.

6 OPERATION KEYS

Z-CHK Enables/disables zero check; enable zero check before changing functions.
 REL Enables/disables relative reading.
 FILTER Displays digital filter status for present function and toggles filter on/off.
 MATH Displays math calculation and toggles math on/off if configured.
 TRIG Triggers unit.
 SEQ Performs selected test sequence.
 ◀ and ▶ Moves cursor among data entry digits, menu selections, and information displays.
 INFO Shows context-sensitive information about the present display.
 LOCAL Cancels remote operation.
 STORE Enables data storage.
 RECALL Displays reading data (reading, number, time);
 use PREV/NEXT DISPLAY for maximum, minimum average, standard deviation.
 CONFIG Configures functions and operations.
 MENU Saves/restores instrument conditions; sets up communications; performs calibration
 and self-tests; defines limits, digital output, and other miscellaneous operations.
 EXIT Cancels selection, moves back within menu structure.
 ENTER Holds reading, enters selection, moves down within menu structure.

7 VOLTAGE SOURCE KEYS

OPER Toggles V-source between operate and standby.
 △ and ▽ Adjusts V-source value.

8 VOLTAGE SOURCE OPERATE

Indicator on when in operate, off when in standby.

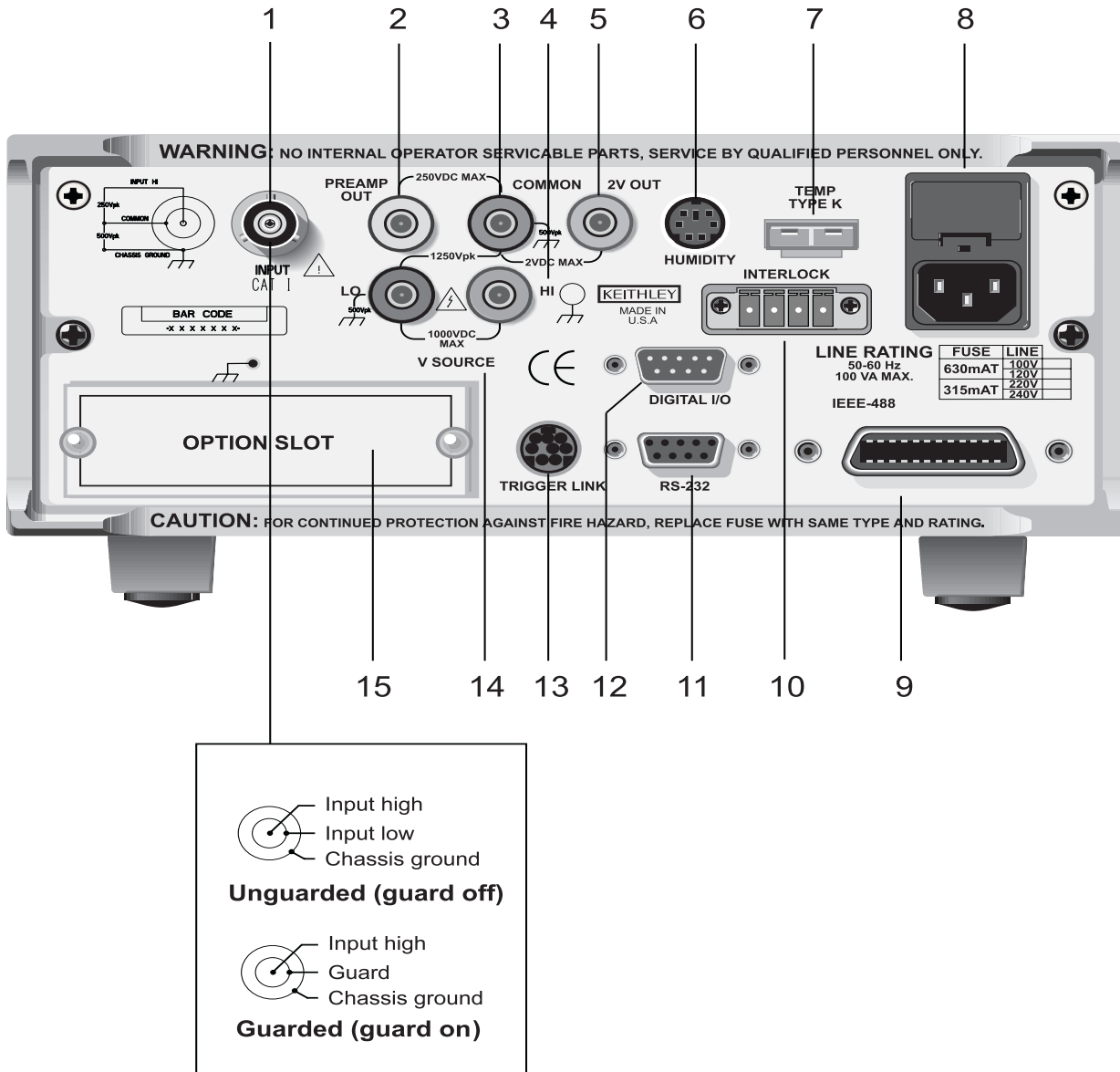
9 OPTION CARD KEY

Use to program and operate an installed option. Also used to scan external scanner channels.

Rear panel summary

The rear panel of the Model 6517B is shown in [Figure 2-2](#). The descriptions of the rear panel components follow [Figure 2-2](#).

Figure 2-2
Model 6517B rear panel



1 INPUT CONNECTOR

- Unguarded Configuration Disable **GUARD** for amps, ohms, coulombs and unguarded volts measurements
- Guarded Configuration Enable **GUARD** for guarded volts measurements

2 PREAMP OUT

Follows the signal amplitude applied to the **INPUT** terminal. With **GUARD** on, **PREAMP OUT** is internally connected to the inner shell of the **INPUT** triax connector to configure the input for guarded volts measurements. Referenced to **COMMON**. Rated at 200 V DC max. See [Section 5](#) for more information.

3 COMMON

Connector that is internally connected to **INPUT** low.

4 CHASSIS GROUND

Attached cable that connects the chassis to ground through the power line cord. **COMMON** can also be grounded by plugging the cable into **COMMON**. For floating measurements, make sure the cable connection between **COMMON** and Chassis Ground is open.

5 2V ANALOG OUTPUT

Connector that provides a scaled 0 V to 2 V output that is referenced to **COMMON**. Typically connected to a measuring device such as a chart recorder. Rated at 2 V DC max. See [Section 5](#) for more information.

6 HUMIDITY

Connect the optional Model 6517-RH probe for relative humidity measurements.

7 TEMP TYPE K

Connect the Model 6517-TP type K thermocouple for temperature measurements.

8 POWER LINE INPUT MODULE

Provides connections for power line input and contains the line fuse. If the fuse needs to be replaced, refer to [Line fuse replacement](#).

9 IEEE-488 CONNECTOR

Connects the instrument to the IEEE-488 (GPIB) bus; use shielded IEEE-488 cables.

10 INTERLOCK

Connects the safety interlock to a test fixture using an appropriate cable. Interlock is automatically enabled when the appropriate interlock cable is connected to the Model 6517B. Rated at 50 Hz to 60 Hz, 140 VA max. The interlock's CS-1305 connector includes four pins (left to right as viewed from rear of the Model 6517B):

- Pin 1: Interlock safe
- Pin 2: Ground
- Pin 3: +5 VDC output
- Pin 4: Surface/volume select (low = volume, high = surface)

See [Section 5](#) for more information.

11 RS-232

DB-9 connector for the RS-232 interface; use a standard RS-232 cable.

12 DIGITAL I/O

A male DB-9 connector for the four TTL-compatible digital output lines.

13 TRIGGER LINK

An 8-pin micro DIN connector for sending and receiving trigger pulses to and from other instruments.

14 V-SOURCE HI and LO

Safety banana jacks for the voltage source. Rated at 1000 V max.

15 OPTION SLOT

An option card, such as the Model 6521 or Model 6522 scanner card, installs in this slot.

Power-up

Line power connection

Follow the procedure below to connect the Model 6517B to line power and turn on the instrument

CAUTION Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.

1. Before plugging in the power cord, make sure that the front panel power switch is in the off (O) position. Be sure that line input voltage is set to the correct range for the power supply being used to power the Model 6517B.

NOTE Line voltage is pre-set at the factory, but may be reset in the field by adjusting the voltage selector behind the left ear (when looking at the front panel of the Model 6517B). To access the voltage selector, first remove the handle then remove the left mounting ear. The current voltage setting is the marking closest to the small circle.

2. Connect the female end of the supplied power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

WARNING *The power cord supplied with the Model 6517B contains a separate ground wire for use with grounded outlets. When proper connections are made, instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.*

Line fuse replacement

A rear panel fuse located in the power module protects the power line input of the instrument. A rear panel fuse drawer is located below the AC receptacle (see [Figure 2-2](#) item number 8). This fuse protects the power line input of the instrument. If the line voltage fuse needs to be replaced, perform the following steps.

WARNING *Make sure the instrument is disconnected from the AC line and other equipment before changing the line voltage setting or replacing the line fuse.*

1. On the side of the fuse holder are two small tabs. Use a small flat blade screwdriver to pry the fuse drawer open.
2. Slide the fuse drawer out to gain access to the fuses. Snap the old fuse out of the drawer and replace it with the same type:
 - a) For 100 V and 120 V line voltage, use a 0.630 A, 250 V, 5 mm x 20 mm fuse (Keithley P/N: FU-106-.630).
 - b) For 220 V and 240 V line voltage, use a 0.315 A, 250 V, 5 mm x 20 mm fuse (Keithley P/N: FU-106-.315).
3. Push the fuse drawer back into the power module.

CAUTION For continued protection against fire or instrument damage, only replace fuse with the type and rating listed. If the instrument repeatedly blows fuses, locate and correct the cause of the problem before replacing the fuse.

Power-up sequence

When the Model 6517B is powered up, it performs self-tests on its EPROM and RAM, and checksum tests on data stored in non-volatile memory (see [Table 2-1](#)). If a failure is detected, the instrument momentarily displays an error message and the **ERR** annunciator turns on (messages are listed in [Table 2-2](#)). If a problem develops while the instrument is under warranty, return it to Keithley Instruments for repair.

If the instrument passes the self-tests, the firmware revision levels and the communications status are displayed. An example of this display is shown as follows:

```
Model 6517B
Rev. A01 700x SCPI: 27
```

The firmware revision levels (left to right) are for the main microcontroller and display microcontroller. The revision level number may be different in your particular unit. The IEEE-488 address is its default value of 27 and the SCPI language is selected. If the RS-232 interface is selected, the message “RS-232 MODE” is displayed instead of the IEEE-488 address.

Next, if the unit is configured to display the calibration due date when it is turned on, the unit shows the following:

```
Model 6517B
Calibration due: mmm/dd/yy
```

Where: “mmm” is the month abbreviation, “dd” is the day, and “yy” is the year. If no calibration date is set, the display shows that it is due now.

After the power-up sequence, the instrument begins its normal display with zero check enabled (“**Zero Check**” displayed).

Power-up error messages

Error messages that may be displayed during the power-up sequence are summarized in [Table 2-2](#). These are shown when one of the checksum tests listed in [Table 2-1](#) fails.

Table 2-1

Data checked on power-up

Data	Type of storage
IEEE-488 address	Electrically-erasable PROM
Power-up default	Electrically-erasable PROM
Calibration constants	Electrically-erasable PROM
Calibration dates	Electrically-erasable PROM
Instrument setups	10 in electrically-erasable PROM
Reading buffer	Non-volatile RAM

Table 2-2
Power-up error messages

Message	Description	Action
Error -314,	Save/recall memory lost	Instrument setup is reset to bench defaults are stored in EEPROM.
Error +510	Reading buffer data lost	The reading buffer controls are reset to factory defaults, but they are not stored into NVRAM. To do this, store readings in the buffer.
Error +511	GPIB address lost	GPIB address is reset to factory default (27) and stored into EEPROM.
Error +512	Power-up state lost	Power-up defaults are reset to factory defaults (bench) and stored into EEPROM.
Error +514	Calibration lost	Cal constants are set to factory default values, but they are not stored into EEPROM. To do this, perform a comprehensive calibration.
Error +515	Calibration dates lost	The cal dates are set to factory default values, but they are not stored into EEPROM. To do this, perform a comprehensive calibration.

Note: Any of these error conditions may occur the first time a unit is turned on or after replacing the firmware.

Power-up default conditions

Power-up default conditions are those conditions the instrument assumes when it is first turned on. You can change these power-up default conditions (except the primary address) by using the save setup feature that is available with the **MENU** key.

Warmup period

The Model 6517B can be used within one minute after it is turned on. However, the instrument should be turned on and allowed to warm up for at least one hour before use to achieve rated accuracy.

IEEE-488 primary address

The IEEE-488 primary address of the instrument must be the same as the primary address you specify in the controller's programming language. The default primary address of the instrument is 27, but you can set the address to any value from 0 to 30 by using the **MENU** key.

Display

The display of the Model 6517B is primarily used to display readings along with the units and type of measurement. When not displaying readings, it is used for informational messages, such as menu headings and selections. At the top of the display are annunciators to indicate various states of operation.

Exponent mode (Engineering or Scientific)

Readings on the display can be expressed in engineering units or in scientific notation as shown in [Table 2-3](#). In the scientific mode, the exponent can be fixed to a specified value, or it can be floating. In the floating mode, the instrument will automatically select the exponent value.

All exponent mode selections are performed from the **DISPLAY** option of the **GENERAL** menu, which is part of the **MAIN MENU**.

Table 2-3

Typical display exponent values

Engineering units		Scientific notation	
Value	Display	Value	Display
Picoamperes	pA	10^{-12} A	e-12A
Nanoamperes	nA	10^{-9} A	e-9A
Microamperes	μ A	10^{-6} A	e-6A
Milliamps	mA	10^{-3} A	e-3A
Nanocoulombs	nC	10^{-9} C	e-9C
Microcoulombs	μ C	10^{-6} C	e-6C
Kilo-ohms	k Ω	10^3 Ω	e3 Ω
Mega-ohms	M Ω	10^6 Ω	e6 Ω
Giga-ohms	G Ω	10^9 Ω	e9 Ω
Tera-ohms	T Ω	10^{12} Ω	e12 Ω
Peta-ohms	P Ω	10^{15} Ω	e15 Ω

Information messages

Press the **INFO** key to view context-sensitive information from most of the displays. An arrow (\blacktriangleleft or \blacktriangleright) on the bottom line indicates that there is more information. Use the cursor keys (\blacktriangleleft and \blacktriangleright) to view the complete line. To exit an INFO display, just press **INFO**, **ENTER**, **EXIT** or a function key.

Range messages

The following display messages may occur when making measurements:

OVERFLOW: This message is displayed when the integrated (average) input signal level (voltage, current, or charge) exceeds 105% of full scale for the selected measurement range. For example, on the 20 nA measurement range, the OVERFLOW message occurs when the integrated input level exceeds 21 nA.

An OVERFLOW condition can be resolved by selecting a higher measurement range, using **AUTO** range, or reducing the magnitude of the input signal.

The OVERFLOW message will NOT occur during resistance or resistivity measurements.

UNDERFLOW: This condition is similar to OVERFLOW but pertains to resistance and resistivity measurements. An ohms measurement is performed by sourcing voltage and measuring current. An ohms measurement that is too low causes the current to exceed full scale. The message UNDERFLOW is used to indicate that the measured resistance or resistivity is lower than the lower limit of the selected range.

The UNDERFLOW condition can usually be resolved by selecting a lower ohms range or by using **AUTO** range.

OUT OF LIMITS: This message indicates that a momentary or transient out-of-range condition appeared at the input, even though the integrated (or average) signal was within the full scale range of the analog to digital converter (A/D). It usually indicates that there is too much noise on the input signal for a valid measurement or that the signal exceeds 120% of the range.

Generally, the OUT OF LIMITS condition can be eliminated by better shielding of the signal source or by using other noise reduction methods. Another solution is to select the next higher range (or lower R range) to keep the transients less than full scale.

The 2 nA, 20 nA, 200 nA ranges, and the resistance (R) measurements that use these current ranges are particularly susceptible to this condition because of the combination of speed and sensitivity.

A sine wave signal riding on a DC bias level is used to demonstrate an OUT OF LIMIT reading. [Figure 2-3](#) shows a sine wave riding on a 20 nA bias level. If this signal is measured on the 200 nA range at normal speed, it would simply read 20 nA (which is the DC average). If however, you use the 20nA range, the positive peaks of the sine wave will be clipped as shown in [Figure 2-4](#). Clipping occurs at 110% of full range (22 nA on the 20nA range). Because of clipping, the measurement of the input signal is significantly less than 20 nA.

To avoid these bad readings, the Model 6517B displays the OUT OF LIMITS message instead of the inaccurate reading.

Note that the positive peaks of the input signal (which exceed full scale) will not cause an OVERFLOW condition on the 20 nA range since the average reading over the 16.67 ms integration period is less than full scale.

The A/D hardware limit detection circuit can be disabled, which in turn disables the OUT OF LIMITS message. However, the presence of OUT OF LIMIT readings may result in measurements that are slightly, moderately, or completely inaccurate. When both OVERFLOW and OUT OF LIMITS conditions occur, the OUT OF LIMIT message will be displayed.

Figure 2-3
Input signal

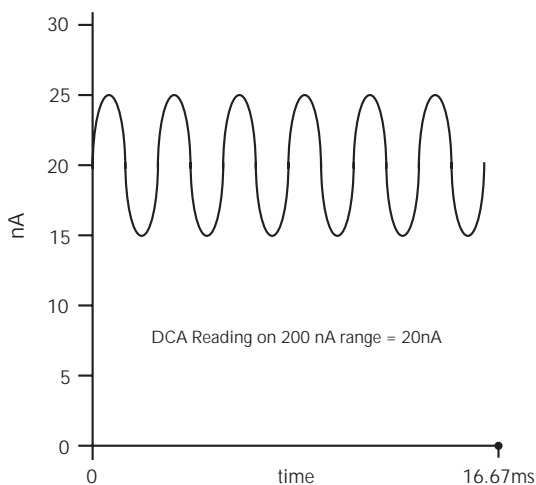
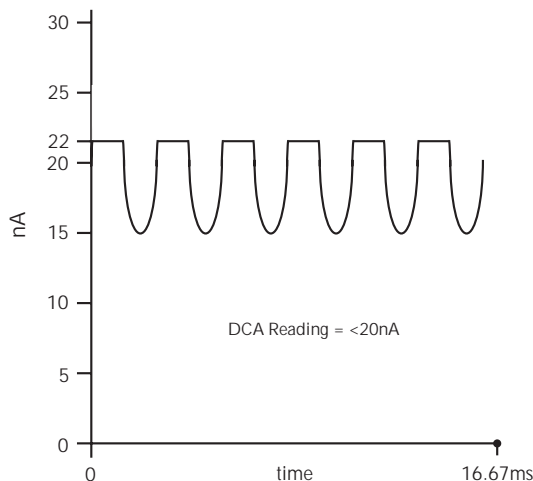


Figure 2-4
Measurement on 20nA range



Status and error messages

During Model 6517B operation and programming, you will encounter a number of front panel messages. Typical messages are either of status or error variety, as listed in [Table 2-4](#).

The most recent status or error messages can be momentarily displayed by entering a configuration menu or the main menu, and pressing the **PREV** display key (the display is blank if no message is queued).

Table 2-4
Status and error messages

Number	Description	Event
-440	"Query UNTERMINATED after indefinite response"	EE
-430	"Query DEADLOCKED"	EE
-420	"Query UNTERMINATED"	EE
-410	"Query INTERRUPTED"	EE
-350	"Queue overflow"	EE
-330	"Self test failed"	EE
-314	"Save/recall memory lost"	EE
-285	"Program syntax error"	EE
-284	"Program currently running"	EE
-282	"Illegal program name"	EE
-281	"Cannot create program"	EE
-260	"Expression error"	EE
-241	"Hardware missing"	EE
-230	"Data corrupt or stale"	EE
-224	"Illegal parameter value"	EE
-223	"Too much data"	EE
-222	"Parameter data out of range"	EE
-221	"Settings conflict"	EE
-220	"Parameter error"	EE
-215	"Arm deadlock"	EE

Table 2-4 (continued)
Status and error messages

Number	Description	Event
-214	"Trigger deadlock"	EE
-213	"Init ignored"	EE
-212	"Arm ignored"	EE
-211	"Trigger ignored"	EE
-210	"Trigger error"	EE
-202	"Settings lost due to rti"	EE
-201	"Invalid while in local"	EE
-200	"Execution error"	EE
-178	"Expression data not allowed"	EE
-171	"Invalid expression"	EE
-170	"Expression error"	EE
-168	"Block data not allowed"	EE
-161	"Invalid block data"	EE
-160	"Block data error"	EE
-158	"String data not allowed"	EE
-154	"String too long"	EE
-151	"Invalid string data"	EE
-150	"String data error"	EE
-148	"Character data not allowed"	EE
-144	"Character data too long"	EE
-141	"Invalid character data"	EE
-140	"Character data error"	EE
-128	"Numeric data not allowed"	EE
-124	"Too many digits in number"	EE
-123	"Exponent too large"	EE
-121	"Invalid character in number"	EE
-120	"Numeric data error"	EE
-114	"Header suffix out of range"	EE
-113	"Undefined header"	EE
-112	"Program mnemonic too long"	EE
-111	"Command Header Separator Error"	EE
-110	"Command Header Error"	EE
-109	"Missing Parameter"	EE
-108	"Parameter not allowed"	EE
-105	"GET not allowed."	EE
-104	"Data Type Error"	EE
-103	"Invalid Separator"	EE
-102	"Syntax Error"	EE
-101	"Invalid Character"	EE
-100	"Command Error"	EE
000	"No Error"	SE
+101	"operation complete"	SE
+121	"Device calibrating"	SE
+122	"Device settling"	SE
+123	"Device ranging"	SE

Table 2-4 (continued)
Status and error messages

Number	Description	Event
+124	"Device sweeping"	SE
+125	"Device measuring"	SE
+126	"Device calculating"	SE
+161	"Program running"	SE
+171	"Waiting in trigger Layer"	SE
+172	"Waiting in arm layer 1"	SE
+173	"Waiting in arm layer 2"	SE
+174	"Re-entering the idle layer"	SE
+301	"Reading overflow"	SE
+302	"Low limit 1 event"	SE
+303	"High limit 1 event"	SE
+304	"Low limit 2 event"	SE
+305	"High limit 2 event"	SE
+306	"Reading Available"	SE
+307	"Voltmeter Complete"	SE
+308	"Buffer Available"	SE
+309	"Buffer half-full"	SE
+310	"Buffer full"	SE
+311	"Buffer Overflow"	SE
+312	"Buffer Pretriggered"	SE
+313	"Reading out of Limit"	SE
+315	"V-source compliance detected"	SE
+320	"Buffer & Format element mismatch"	EE
+321	"Buffer Sizing error; set to MAX"	EE
+322	"Buffer Sizing error; set to MIN"	EE
+350 to +427	Calibration commands, <i>see "Error codes" on page 15-20 for more information</i>	
+510	"Reading buffer data lost"	EE
+511	"GPIB address lost"	EE
+512	"Power-on state lost"	EE
+513	"Calibration data lost"	EE
+514	"Calibration dates lost"	EE
+515	"Calibration tolerances lost"	
+516	"Calibration tables lost"	EE
+517	"Voltage Offset lost"	EE
+518	"Current Offset lost"	EE
+519	"Installed option id lost"	EE
+520	"Option card not supported"	EE
+521	"Cal Card Data Error"	EE
+522	"GPIB communication language lost"	EE
+610	"Questionable Calibration"	SE
+611	"Questionable Temperature"	SE
+612	"Questionable Humidity"	SE
+617	"Questionable Test sequence"	SE
+618	"Resistivity: I OutOfLimit"	EE
+700	"Low Battery detected"	EE

Table 2-4 (continued)
Status and error messages

Number	Description	Event
+800	"RS-232 Framing Error detected"	EE
+801	"RS-232 Parity Error detected"	EE
+802	"RS-232 Overrun detected"	EE
+803	"RS-232 Break detected"	EE
+804	"RS-232 Noise detected"	EE
+805	"Invalid system communication"	EE
+806	"RS-232 Settings Lost"	EE
+807	"RS-232 OFLO: Characters Lost"	EE
+808	"ASCII only with RS-232"	EE
+850	"Invalid Test sequence Setting"	EE
+851	"Test sequence running"	SE
+860	"Interlock Violation Error"	EE
+861	"Vsource Limit too low for auto"	EE
+900	"Internal System Error"	EE
+950	"DDC Reading overflow"	SE
+951	"DDC Reading Available"	SE
+952	"DDC Buffer full"	SE
+953	"DDC Mode IDDC Error"	EE
+954	"DDC Mode IDDCO Error"	EE
+955	"DDC Trigger Overrun Error"	EE
+956	"DDC No Remote Error"	EE
+957	"DDC Number Error"	EE
+958	"DDC Ready"	SE

SE = Status event

EE = Error event

Multiple displays

Each measurement function has its own set of “multiple displays” shown in the bottom line of the front panel display. The **PREV** and **NEXT** display keys scroll through the selections for the present function.

The multiple displays can show a reading in a different form, or give additional information about the reading, for example:

- Top line shows a reading.
- Bottom line shows a zero-center bar graph with adjustable limits.

To scroll through the multiple displays available for each measurement functions, repeatedly press and release the **NEXT** display key. The same action with the **PREV** display key does a reverse scroll through the displays.

Multiple displays that are specific to a particular function or operation are discussed later in this section, such as the calculations display in math (see [Table 2-5](#)). Some of the displays that are common to all measurement functions are discussed here.

Time/day/date

This display provides the time, day of week, and the date. The time, date and format (12-hour or 24-hour) are set from the **CLOCK** option of the **GENERAL MENU** (which is selected from the **MAIN MENU**).

Table 2-5
Multiple (Next) displays by function

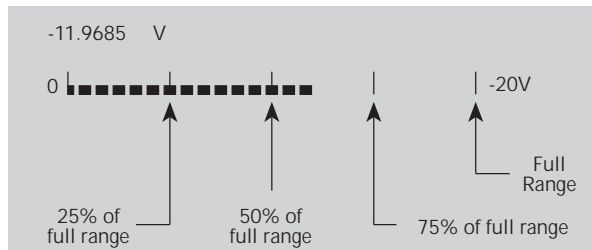
Function	Next display
All	Time, day, and date Bar graph Zero-centered bar graph Maximum and minimum values Relative and actual values Calculated and actual values Limits bar graph Relative humidity and external temperature stamp
R	Source (V) and measure (I) values

Bar graph

The “normal” bar graph, with a zero at the left end, is a graphical representation of a reading as a portion of a range (see [Figure 2-5](#)). The vertical lines displayed along the bar designate 0%, 25%, 50%, 75%, and 100% of full scale. Each full segment of the bar represents approximately 4% of the range limit.

The right endpoint of the bar graph is plus full scale of the present range for positive readings, and minus full scale for negative readings. When the 100% line changes to an arrow, the reading exceeds the current range.

Figure 2-5
Bar graph (zero-at-left) multiple display

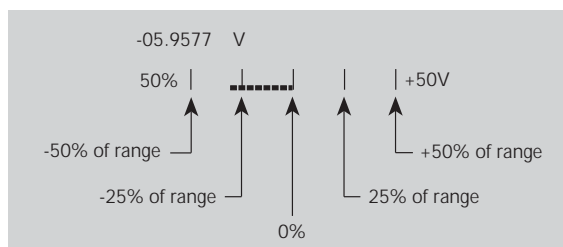


Zero-centered bar graph

The zero-centered bar graph is a graphical representation of a reading with positive and negative limits (see [Figure 2-6](#)). The limits are expressed in a user-selectable percentage of range.

The vertical lines displayed along the bar designate the positive and negative limits, zero, and halfway to either limit. There are ten full segments between zero and each end, so each full segment represents 10% of the limit. When a line at the limit changes to an arrow, the reading exceeds the programmed range.

Figure 2-6
Zero-centered bar graph multiple display



The plus and minus percentage of range that is programmed (0.01 - 99.99%) applies to all functions. Because of rounding, values greater than 99.5% are shown as 100% and, likewise, values greater than 1% (such as 1.67%) are shown rounded to the nearest integer percent.

Perform the following to view or change the plus and minus percentage of range:

1. From a measurement function, press **CONFIG** and then **NEXT** or **PREV** display key. The following is displayed:

ZERO-BARGRAPH+/-50.00%

2. Change the percentage by using the cursor keys (**◀** and **▶**) and the **RANGE** keys (**△** and **▽**) to enter a numeric value (0.01 -99.99%). Press **ENTER** when done.

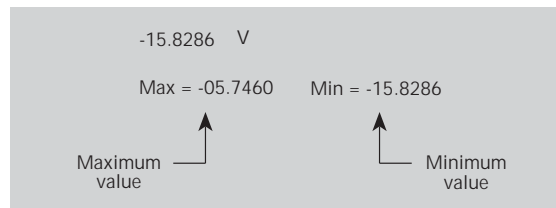
Maximum and minimum

The maximum and minimum multiple display shows the maximum and minimum readings since the display was entered (see [Figure 2-7](#)). The maximum and minimum values are reset by the following:

- Pressing the present function key.
- Leaving the display by changing function or entering a menu.

The resolution, units, and prefix on the bottom line are the same as shown for top line reading.

Figure 2-7
Maximum and minimum multiple display



Relative humidity and external temperature

This display provides the relative humidity and the external temperature readings. Note that the appropriate sensors have to be connected to instrument, and they have to be enabled in order to get valid readings.

Navigating menus

Menu types

There are two types of menu structures; the Main Menu and the Configure menus. The Main Menu accesses items for which there are no dedicated keys, and Configure menus are used to configure measurement functions and other instrument operations.

Navigation rules

Use the following rules to navigate through the menu structure:

1. The top level of the Main Menu is accessed by pressing the **MENU** key. A Configuration menu is accessed by pressing CONFIG and then the desired function (**V**, **I**, **R** or **Q**.) or operation (**TRIG**, **STORE**, etc.).
2. A menu item is selected by placing the cursor on it and pressing **ENTER**. Cursor position is denoted by the blinking menu item or parameter. The cursor keys (◀ and ▶) control cursor position.
3. A displayed arrow (◀ and ▶) on the bottom line indicates that there are one or more additional items (messages) to select from. Use the appropriate cursor key to display them.
4. A numeric parameter is keyed in by placing the cursor on the digit to be changed and using the **RANGE** △ or ▽ key to increment or decrement the digit.
5. A change is only executed when **ENTER** is pressed. Entering an invalid parameter generates an error and the entry is ignored.
6. The **EXIT** key is used to back out of the menu structure. Any change that is not entered is cancelled when EXIT is pressed. The EXIT key has additional actions and are summarized in [Table 2-6](#).
7. The **VOLTAGE SOURCE** △ and ▽ keys are used adjust the V-source value. The V-source is decremented or incremented by placing the cursor on the desired digit and pressing △ or ▽. With the cursor on the polarity sign, pressing △ or ▽ toggles the

polarity. Pressing **CONFIG** and then Δ or ∇ displays the **CONFIGURE V-SOURCE** menu.

Table 2-6

EXIT key actions

Condition	EXIT key action
Temporary message displayed (such as TRIGGERS HALTED)	Cancels display of temporary message.
INFO message displayed	Cancels INFO message, returns to menu or normal reading display.
Reading display hold	Cancels reading display hold, resumes normal reading display.
Scanning	Disables scanning; also stops data storage if enabled.
Data storage	Stops data storage; temporary message STORAGE INTERRUPTED is displayed.

Menu

The main menu accesses the various instrument operations for which there are no dedicated keys, such as setup storage, communication setup, calibration, self-test and limits. The main menu structure is summarized in [Table 2-7](#) along with the reference section number that includes more detailed information on that particular menu selection.

The top level of the main menu is displayed by placing the instrument in the reading display state, and then pressing the **MENU** key (see [Navigating menus](#) for more information).

Table 2-7

Main MENU structure

Menu item	Description	Section
SAVESETUP SAVE RESTORE POWERON BENCH GPIB USER-SETUP-NUMBER RESET BENCH GPIB	Setup menu: Save setup at a memory location (0-9) Return 6517B to setup stored at a memory location (0-9) Power-on Menu: Power on to bench default setup conditions Power on to GPIB default setup conditions Power on to setup stored at a memory location (0-9) Reset Menu: Return 6517B to bench default setup Return 6517B to GPIB default setup	2
COMMUNICATION GPIB ADDRESS ELEMENTS RS-232 BAUD TERMINATOR FLOW-CTRL ELEMENTS	Communications Menu: Select and configure GPIB: Check/change IEEE-488 bus address (0-30) Selects GPIB data elements (reading, units, reading number, relative humidity, channel number, time stamp, internal temperature, external temperature, status) Select and configure RS-232: Selects baud rate (300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K) Selects terminating character (CR, CR+LF, LF, LF+CR) Selects RS-232 flow control (NONE, XON-XOFF) Selects data elements (reading, units, reading number, relative humidity, channel number, time stamp, internal temperature, external temperature, status)	11
TEST DISPLAY TESTS KEYS DISPLAY-PATTERNS CHAR-SET	Self-test menu: Test display board Verify operation of front panel keys Verify operation of display Display the entire character set	2

Table 2-7 (continued)
Main MENU structure

Menu item	Description	Section
CAL VIEW DISPLAY-AT-POWERUP	Calibration menu: View calibration dates Selects whether to show calibration dates at power-up	See Section 15
LIMITS LIMIT-SET-1 CONTROL LOLIM1 HILIM1 LIMIT-SET-2 CONTROL LOLIM2 HILIM2 STROBE-CONTROL PASS-PATTERN	Limits menu: Limit-Set-1 menu: Enable/disable limit set #1 Set value of low limit #1 Set value of high limit #1 Limit-Set-2 menu: Enable/disable limit set #2 Set value of low limit #2 Set value of high limit #2 Enable/disable limit strobe signal of digital output #4 when trigger occurs Specify patterns on digital outputs to signify limit pass	10
STATUS-MSG	Enable/disable status message mode.	2
GENERAL DIGOUT STATE LOGIC-SENSE SERIAL # A/D-CONTROLS LINE-SYNC DATA-STAMP LIMIT-CTRL AUTORANGE-SPEED TIMESTAMP TYPE RELATIVE-TIME REAL-TIME RESET-TIME RESET-RDG# DISPLAY NUMERIC-FORMAT DECIMAL-CHAR TEMP-UNITS CLOCK TIME DATE FORMAT	General menu: Digital output menu: Checks/changes states of digital output lines Checks/changes sense of digital output lines Displays serial number, memory option SCPI version, and firmware revisions A/D menu: Enables/disables line synchronization. Also displays power line frequency Configures A/D to measure additional inputs (humidity and external temperature) Enables/disables A/D hardware limit Sets the autoranging speed (NORMAL or FAST) Configure time stamp: Check or change type References time stamp to relative time References time stamp to real time Resets relative time stamp to zero Resets reading number to zero Display menu: Selects measurement units (engineering or scientific) Selects period or comma as decimal point Selects temperature units (C, K, F) Clock menu: Checks or set time of day Checks or set date Selects clock format: (12-hour or 24-hour format)	10 2 2 2 2

SAVESETUP

The **SAVESETUP** option of the main menu is used for the following operations:

- To save the present instrument configuration in non-volatile memory
- To restore the instrument to a previously saved instrument configuration
- To set the instrument's power-up configuration
- To reset the instrument to a factory default configuration

SAVE

Use this menu item to save the present instrument setup in a specific memory location. You can store up to 10 setups in non-volatile memory.

After selecting **SAVE**, you will be prompted to save the present setup in a memory location. Note that the numbering of setup locations starts with setup #0. You can save the setup in memory location #0 or you can use the **RANGE** (Δ and ∇) keys to enter a different value. With the desired memory location displayed, press **ENTER**.

RESTORE

Use this menu item to return the instrument to a setup that was previously stored (see [SAVE](#) above) in memory.

After selecting **RESTORE** you will be prompted to enter the memory location number of the setup that you wish to restore. Note that #0 is a valid memory location. Use the **RANGE** (Δ and ∇) keys to enter the desired location and press **ENTER**. The instrument will immediately restore that setup configuration.

POWERON

Use this menu item to select the instrument setup that goes into effect when the instrument is turned on.

The instrument can be set to power up to the factory bench defaults, the factory GPIB defaults, or to a user setup stored (see [SAVE](#) above) at a specific memory location. The **POWERON** options are explained as follows:

BENCH: Use this option to return the instrument to the bench default conditions the next time it is turned on (see [Table 2-8](#)).

GPIB: With this option, the unit returns to the GPIB default conditions the next time it is turned on. (see [Table 2-8](#).)

USER-SETUP-NUMBER: Using this option, the instrument powers up to the user setup saved at a specific memory location (see [SAVE](#) above).

After selecting **USER-SETUP-NUMBER**, you will be prompted to enter the memory location number of the setup that you wish the instrument to power up to. Note that #0 is a valid memory location. Use the **RANGE** (Δ and ∇) keys to enter the desired memory location and press **ENTER**.

RESET

Use this menu option to reset the instrument to the bench or GPIB default conditions (see [Table 2-8](#)). The **RESET** options are explained as follows:

BENCH: With this option, the instrument returns to the bench default conditions (see [Table 2-8](#)). After selecting **BENCH**, the instrument returns to the normal display of readings after requesting an **ENTER** to confirm your selection.

GPIB: With this option, the unit returns to the GPIB default conditions (see [Table 2-8](#)). After selecting **GPIB**, the instrument returns to the normal display of readings after requesting an **ENTER** to confirm your selection. Note that the instrument goes to the Idle state.

Table 2-8
Factory default conditions

Function or operation	Bench default (SYSTEM:PRESet)	GPIB default (*RST)
A/D Controls: Line Synchronization Data Stamp: Temperature (external) Humidity Hardware Limit	Off Off Off On	Off Off Off On
Buffer: Control Count time stamp Elements Display	Fill and stop No effect No effect No effect Yes	Fill and stop No effect No effect No effect Yes
Clock	No effect	No effect
Communications: Interface (GPIB or RS-232) GPIB: Address Language Talk-Only (printer setup): Interface Interval Formfeed Page Size Elements RS-232: Control (send/receive or talk-only) Talk-Only (printer setup): Interval Formfeed Page Size Baud Rate Data Bits Parity Stop Bits Elements	No effect No effect No effect IEEE-488 1 Off 60 Lines (see note) No effect 1 Off 60 Lines (see note) No effect No effect No effect No effect No effect No effect (see note)	No effect No effect No effect IEEE-488 1 Off 60 Lines (see note) No effect 1 Off 60 Lines (see note) No effect No effect No effect No effect No effect No effect (see note)
Digital Output: States Logic Sense	No effect No effect	No effect No effect
Display: Numeric Format Scientific Format Decimal Character Temperature Units	Engineering Floating Exp Period °C	Engineering Floating Exp Period °C

Table 2-8 (continued)
Factory default conditions

Function or operation	Bench default (SYSTem:PRESet)	GPIB default (*RST)
Filter	On	Off
Digital Filter	On	On
Averaging	On	On
Readings	10	10
Advanced	Off	Off
Readings	10	10
Noise Tolerance Level	1%	1%
Filter Mode	Moving	Repeat
Median Filter	On	On
Rank	1	1
I (Amps):		
Damping	Off	On
Range	Manual (20mA)	Manual (20mA)
Autorange	Off	Off
Limits	Use all ranges	Use all ranges
Limits:		
Limit Set #1 and #2f	Off	Off
Low Limit	-1.0	-1.0
Action	0	0
High Limit	1.0	1.0
Action	0	0
Strobe Control	Off	Off
Pass Pattern	0	0
Math	Off	On
Function	Polynomial	Polynomial
Percent Target Value	1.0	1.0
Polynomial Constants:		
"a0"	0.0	0.0
"a1"	1.0	1.0
"a2"	0.0	0.0
%Deviation Reference	1.0	1.0
Deviation Reference	1.0	1.0
Ratio Reference	1.0	1.0
Q (Coulombs):		
Auto Discharge	Off	Off
Range	Manual (2 μ C)	Manual (2 μ C)
Autorange	Off	On
Limits	High	High
R (Ohms):		
Amps Rel	Off	Off
Damping	Off	Off
Measurement Type	Resistance	Resistance
Resistivity Type	Surface	Surface
Fixture	User	User
Ks, Kv	1.0	1.0
Thickness	1.0 mm	1.0 mm

Table 2-8 (continued)
Factory default conditions

Function or operation	Bench default (SYSTem:PRESet)	GPIB default (*RST)
R (Ohms): Auto V-source Ohms Range Autorange Limits Manual V-source Ohms Range Autorange Limits V-source	 2MΩ Off Use all ranges Manual (200k¾) Off N/A Manual	 2MΩ On Use all ranges Manual (200k¾) Off N/A Manual
Relative Value Auto	Off 0.0	Off 0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Scanning: Scan Type Internal Scan: Channels Count Memory Scan Mode Settling Time Timer Interval V-source Limit External Scan: External Inputs Trigger source Scan Count Timer Interval Memory	 Internal All 10 Yes Voltage 0.0 sec No 2.5 sec Yes 10 Triglink 10 No 2.5 sec Yes	 Internal All 10 Yes Voltage 0.0 sec No 2.5 sec Yes 10 Triglink 10 No 2.5 sec Yes
Speed	Normal (1 PLC)	Normal (1 PLC)
Status Messages	Off	Off
time stamp	No effect	No effect

Table 2-8 (continued)
Factory default conditions

Function or operation	Bench default (SYSTem:PRESet)	GPIB default (*RST)
Test sequence	Diode	Diode
Diode:		
Start Voltage	1V	1V
Stop Voltage	10V	10V
Step Voltage	1V	1V
Delay	1 sec	1 sec
Capacitor:		
Bias Voltage	1V	1V
Points	10	10
Interval	1 sec	1 sec
Cable:		
Bias Voltage	1V	1V
Points	5	5
Interval	1 sec	1sec
Resistor:		
Source V1	1V	1V
Delay 1	1 sec	1 sec
Source V2	2V	2V
Delay 2	1 sec	1 sec
Surface Resistivity:		
Pre-discharge Time	0.2 sec	0.2 sec
Bias Voltage	500V	500V
Bias Time	1 sec	1 sec
Measure Voltage	500V	500V
Measure Time	1 sec	1 sec
Discharge Time	2 sec	2 sec
Volume Resistivity:		
Pre-discharge Time	10 sec	10 sec
Bias Voltage	500V	500V
Bias Time	1 sec	1 sec
Measure Voltage	500V	500V
Measure Time	1 sec	1 sec
Discharge Time	2 sec	2 sec
Alternating polarity:		
Offset Voltage	0V	0V
Alternating Voltage	10V	10V
Measurement Time	15 sec	15 sec
Discarded Readings	3	3
Stored Readings	1	1

Table 2-8 (continued)
Factory default conditions

Function or operation	Bench default (SYSTem:PRESet)	GPIB default (*RST)
Test sequence SIR: Bias Voltage Bias Time Measure Voltage Measure Time Square Wave Sweep: High Level High Time Low Level Low Time Cycle Count Staircase Sweep: Start Stop Step Step Time Start source Triglink Line	50V 1 sec 100V 1 sec 1V 1 sec -1V 1 sec 10 1V 10V 1V 1 sec Manual Line #1	50V 1 sec 100V 1 sec 1V 1 sec -1V 1 sec 10 1V 10V 1V 1 sec Manual Line #1
Triggers Advanced: Measure layer: Source Triglink Mode Triglink Input Triglink Output Delay Count Control Scan layer: Source Triglink Input Triglink Output Delay Count Control Arm layer: Source Triglink Input Triglink Output Count Control Basic: Trigger Mode Trigger source Timer Interval	Advanced (armed) Immediate Asynchronous Line #2 Line #1 0.0 sec Infinite Acceptor Immediate Line #2 Line #1 0.0 sec Infinite Acceptor Immediate Line #2 Line #1 1 Acceptor Continuous Immediate 0.1 sec	Advanced (idled) Immediate Asynchronous Line #2 Line #1 0.0 sec 1 Acceptor Immediate Line #2 Line #1 0.0 sec 1 Acceptor Immediate Line #2 Line #1 1 Acceptor Continuous Immediate 0.1 sec
V (Volts): External Feedback Guard Range Autorange	Off Off Manual (200V) Off	Off Off Manual (200V) On

Table 2-8 (continued)
Factory default conditions

Function or operation	Bench default (SYSTem:PRESet)	GPIB default (*RST)
V-source:		
Range	100V	100V
Voltage Limit	Off	Off
Value	1000V	1000V
Resistive I-Limit	Off	Off
Meter Connect	Off	Off
Zero Check	On	On

Note: The default selects all elements except HUM, DT, and ET.

COMMUNICATION

The COMMUNICATION menu option allows you to select and configure the GPIB or RS-232 bus. See [Section 11](#) for details.

CAL

The CALIBRATION menu is used for viewing the calibration dates and setting the option to display calibration dates on power up. See [Section 15](#) for calibration information.

TEST

The SELF-TEST menu is used as a diagnostic tool to isolate problems with the Model 6517B front panel display. Each SELF-TEST menu item features prompts to guide the user through the diagnostics.

LIMITS

The LIMITS menu is used to set and control the limit values that determine the PASS/FAIL and HI/LO status of subsequent measurements and to set the digital output patterns that signify passing or failing limit checks. See [Section 10](#) for details.

STATUS-MSG

This selection is used to enable or disable the status messages mode. When enabled, status messages are displayed to identify specific operations that are performed.

ON: Enable the status message mode

OFF: Disable the status message mode

The instrument may become so busy displaying status messages, that key presses are no longer acknowledged. You may have to clear status message display by pressing the EXIT key or sending a bus command (:DISPlay:SMESsage OFF) to exit this mode.

GENERAL

The GENERAL menu is used for the following operations:

- To control the state and sense of the digital outputs.
- To view the serial number, SCPI version, and firmware revision levels of the Model 6517B.
- To set line synchronization of readings, display the frequency of the line power, and configure the A/D to measure humidity and external temperature.

- To configure time stamp.
- To choose the character displayed for a decimal and select measurement units.
- To set the real-time clock.

DIGOUT (Digital I/O menu)

DIGOUT controls the Digital I/O port. See [Section 10](#) for complete information.

SERIAL

This item displays the serial number, SCPI version, and firmware revision levels of the instrument. The following information is displayed:

Serial #XXXXXX

SCPI version 1996.0 software rev AXX AYY

Where: #XXXXXX is the serial number of the instrument
 AXX is the firmware level for the main microcontroller
 AYY is the firmware level for the display microcontroller

A/D CONTROLS

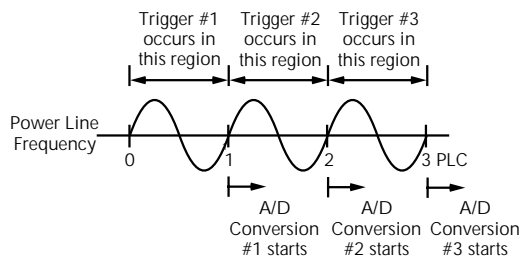
With this **GENERAL** menu item, you can control line synchronization, and enable or disable humidity and external temperature measurements.

LINE-SYNC: Synchronizing A/D conversions with the power line frequency increases common mode and normal mode rejection. When line cycle synchronization is enabled, the measurement is initiated at the first positive-going zero crossing of the power line cycle after the trigger (see [Figure 2-8](#)).

When **LINE-SYNC** is selected, the power line frequency is displayed and the options for line synchronization are displayed:

- ENABLED: Enables line synchronization
- DISABLED: Disables line synchronization

Figure 2-8
Line cycle synchronization



Note: A/D conversions assume an integration time of ≤ 1 PLC (Power Line Cycle)

Changing the state of line synchronization halts triggers and puts the instrument into idle. Press TRIG to return to re-arm triggers.

DATA-STAMP: This menu item is used to enable or disable humidity and external temperature measurements. The relative humidity reading is controlled by placing the cursor on **HUMIDITY** and using a **RANGE** (Δ or ∇) key to toggle between the desired state (ON or OFF). In a similar manner, external temperature is enabled or disabled from the **TEMPERATURE** item.

Temperature measurements can be expressed in °C, °F or K (see [DISPLAY](#) (below) of the **GENERAL** menu to select the desired reading unit).

LIMIT-CTRL: The Model 6517B incorporates an A/D hardware limit circuit to detect out of range noise spikes. When enabled (ON), the “OutOfLimit” message is displayed when an out of range noise spike occurs. With the hardware OFF, the error message is disabled. In the OFF state, out of range spikes may cause erroneous readings.

TIMESTAMP

A time stamp is available for readings sent over the bus and for readings stored in the buffer. This **GENERAL** menu selection is used to configure the time stamp for readings sent over the bus. From the front panel, readings are sent over the bus through the COMMUNICATION selection of the MAIN menu.

Specifically, this selection is used to perform the following operations:

- Select the type of time stamp; relative or real-time.
- Reset the relative time stamp to zero.
- Reset the reading number to zero.

Timestamp and the reading number are only included with each reading if they are selected as GPIB or RS-232 data elements.

The menu items for **TIMESTAMP** are explained as follows:

TYPE: This item is used to check or change time stamp type. Note that changing the time stamp type clears the buffer. The two time stamp types are described as follows:

- **RELATIVE TIME:** With this selection, time stamps are oriented to a timer and reference each reading to a point in time. The timer starts at 0.000000 seconds when the instrument is turned on or when the relative time stamp is reset (See “RESET-TIME” below). After 99,999.999999 seconds, the timer resets to zero seconds and starts over.
- **REAL-TIME:** With this selection, time stamps are oriented to the real-time clock and provide the current time (24-hour format) and date for each reading.

Time stamp type for bus readings is coupled to time stamp type for buffer readings. Therefore, if you change time stamp type from this menu structure, it also changes in the CONFIG DATA STORE menu structure (see [Section 8](#)).

RESET-TIME: This item is used to reset the relative time-stamp to 0.000000 seconds. The time stamp also resets to zero seconds when the instrument is turned on. It has no effect on the real-time clock.

RESET-RDG#: This menu item is used to reset the reading number to zero. The reading number also resets to zero when the instrument is turned on.

DISPLAY

This menu item is used to select the exponent mode (engineering units or scientific notation) for display readings, and lets you specify displayed decimal points as either periods or commas:

NUMERIC-FORMAT: This item is used to select the exponent mode:

- **ENGR:** Use this option to display readings using engineering units (for example, 1.00000 μ A)
- **SCIENTIFIC:** Use this option to display readings using scientific notation (for example, 1.00000e-06 A); the two following options are available for the scientific notation exponent mode:

FLOATING: With this selection, the exponent value will change automatically to provide optimum reading resolution.

FIXED: With this selection, the exponent value will remain fixed. Only the mantissa part of the reading will change. After selecting **FIXED**, the currently selected exponent value will be displayed. If you change the exponent value, be sure to press **ENTER**.

DECIMAL-CHAR: This item is used to select between periods and commas to signify decimal points on the front panel display:

- **PERIOD:** This option selects the period (.) as the decimal point for readings.
- **COMMA:** This option selects the comma (,) as the decimal point for readings.

TEMP-UNITS: Use this menu item to select the units (°C, K or °F) for internal or external temperature measurements.

CLOCK

The Model 6517B has a real-time clock that is used for time-stamping bus and buffer readings (real-time time stamp), and as a control source for the arm layer (Arm Layer 1). This **GENERAL** menu selection is used to set the time date and format (12-hour or 24-hour) for the real time clock.

TIME: This item is used to set the time for the clock. If the 12-hour format is selected, “AM” or “PM” will be displayed. The absence of “AM” or “PM” denotes the 24-hour format. The format for time can be changed with the **FORMAT** menu item. Use the cursor keys (◀ and ▶) and the **RANGE** keys (△ and ▽) to set the time (hours:minutes:seconds). Press **AUTO** to set seconds to zero.

DATE: This item is used to set the date for the clock. Use the cursor keys (◀ and ▶) and the **RANGE** keys (△ and ▽) to set the date. Note that the day of the week (Sun, Mon, etc.) is automatically calculated and displayed for the date.

FORMAT: This item is used to select the time format for the clock:

- **12-HOUR:** With this selection, real-time time stamps for buffer readings are provided in the 12-hour format (AM or PM). Also, the real-time clock control source for the arm layer must be set using the 12-hour format.
- **24-HOUR:** With this selection, real-time time stamps for buffer readings are provided in the 24-hour format. Also, the real-time clock control source for the arm layer must be set using the 24-hour format.

Note that real-time time stamps for bus readings are always provided in the 24-hour format, regardless of the **FORMAT** selection.

In this section:

Topic	Page
Introduction	3-2
Electrometer input connector	3-2
Input configurations	3-2
Maximum input levels	3-3
Input protection	3-4
Connection methods	3-4
High-resistance meter connections	3-4
Voltage source output connections	3-5
V-source probes and cables	3-6
Low noise cables, shielding, and guarding	3-6
Low noise input cables	3-6
Shielding and guarding	3-7
Floating circuits	3-9
Floating measurements	3-9
Floating voltage source	3-10
Test fixtures	3-11
Keithley Instruments Model 8009 test fixture	3-11
Custom built test fixtures	3-11

Introduction

This section contains basic information on electrometer, high-resistance meter, and V-source connections. The use of low-noise cables and shielding is also covered here. The concepts of guarding and floating circuits are introduced as well.

Detailed connection schemes are included with the measurement procedures in [Section 4](#).

WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

Electrometer input connector

The rear panel triax INPUT connector is a 3-lug female triax connector that mates to a cable terminated with a 3-slot male triax connector.

Input configurations

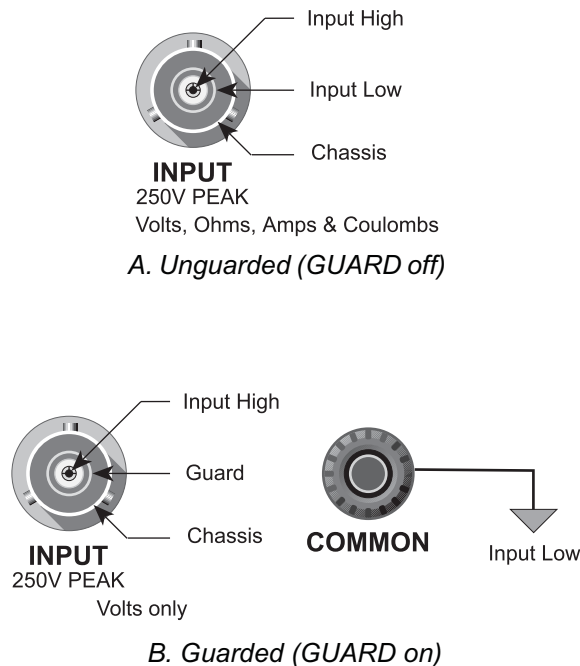
As shown in [Figure 3-1](#), the input connector can be configured in two ways. With GUARD off ([Figure 3-1A](#)), input low is connected to the inner shell of the connector. This configuration is used for current, resistance, coulombs and unguarded voltage measurements.

Where possible, make input low connections directly to the INPUT connector low terminal instead of using COMMON to avoid internal voltage drops that may affect measurement accuracy.

With GUARD on ([Figure 3-1B](#)), guard is connected to the inner shell of the triax connector. Input low is accessed through the COMMON connecto on the rear panel. This configuration is used for guarded voltage measurements only. Note that guard can only be enabled (on) for the volts function. For ohms, amps and coulombs, guard is always disabled (off). For voltage measurements, guard is enabled or disabled from the Configure Voltage menu structure.

The INPUT triax connector is also used for the force voltage measure current configuration. This configuration utilizes the V-source to make resistance measurements and current measurements.

Figure 3-1
Input connector configuration



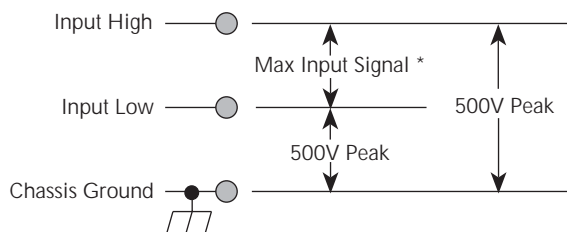
Maximum input levels

The maximum input levels to the Keithley Instruments Model 6517B Electrometer are summarized in [Figure 3-2](#).

WARNING *The maximum common-mode input voltage (the voltage between input low and chassis ground) is 500V peak. Exceeding this value may create a shock hazard.*

CAUTION **Connecting PREAMP OUTPUT, COMMON, or 2V ANALOG OUTPUT to earth while floating the input may damage the instrument.**

Figure 3-2
Maximum input levels

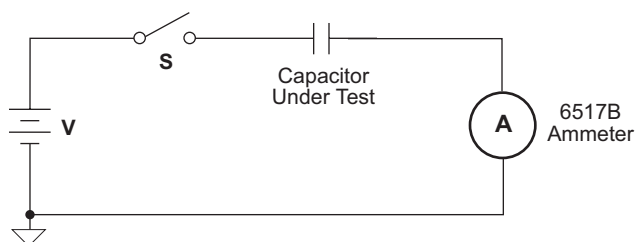


* Max Input Signal - 250VRMS, DC to 60Hz sine wave (10 seconds maximum in mA ranges).

Input protection

The Model 6517B incorporates protection circuitry against nominal overload conditions. However, a high voltage (>250V) and resultant current surge could damage the input circuitry. A typical test circuit to measure the leakage current of a capacitor is shown in Figure 3-3. When Switch S is closed, an initial surge of charging current will flow and the high voltage will be seen across the input of the Model 6517B.

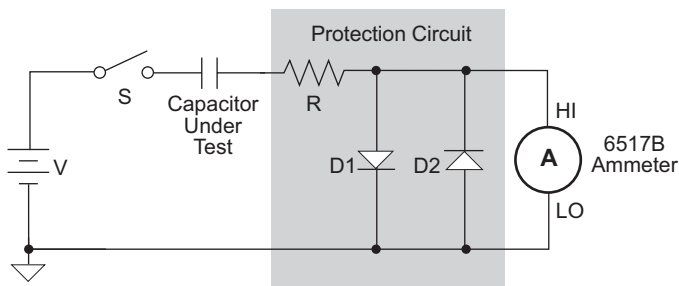
Figure 3-3
Capacitor test circuit without protection



Adding a resistor and two diodes (1N3595) as shown in Figure 3-4 will provide considerable extra protection. The resistor must be large enough to limit the current through the diodes to 10mA or less. It must also be large enough to withstand the supply voltage. The protection circuit should be enclosed in a light-tight conductive shield.

This same protection circuit is useful when measuring the insulation resistance of films or high-voltage cables. Without such added protection, a pinhole or other defect could cause an arc, damaging the electrometer input.

Figure 3-4
Capacitor test circuit with protection



Connection methods

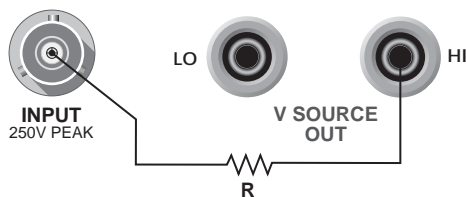
High-resistance meter connections

The Model 6517B uses the force voltage measure current (FVMI) configuration to measure resistance. From the known voltage and measured current, the resistance is calculated ($R = V/I$) and displayed.

The resistance to be measured is connected to the center conductor of the INPUT triax connector and the V SOURCE OUT HI binding post as shown in Figure 3-5A. This configuration assumes that V-source LO is internally connected to ammeter LO through the METER-CONNECT option of the **CONFIGURE V-SOURCE** menu structure. The equivalent circuit for this configuration is shown in Figure 3-5B.

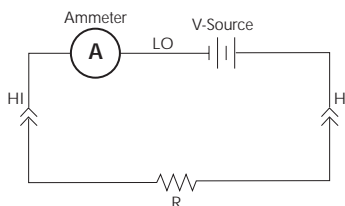
WARNING *The maximum common-mode voltage (the voltage between V-source/ Electrometer LO and chassis ground) is 500V peak. Exceeding this value may create a shock hazard.*

Figure 3-5
Force voltage measure current



Note: V-SOURCE LO connected to ammeter input LO via METER-CONNECT option of CONFIGURE V-SOURCE Menu.

A. Basic connections



B. Equivalent circuit

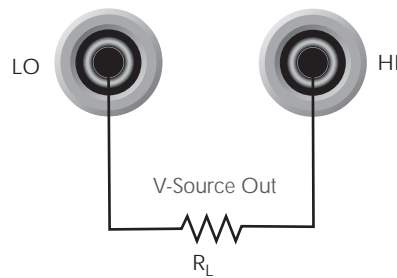
Voltage source output connections

The voltage source output is accessed at the rear panel V SOURCE OUT HI and LO binding posts as shown in [Figure 3-6A](#). Using these terminals simply places the independent V-source in series with the external circuit (R_L) as shown in [Figure 3-6B](#).

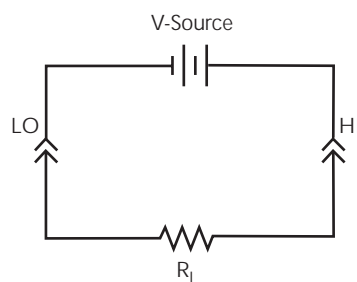
The V-source can also be used be with the Electrometer to form the FVMI configuration as shown in [Figure 3-5](#). This configuration is used for resistance measurements and current measurements. For these measurements, V-source LO and ammeter input LO can be connected internally through the **METER-CONNECT** option of the **CONFIGURE V-SOURCE** menu.

WARNING *The maximum common-mode voltage (the voltage between voltage source low and chassis ground) is 750V peak. Exceeding this value may create a shock hazard.*

Figure 3-6
V-source output



A. Basic connections



B. Equivalent Circuit

V-source probes and cables

The following probe and cable sets are available from Keithley Instruments as options:

- **Model 8606 High Performance Probe Tip Kit:** Consists of two spade lugs, two alligator clips, and two spring hook test probes. (The spade lugs and alligator clips are rated at 30V RMS, 42.4V peak; the test probes are rated at 1000V.) These components are designed to be used with high performance test leads terminated with banana plugs, such as the Model 8607 Performance Banana Cables.
- **Model 8607 High Performance Banana Cables:** Consists of two high voltage (1000V) banana cables. The cables are terminated with banana plugs that have retractable sheaths.

Low noise cables, shielding, and guarding

When making precision measurements, you should always use low noise cables and utilize proper shielding and guarding techniques.

Low noise input cables

Triax cables can generate enough triboelectric currents to corrupt the measurement. These currents are caused by friction between the center conductor and the inner shield when the cable is flexed or allowed to move around. The use of low noise cables help minimize these triboelectric currents.

The following low noise cables are recommended for use with the Model 6517B:

- Model 237-ALG-2: This 2-meter low noise triax cable is terminated with a 3-slot male triax connector on one end and three alligator clips on the other end. The alligator clip with the red boot is connected to the center conductor (input high). The black booted clip is connected to the inner shield (input low or guard). The green booted clip is connected to the outer shield (chassis ground).
- Model 7078-TRX-3: This 3-foot low noise triax cable is terminated with a 3-slot male triax connector at each end.
- Model 7078-TRX-10: This is the same as the Model 7078-TRX-3 except that it is 10 feet in length.
- Model 7078-TRX-20: This is the same as the Model 7078-TRX-3 except that it is 20 feet in length.

When using cables, keep the following points in mind:

- For voltage measurements, the increased input capacitance caused by a long input cable can significantly slow down the reading response. To minimize this problem, always use the shortest possible triax input cable and use guarding.
- For current and resistance measurements, the increased input capacitance caused by a long input cable can result in noisy readings. To minimize this problem, always use the shortest possible triax input cable and enable damping. Damping will reduce the noise but it will also slow down the response time of the measurement.

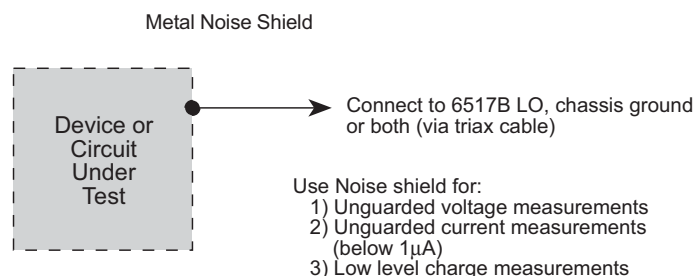
Shielding and guarding

The following information covers the basics on using noise shields, guard shields, and safety shields.

Noise shield

A noise shield is used to prevent unwanted signals from being induced on the electrometer input. Effective shielding encloses the circuit or device under test (DUT) and extends to the electrometer input through a triax cable. The generic connection for the noise shield is shown in [Figure 3-7](#) which also summarizes the measurements that may benefit from it.

Figure 3-7
Noise shield

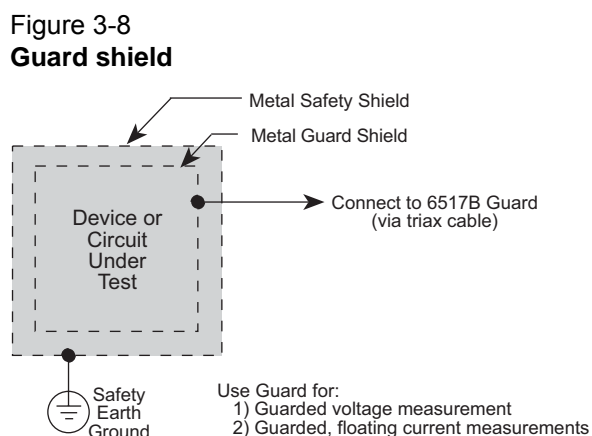


Typically, the noise shield is connected to electrometer input LO. However, sometimes better noise performance can be achieved by instead connecting the noise shield to both electrometer LO and chassis ground. Electrometer LO can be connected to chassis ground at the rear panel of the Model 6517B by installing the ground link between the COMMON binding post and the chassis ground binding post. You may have to experiment to determine which method provides the best noise performance.

CAUTION Do not make floating measurements with electrometer LO connected to chassis ground. If the rear panel ground link is installed between COMMON and chassis ground, remove it before floating the instrument.

Guard shield

Guarding is used to greatly reduce leakage current in a high impedance test circuit. Leakage resistance exists in the input cable (between conductor paths) and in the test fixture (at connectors and insulators). The concept of guarding is to surround the input high node or DUT with a guard shield that is at the same potential. Current cannot flow through a leakage resistance that has a 0V drop across it. A typical connection for the guard shield is shown in Figure 3-8, which also summarizes the measurements that guard is used for. Notice that a safety shield is also used since guarded measurements can place hazardous voltages on the guard shield (see [Safety shield](#) below).



NOTE For voltage measurements, guarding should be used when the test circuit impedance is $\geq 1\text{G}\Omega$ or when long input cables are used. Guard is enabled from the Configure Voltage menu structure. When enabled, the guard potential is placed on the inner shield of the triax input cable.

For current measurements, guarding should be used when the test circuit impedance $\geq 1\text{G}\Omega$. Significant leakage could occur across a DUT through insulators and corrupt the measurement. Input LO (inner shield of the input triax cable) is used as the guard.

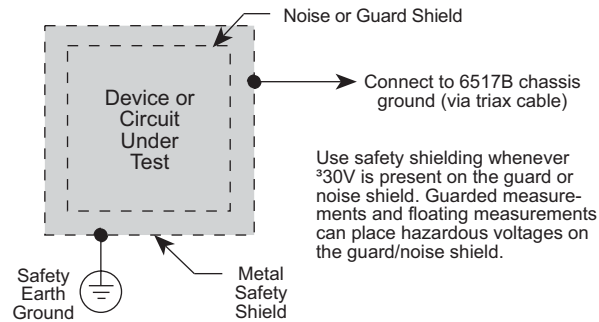
For floating current measurements, a unique guard technique is used in a high impedance test circuit where significant leakage current may exist between the ammeter input and test circuit common.

Safety shield

A safety shield is required whenever a hazardous voltage is present on the noise shield or guard shield, or when a test circuit is floated above earth ground at a hazardous voltage level. A shock hazard exists at a voltage level equal to or greater than 30V rms. Hazardous voltages up to 500V may appear on the noise/guard shield when performing floating measurements or guarded measurements.

Typical connections for the safety shield are shown in [Figure 3-9](#). The metal safety shield must completely surround the noise or guard shield, and must be connected to safety earth ground using #18 AWG or larger wire.

Figure 3-9
Safety shield



* Connect the safety shield to safety earth ground using #18 AWG wire or larger.

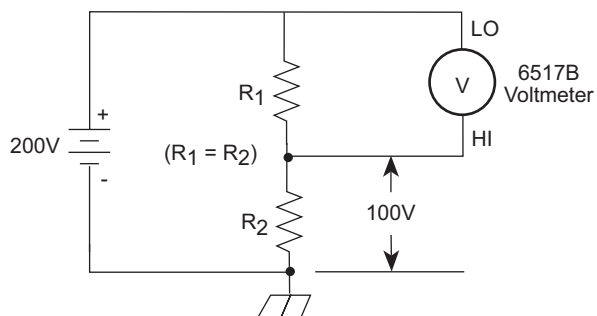
Floating circuits

Many measurements are performed above earth ground and, in some test situations, can result in safety concerns.

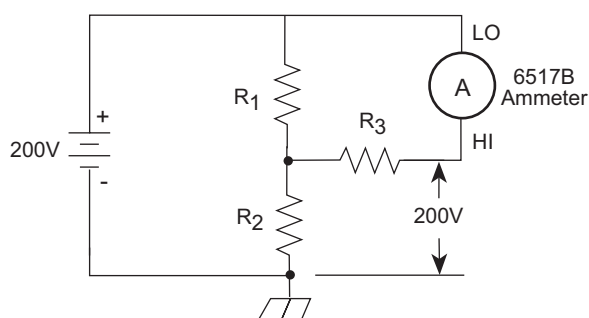
Floating measurements

[Figure 3-10](#) shows two examples where the Model 6517B floats at a hazardous voltage level. In [Figure 3-10A](#), a shock hazard (100V) exists between meter input LO and chassis ground. If meter input LO is connected to a noise shield, then the shock hazard will also be present on that shield. In [Figure 3-10B](#), a shock hazard (200V) exists between the meter input (HI and LO) and chassis ground. If meter input LO is connected to a noise or guard shield, then the shock hazard will also be present on that shield.

Figure 3-10
Floating measurements



A. Voltage measurement



B. Current measurement

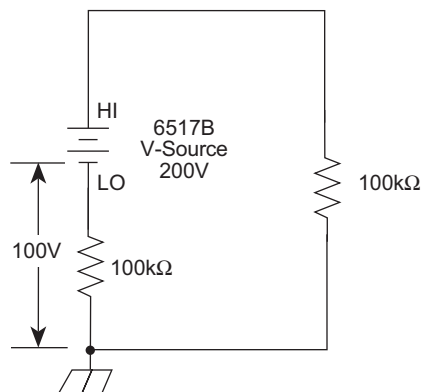
Floating voltage source

The V-source of the Model 6517B can also be operated above earth ground as shown in [Figure 3-11](#). In this circuit, the V-source is floating 100V above ground. Therefore, a shock hazard (100V) exists between V-source LO and chassis ground. A shock hazard exists at a voltage level equal to or greater than 30V rms. To avoid possible shock hazards, always surround exposed floating circuits and shields with a safety shield (see [Safety shield](#) for more information).

WARNING *The maximum voltage (common-mode) between electrometer LO and chassis ground is 500V. The maximum voltage between V-source LO and earth (chassis) ground is 750V. Exceeding these values may create a shock hazard. When floating input LO above 30V from earth (chassis) ground, hazardous voltage will be present at the analog outputs (PREAMP OUTPUT and 2V ANALOG OUTPUT). Hazardous voltage may also be present when the input voltage exceeds 30V in the volts function.*

CAUTION *Connecting PREAMP OUTPUT, COMMON, or 2V ANALOG OUTPUT to earth (chassis) ground while floating the input may damage the instrument.*

Figure 3-11
Floating V-source



Test fixtures

Whenever possible, use shielded, low leakage test fixtures to make precision measurements.

Keithley Instruments Model 8009 test fixture

This test fixture allows volume resistivity in the range from 10^3 to $10^{18}\Omega\text{-cm}$, and surface resistivity in the range from 10^3 to $10^{17}\Omega/\text{sq. cm}$. Features include:

- A 3-lug triax connector and dual binding posts simplify connections to the Model 6517B.
- Guarded electrodes that can accommodate samples up to 1/8" thick and 4" × 4".
- Safety Interlock: When connected to the Model 6517B, the V-source goes into standby when the test fixture lid is open.
- Screw terminal on test fixture chassis for connection to safety earth ground.

Custom built test fixtures

Two examples of custom built test fixtures are shown in [Figure 3-12](#) and [Figure 3-13](#). The first is a dedicated test fixture to source voltage and measure current to a single DUT (resistance measurements). The second is a multi-purpose test fixture that can be used to make any Model 6517B measurement. These two examples illustrate the basic techniques that should be applied when building a test fixture. These same basic techniques should be used if you need to build a more complex test fixture to accommodate your test measurement requirements.

The test fixture in [Figure 3-12](#) assumes that ammeter input LO is connected to V-source LO inside the Model 6517B. This LO-to-LO connection is controlled from the METER CONNECT selection in the CONFIGURE V-SOURCE menu.

The following requirements, recommendations and guidelines are provided in order to build a quality test fixture that is safe to use. After building a test fixture you should clean it (see [Handling and cleaning test fixtures](#)).

Test fixture chassis

- The chassis of the test fixture should be metal so that it can function as a shield for the DUT or test circuit mounted inside. The chassis of the test fixture will be connected to chassis ground of the Model 6517B through the triax cable.
- The test box must have a lid that closes to prevent contact with live circuitry inside.

WARNING *Safe operation requires that a safety interlock switch be used to place the V-source in standby when the test fixture lid is open or ajar (see [Interlock](#)).*

- The test fixture chassis must have a screw terminal that is used exclusively for connection to safety earth ground.

WARNING *To provide protection from shock hazards, the test fixture chassis must be properly connected to safety earth ground. A grounding wire (#18 AWG or larger) must be attached securely to the test fixture at a screw terminal designed for safety grounding. The other end of the ground wire must be attached to a known safety earth ground.*

Guard plate

A metal guard plate will provide guarding or noise shielding for the DUT or test circuit. It will also serve as a mounting panel for the DUT or test circuits. The guard plate must be insulated with 1000V spacing from the chassis of the test fixture.

Connectors, terminals, and internal wiring

[Figure 3-12](#) and [Figure 3-13](#) show the types of connectors needed to use the test fixtures with the Model 6517B. All connectors, except the triax connector, must be insulated from the chassis of the test fixture. The outer shell of the triax connector must be referenced to chassis ground. Therefore, DO NOT insulate the outer shell of the triax connector from the metal chassis of the test fixture.

The DUT and test circuits are to be mounted on the guard plate using insulated terminals. To minimize leakage, select terminals that use virgin Teflon insulators.

Inside the chassis of the test fixture, you may use coaxial cable to extend guard from the triax connector to the DUT. The shield (guard) of the cable should extend as far as possible to the DUT.

Figure 3-12
Test fixture to source voltage, measure current

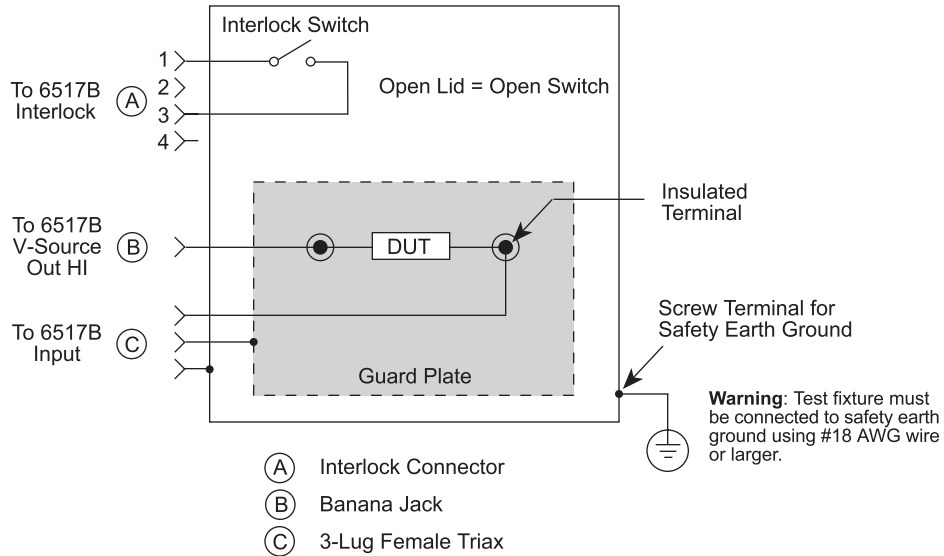
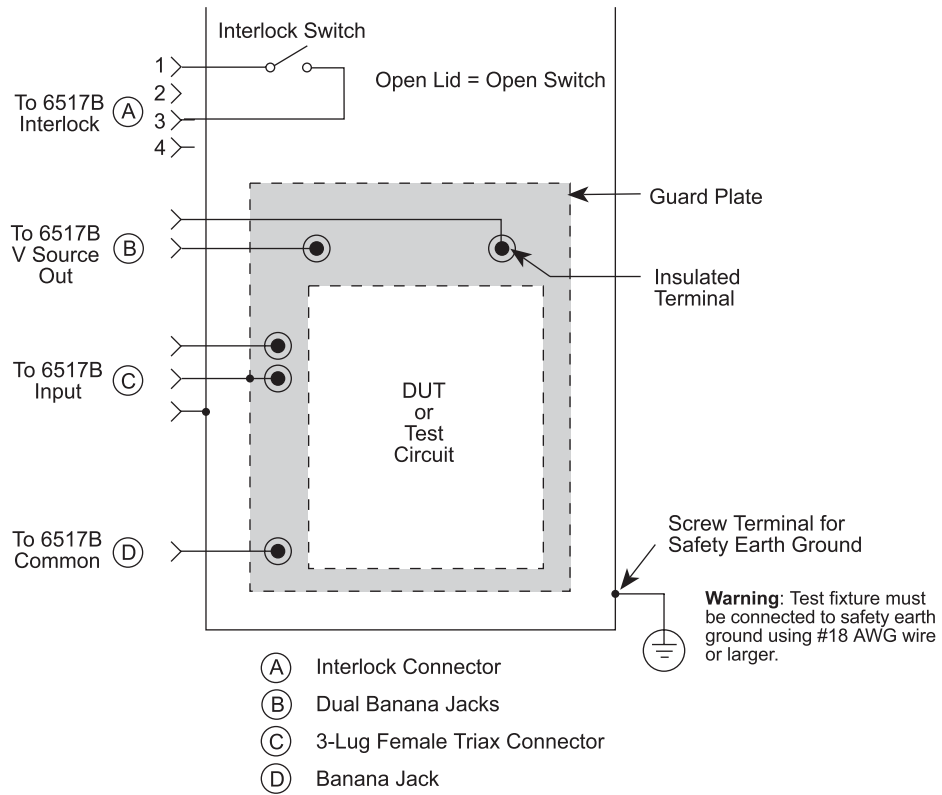


Figure 3-13
Multi-purpose test fixture

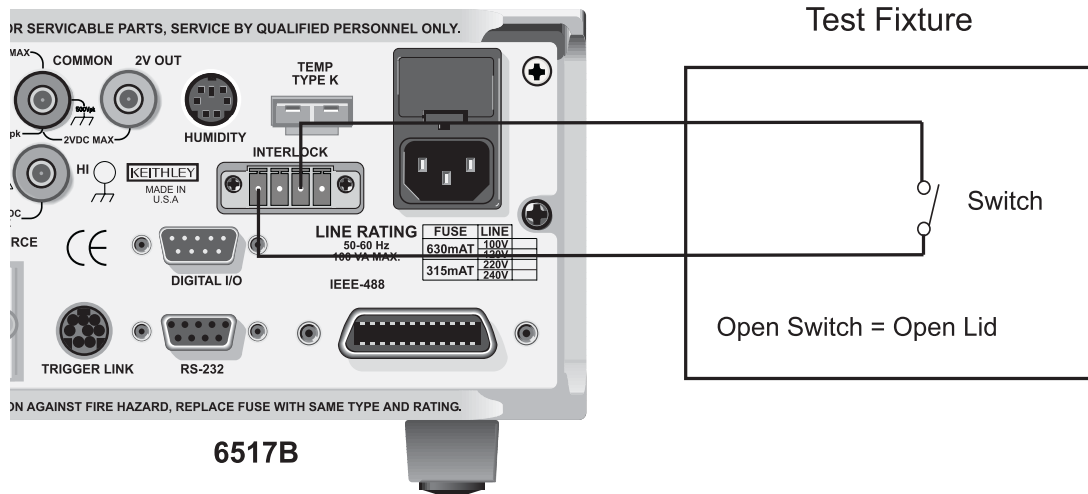


Interlock

When a normally-open, SPST momentary switch is properly implemented as a safety interlock, the V-source will go into standby whenever the test fixture lid is open or ajar.

The switch must be mounted inside the test box such that it will be closed when the lid of the test fixture is closed. Opening the lid must cause the interlock switch to open. There must never be enough clearance to allow finger access inside the box while the switch is closed. The interlock must be designed so that it cannot be defeated. See [Figure 3-14](#) for typical interlock connections.

Figure 3-14
Interlock connections



Handling and cleaning test fixtures

Dust, body oil, solder flux, and other contaminants on connector and terminal insulators can significantly decrease the leakage resistance resulting in excessive leakage currents. Also, contaminants on DUT and test circuit components can create a leakage path. These leakage currents may be large enough to corrupt low-level measurements.

Handling tips:

- Do not touch the bodies of DUT or test circuit components. If you cannot handle them only by their leads, use clean cotton gloves to install them in the test fixture.
- Do not touch any connector or terminal insulator.
- If installing a test circuit that is on a pc-board, handle the board only by the edges; do not touch any board traces or components.

Cleaning tips:

- Use dry nitrogen gas to clean dust off of connector and terminal insulators, DUT, and other test circuit components.
- If you have just built the test fixture, remove any solder flux using methanol along with clean foam-tipped swabs or a clean soft brush.
- To clean contaminated areas, use methanol and clean foam-tipped swabs. After cleaning a large area, you may want to flush the area with methanol. Blow dry the test fixture with dry nitrogen gas.
- After cleaning, the test fixture (and any other cleaned devices or test circuits) should be allowed to dry in a 50°C low-humidity environment for several hours.

In this section:

Topic	Page
Introduction	4-2
Voltage measurements	4-2
Basic measurement procedure	4-2
Volts configuration	4-5
Voltage measurement considerations	4-6
Current measurements	4-9
Basic measurement procedure	4-9
Amps configuration	4-11
Current measurement considerations	4-13
Resistance and resistivity measurements	4-18
Overview	4-18
Resistance measurements	4-19
Resistivity measurements	4-22
Ohms configuration	4-27
Ohms measurement considerations	4-30
Charge measurements (Q)	4-31
Basic measurement procedure	4-31
Coulombs configuration	4-33
Charge measurement considerations	4-34
Other measurement considerations	4-35
Ground loops	4-35
Triboelectric effects	4-36
Piezoelectric and stored charge effects	4-36
Electrochemical effects	4-36
Humidity	4-36
Light	4-37
Electrostatic interference	4-37
Magnetic fields	4-37
Electromagnetic interference (EMI)	4-38
Relative humidity and external temperature readings	4-38

Introduction

This section contains detailed procedures for making voltage, current, resistance, and charge measurements.

Voltage measurements

The Keithley Instruments Model 6517B Electrometer can make unguarded or guarded voltage measurements from 1 μ V to 210V. Guard should be used if response time or leakage resistance is a consideration.

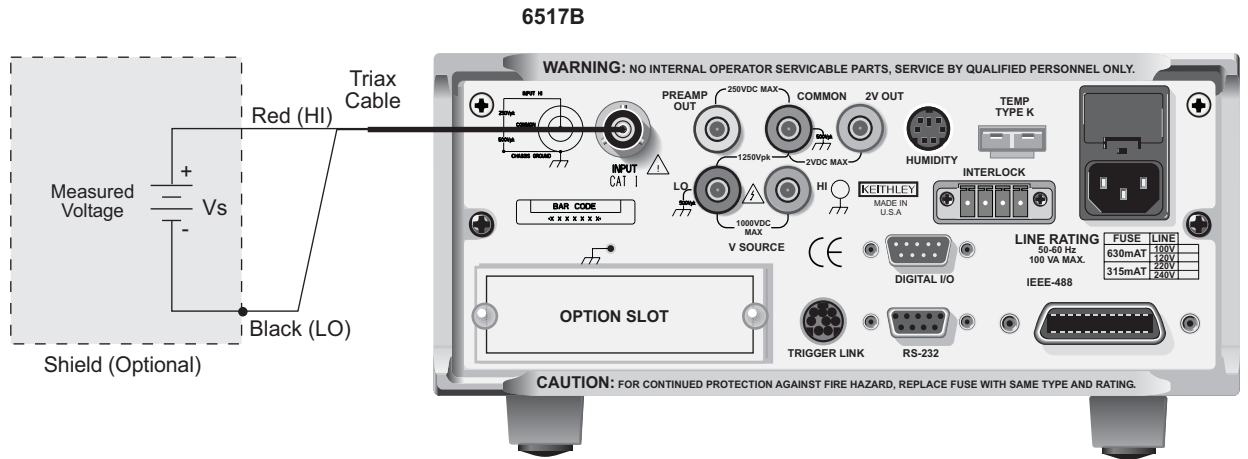
Basic measurement procedure

The voltage measurement procedure is summarized below. To ensure proper operation, always enable zero check (“ZeroCheck” displayed) before changing functions (V, I, R, or Q). The Z-CHK key controls zero check.

1. With zero check enabled (“ZeroCheck” displayed), select the volts (**V**) function. The **Z-CHK** key toggles zero check between the on and off states. Note that the input circuit configuration changes with zero check enabled.
2. Enable or disable guard as needed. Guard is controlled from the GUARD option of the Voltage Configuration menu. The “Grd” message on the display indicates that guard is enabled (on).
3. To achieve optimum accuracy for low voltage measurements, it is recommended that you zero correct the instrument. To do so, select the lowest measurement range (2V) and press **REL**. The REL indicator turns on and the “ZCor” message is displayed. Correcting zero on the lowest range will correct all ranges because of internal scaling. If guard is enabled, the “ZCor” message will replace the “Grd” message. Keep in mind that guard is still enabled even though the “Grd” message is not displayed.
4. Select a manual measurement range that is consistent with the expected reading, or enable auto range.
5. Connect the Model 6517B to the voltage to be measured. [Figure 4-1](#) shows typical connections for unguarded measurements, and [Figure 4-2](#) shows typical connections for guarded measurements.
6. Press **Z-CHK** to disable zero check and take a reading from the display. To disable zero correct, enable zero check and press **REL**.

<p>WARNING Hazardous voltage may be present on the inner shield of the triax cable when GUARD is on. A safety shield connected to safety earth ground (as shown in Figure 4-2) should be used for voltage measurements at or above 30V.</p>

Figure 4-1
Unguarded voltage measurements



A. Connections

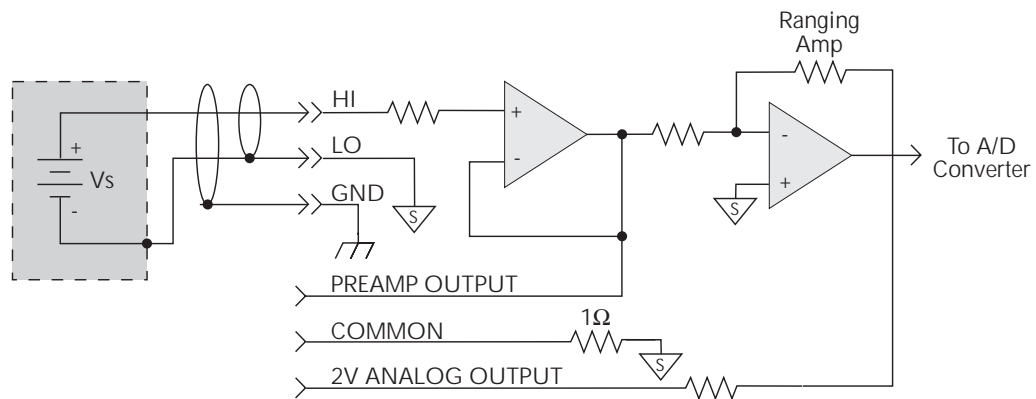
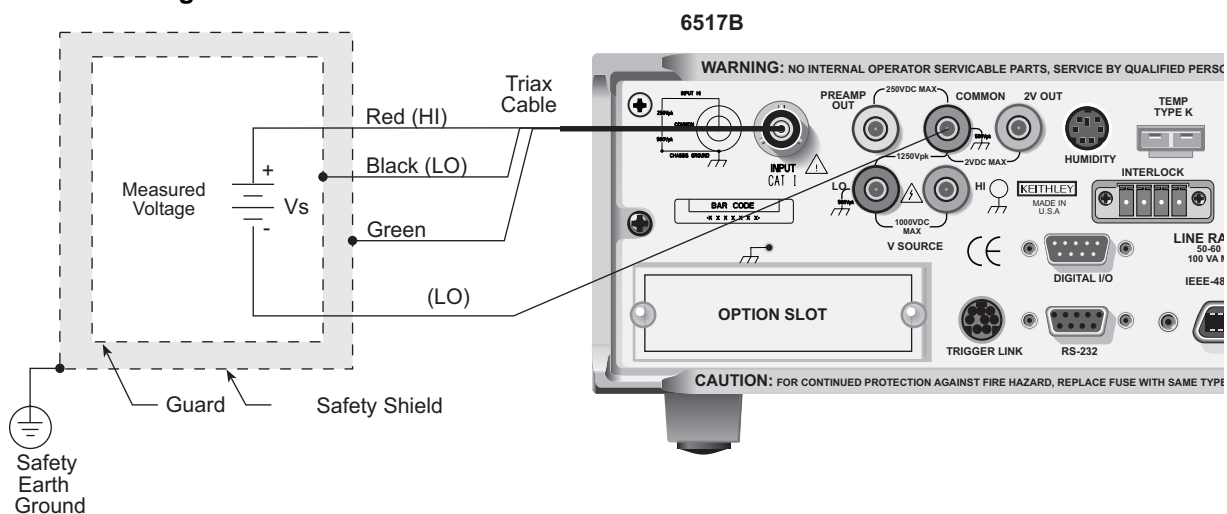
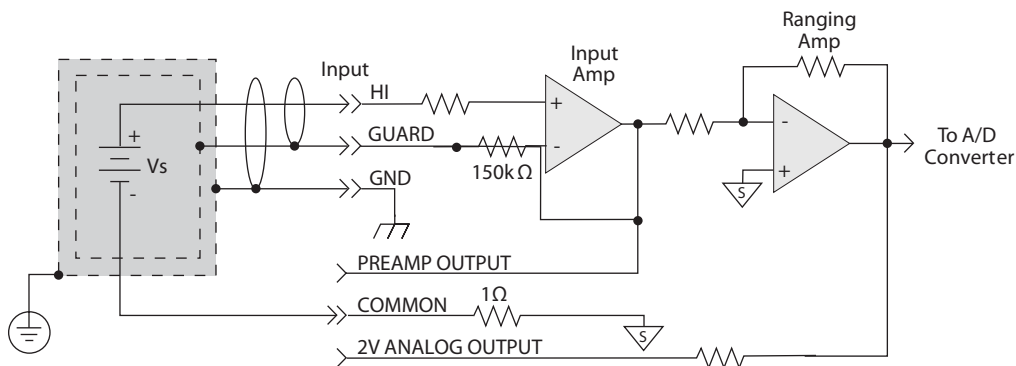


Figure 4-2
Guarded voltage measurements



A. Connections



B. Equivalent circuit

B. Equivalent circuit

Volts configuration

The following information explains the various configuration options for the volts function. The configuration menu is summarized in [Table 4-1](#). This menu is accessed by pressing **CONFIG** and then **V**. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 4-1
Volts configuration menu

Menu item	Description
GUARD	Enable or disable guard
EXT-FDBK	Enable or disable external feedback mode
SPEED NORMAL FAST MEDIUM HIACCURACY SET-SPEED-EXACTLY SET-BY-RSLN	Measurement speed (integration time) menu: Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz) Select 0.01 PLC Select 0.1 PLC Select 10 PLC Set integration in PLC (0.01-10) Default to setting appropriate for resolution
FILTER AVERAGING TYPE NONE AVERAGING ADVANCED AVERAGING-MODE MEDIAN DISABLE ENABLE	Filter menu: Configure digital averaging filter: Select type of average filter: No average filtering performed Program a simple average filter (1-100 readings) Program a simple average filter (1-100 readings) with noise tolerance window (0-100% of range) Select moving average or repeating average mode Configure median filter: Disable median filter Enable median filter and specify range (1-5)
RESOLUTION AUTO 3.5d, 4.5d, 5.5d, 6.5d	Display resolution menu: Default to resolution appropriate for integration time Select a specific resolution

GUARD

The GUARD option is used to enable or disable guard. When disabled, the inner shell (shield) of the triax connector (and cable) is connected to meter input LO. This mode is used for unguarded voltage, current and charge measurements. When enabled, the inner shell (shield) of the triax connector (and cable) is connected to guard, which follows the potential of meter input HI. This mode is used for guarded voltage measurements.

Guard is only in effect when the instrument is in the volts function. In any other function, guard is not used. The following menu items are used to control GUARD:

ON: Enable guard

OFF: Disable guard

EXT- FDBK

This option is used to enable or disable the external feedback mode. The following menu items are used to control external feedback:

OFF: Disable external feedback

ON: Enable external feedback

SPEED

The speed parameter sets the integration time of the analog to digital (A/D) converter, the period of time the input signal is measured (also known as aperture). The integration time affects the usable resolution, the amount of reading noise, as well as the ultimate reading rate of the instrument. Any triggers received while the instrument is processing a reading are ignored. From the front panel, the integration time is specified in parameters based on a number of power line cycles (NPLC), where 1 PLC for 60Hz is 16.67msec and 1 PLC for 50Hz and 400Hz is 20mseconds

The SPEED parameters for all functions (except frequency) are explained as follows:

FAST: Sets integration time to 0.01 PLC. Use FAST if speed is of primary importance at the expense of increased reading noise and less usable resolution.

MEDIUM: Sets integration time to 0.1 PLC. Use MEDIUM when a compromise between noise performance and speed is acceptable.

NORMAL: Sets integration time to 1 PLC. A compromise like MEDIUM, but NORMAL provides better noise performance at the expense of speed.

HIACCURACY: Sets integration time to 10 PLC. Use HIACCURACY when high common-mode and normal-mode rejection is required.

SET-SPEED-EXACTLY: When this parameter is selected, the present PLC value is displayed. By using the cursor keys (◀ and ▶) and the **RANGE** keys (△ and ▽), you can enter any PLC value from 0.01 to 10. Be sure to press **ENTER** after keying in a new value. Note that an integer PLC value will increase noise rejection.

SET-BY-RSLN: This parameter optimizes the integration time for the present resolution setting.

FILTER

Use this menu item to configure the two basic filter types: averaging and median. Note that you can use either the averaging filter, the median filter, or both.

The filter menu is available from the function configuration menus (for example, press **CONFIG V**) or by pressing **CONFIG FILTER** with the desired function already selected.

RESOLUTION

All functions can operate with 3.5 to 6.5-digit resolution, or they can default to a setting appropriate for the selected integration time.

3.5d, 4.5d, 5.5d or 6.5d: Sets resolution to the specified number of digits.

AUTO: Optimizes the resolution for the present integration time setting.

Voltage measurement considerations

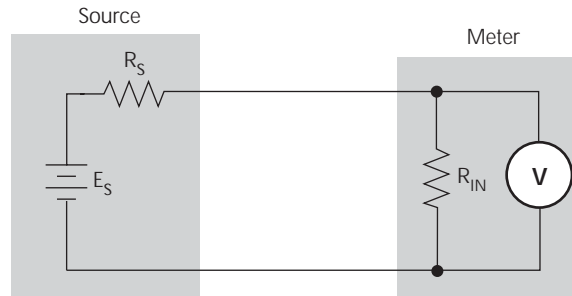
Some considerations for making accurate voltage measurements are summarized in the following paragraphs. For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley Instruments.

Loading effects

Circuit loading can be detrimental to high-impedance voltage measurements. To see how meter loading can affect accuracy, refer to [Figure 4-3](#). R_S represents the resistance component of the source, while R_{IN} represents the input resistance of the meter. The percent error due to loading can be calculated using the formula in the illustration. To keep the error under 0.1%, the input resistance (R_{IN}) must be about 1000 times the value of the source resistance (R_S). The input

resistance of the Model 6517B is $>2 \times 10E^{14}\Omega$. Thus, to keep the error under 0.1%, the source resistance of the measured voltage must be $<2 \times 10E^{11}\Omega$.

Figure 4-3
Meter loading



$$\% \text{ Error} = \frac{100R_S}{R_S + R_{IN}}$$

Cable leakage resistance

In an unguarded voltage measurement, leakage current occurs in the input triax cable between the center conductor (HI) and the inner shield (LO). This leakage resistance shunts the voltage source to be measured. If the resistance of the source is not significantly less than the leakage resistance of the cable, then measurement errors will occur.

The effects of leakage resistance can be eliminated by using guard to make high impedance voltage measurements (see *Guarding* below). In general, guarding should be used when the resistance of the voltage source is $10^9\Omega$ or greater.

Input capacitance

At very high resistance levels, the very large time constants created by even a minimal amount of capacitance can slow down response time considerably. For example, measuring a source with an internal resistance of $100G\Omega$, would result in an RC time constant of one second when measured through a cable with a nominal capacitance of 10pF. If 1% accuracy is required, a single measurement would require at least five seconds.

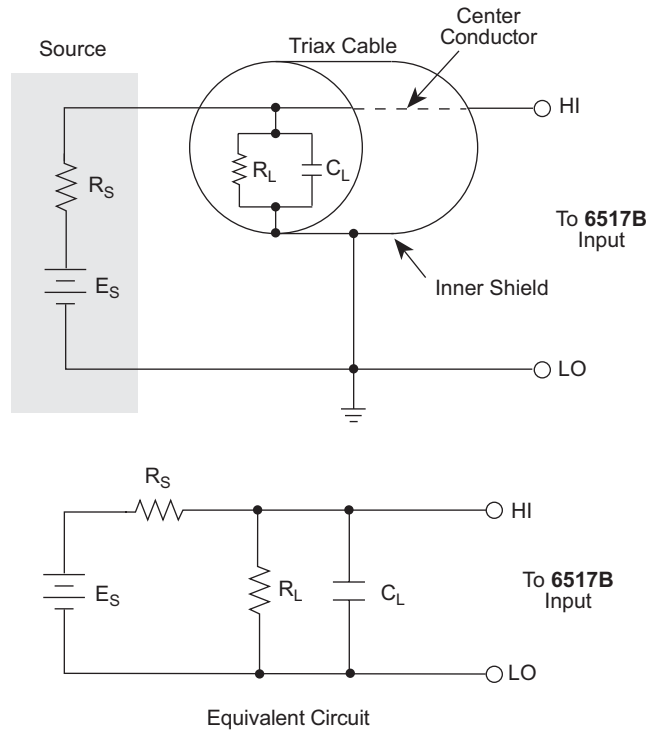
There are two ways to minimize this problem: (1) keep the input cable as short as possible, and (2) use guarding. Of course there is a limit to how short the cable can be. Using guard can reduce these effects by up to a factor of 1000 (see *Guarding* below).

Guarding

Guarding should be used for high-impedance voltage measurements and for voltage measurements that use long input cables.

To understand the concept of guarding, let us first review the unguarded circuit shown in [Figure 4-4](#). E_S and R_S represents the resistance and voltage components of the source, and R_L and C_L represents the leakage resistance and cable capacitance of the triax input cable. The equivalent circuit shows the divider that is formed. If R_S is large enough, the divider will significantly attenuate the voltage seen at the input of the Model 6517B (see *Cable leakage resistance* above). Also, R_S and the cable capacitance (C_L) could create a long RC time constant resulting in a slow measurement response (see *Input capacitance* above).

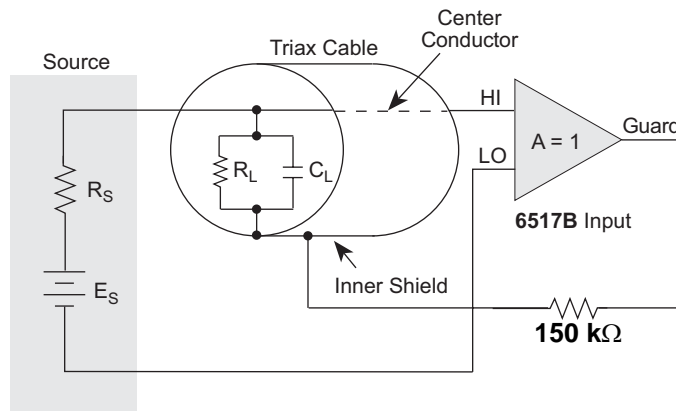
Figure 4-4
Unguarded voltage measurements



Guarding the circuit minimizes these effects by driving the inner shield of the triax cable at signal potential, as shown in Figure 4-5. Here, a unity gain amplifier with a high input impedance and low output impedance is used. Since the center conductor (HI) and the inner shield (Guard) of the cable are at virtually the same potential, the potential across R_L is zero, so no current flows. Also, with a zero potential across C_L , there is no capacitor charging process to slow down the measurement response.

Not shown in Figure 4-5 is the outer shield of the triax cable which is connected to chassis ground. The leakage between the inner shield and the outer shield is of no consequence since that current is supplied by the low impedance source, rather than by the signal itself.

Figure 4-5
Guarded voltage measurements



Current measurements

The Model 6517B can make current measurements from 10aA to 21mA.

Basic measurement procedure

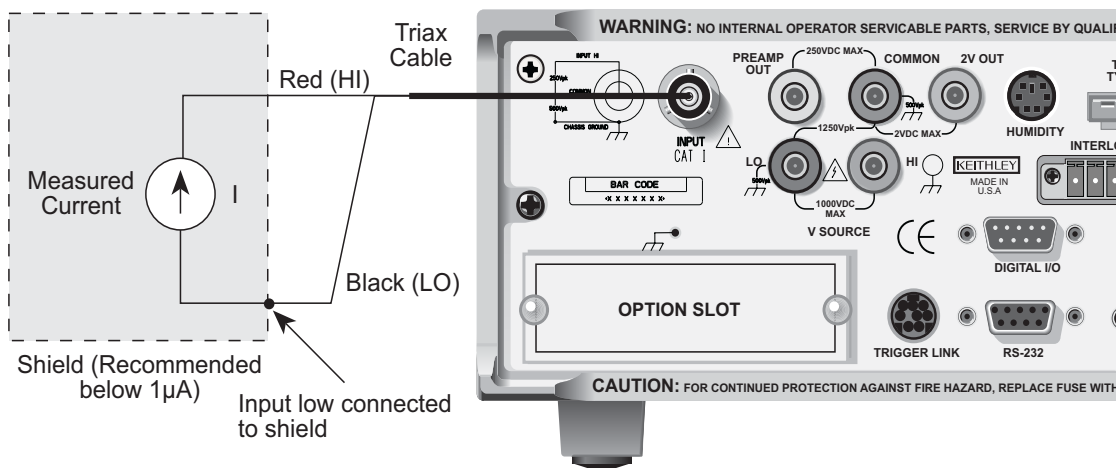
To achieve optimum precision for low-level current measurements, input bias current and voltage burden can be minimized by performing the offset adjustment procedure.

NOTE After measuring high voltage in the volts function, it may take a number of minutes for input current to drop to within specified limits. Input current can be verified by placing the protection cap on the INPUT triax connector and then connecting a jumper between COMMON and chassis ground. With the instrument on the 20pA range and zero check disabled, allow the reading to settle until the input bias current is within specifications.

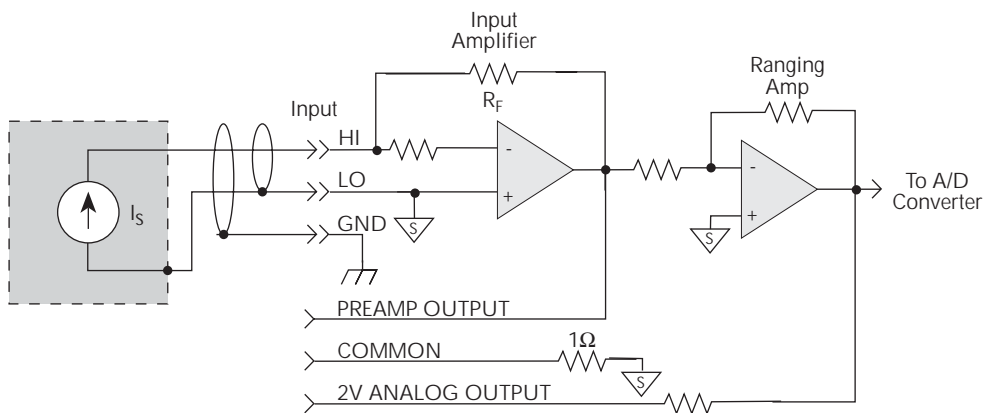
Perform the following steps to measure current. To ensure proper operation, always enable zero check (“ZeroCheck” displayed) before changing functions (**V**, **I**, **R**, or **Q**). The **Z-CHK** key controls zero check.

1. With zero check enabled (“ZeroCheck” displayed), select the amps (**I**) function. The **Z-CHK** key toggles zero check between the on and off states. Note that the input circuit configuration changes with zero check enabled.
2. To achieve optimum accuracy for low current measurements, it is recommended that you zero correct the instrument. To do so, select the lowest measurement range (20pA) and press **REL**. The **REL** indicator turns on and the “ZCor” message is displayed. Correcting zero on the lowest range will correct all ranges because of internal scaling.
3. Select a manual measurement range that is consistent with the expected reading, or enable auto range.
4. Connect the Model 6517B to the current to be measured. [Figure 4-6](#) shows typical connections for current measurements. If measuring current in a floating circuit where significant leakage may exist between the ammeter input and circuit low, connect the Model 6517B to the circuit as shown in [Figure 4-7](#). Notice that ammeter input LO is connected to circuit high. Also note that a safety shield should be used if the input of the ammeter is floating at a hazardous voltage level ($V_F \geq 30V$).
5. Press **Z-CHK** to disable zero check and take a reading from the display. To disable zero correct, enable zero check and press **REL**.

Figure 4-6
Typical connections for current measurements

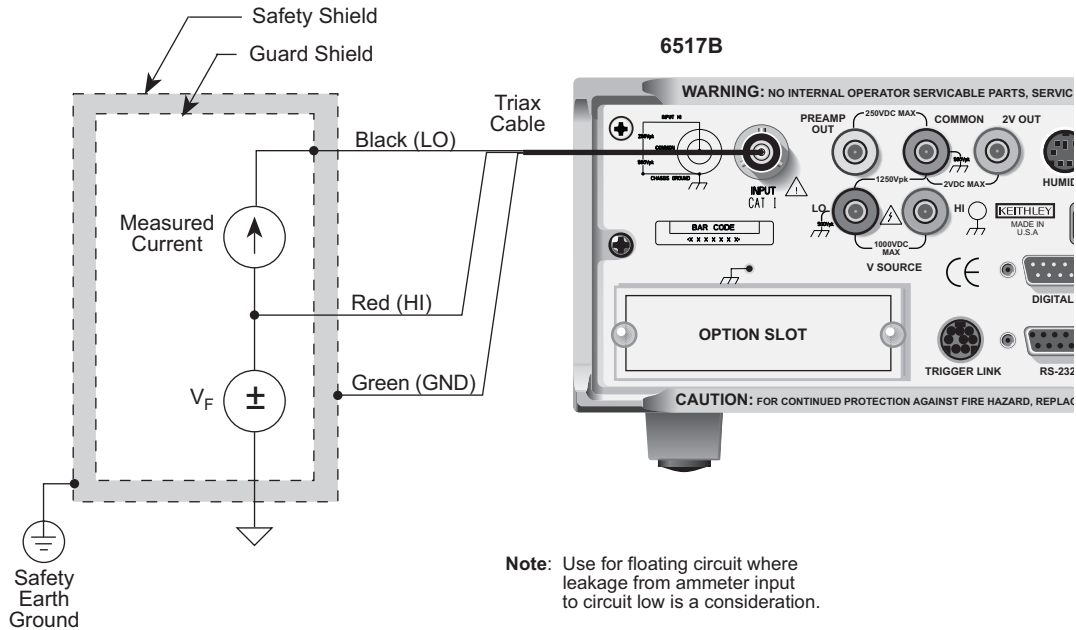


A. Connections



B. Equivalent circuit

Figure 4-7
Connections for guarded, floating current measurements



Amps configuration

The following information explains the various configuration options for the amps function. The configuration menu is summarized in [Table 4-2](#). This menu is accessed by pressing CONFIG and then I.

Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the pre-programmed status.

Table 4-2
Amps configuration menu

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz)
FAST	Select 0.01 PLC
MEDIUM	Select 0.1 PLC
HIACCURACY	Select 10 PLC
SET-SPEED-EXACTLY	Set integration in PLC (0.01-10)
SET-BY-RSLN	Default to setting appropriate for resolution

Table 4-2 (continued)

Amps configuration menu

Menu item	Description
FILTER AVERAGING TYPE NONE AVERAGING ADVANCED AVERAGING-MODE MEDIAN DISABLE ENABLE	Filter menu: Configure digital averaging filter: Select type of average filter: No average filtering performed Program a simple average filter (1-100 readings) Program a simple average filter (1-100 readings) with noise tolerance window (0-100% of range) Select moving average or repeating average mode Configure median filter: Disable median filter Enable median filter and specify rank (1-5)
RESOLUTION AUTO 3.5d, 4.5d, 5.5d, 6.5d	Display resolution menu: Default to resolution appropriate for integration time Select a specific resolution
AUTO-RANGE USE-ALL-RANGES SET-LIMITS MIN-AUTO MAX-AUTO	Autorange menu: Use all ranges when autoranging Limit the ranges used in the autorange search: Specify the minimum range in the search Specify the maximum range in the search
DAMPING	Enable or disable damping

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture).

FILTER

Use this menu item to configure the two basic filter types: averaging and median. Note that you can use either the averaging filter, the median filter, or both.

The filter menu is available from the function configuration menus (for example, press CONFIG V) or by pressing CONFIG FILTER with the desired function already selected.

RESOLUTION

The RESOLUTION parameter sets the display resolution.

AUTO-RANGE

The AUTO-RANGE option is used to configure autorange for the amps function. This option allows you to speed up the autoranging search process by eliminating upper and lower measurement ranges. For example, if you know that readings will not exceed 1 μ A, you can specify the 2 μ A range to be the maximum range. When the instrument autoranges (assuming AUTO RANGE is enabled), it will not search into the current ranges above 2 μ A. Allow sufficient time for settling when autoranging over multiple ranges or down to the lower current ranges, or erroneous readings may occur.

USE-ALL-RANGES: With this selection, all current ranges are used in the autoranging search process.

SET-LIMITS: This selection allows you to specify minimum and maximum ranges in the autoranging search process:

- MIN-AUTO: Use to select the lowest range to which you want the instrument to autorange.
- MAX-AUTO: Use to select the highest range to which you want the instrument to autorange.

DAMPING

High capacitance seen at the input will increase reading noise. This capacitance can be attributed to a long input cable or to the capacitance of the source, or a combination of both. Enabling damping will reduce this type of noise. However, damping will also slow down the response of the measurement.

Do not confuse damping with filtering. Damping is used to reduce noise caused by input capacitance, while filtering is used to reduce noise caused by a noisy input signal.

- ON: Enable current damping
- OFF: Disable current damping

Current measurement considerations

Some considerations for making accurate current measurements are summarized in the following paragraphs (see *Other measurement considerations* for additional measurement considerations). For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley Instruments.

Input bias current

An ideal ammeter would read 0A with an open input. In practice, however, ammeters do have some current that flows when the input is open. This current is known as the input bias (offset) current and may be large enough to corrupt low current measurements.

The input bias current for the Model 6517B is listed in the specifications (see *Accuracy Calculations* in [Appendix B](#)). Input bias current may be reduced by performing the offset adjustment procedure.

Voltage burden

The input resistance of the ammeter causes a small voltage drop across the input terminals. This voltage is known as the voltage burden. If the voltage burden is large in relation to the voltage of the measured circuit, then significant measurement errors will occur.

Refer to [Figure 4-8](#) to see how voltage burden affects current measurements. Assume V_S is 5mV and R_S is 5k Ω to configure a 1 μ A current source (5mV/5k Ω = 1 μ A). An ideal ammeter with zero voltage burden would measure the current source as follows:

$$I_M = \frac{E_S}{R_S} = \frac{5\text{mV}}{5\text{k}\Omega} = 1\mu\text{A}$$

In practice however, every ammeter has a voltage burden. If the voltage burden (V_B) is 1mV, the current will be measured as follows:

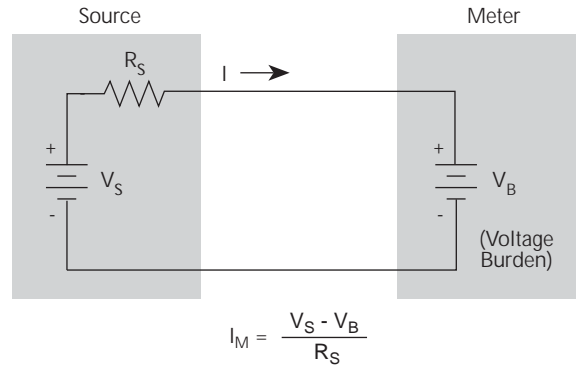
$$I_M = \frac{V_S - V_B}{R_S} = \frac{5\text{mV} - 1\text{mV}}{5\text{k}\Omega} = 0.8\mu\text{A}$$

The 1mV voltage burden caused a 20% measurement error. Percent error in a measured reading (I_M) due to voltage burden can be calculated as follows:

$$I_M^{\% \text{error}} = \frac{100\%}{(V_S/V_B)}$$

The voltage burden of the Model 6517B depends on the selected range (see *Accuracy Calculations* in [Appendix B](#)). Voltage burden may be reduced by performing the offset adjustment procedure.

Figure 4-8
Voltage burden considerations



Noise

Noise can seriously affect sensitive current measurements. The following paragraphs discuss how source resistance and input capacitance affect noise performance.

Source resistance

The source resistance of the DUT will affect the noise performance of current measurements. As the source resistance is reduced, the noise gain of the ammeter will increase.

[Figure 4-9](#) shows a simplified model of the feedback ammeter. R_S and C_S represents the source resistance and source capacitance, V_S is the source voltage, and V_{NOISE} is the noise voltage. Finally, R_F and C_F are the feedback resistance and capacitance respectively.

The source noise gain of the circuit can be given by the following equation:

$$\text{Output } V_{NOISE} = \text{Input } V_{NOISE} (1 + R_F/R_S)$$

Note that as R_S decreases in value, the output noise increases. For example, when $R_F = R_S$, the input noise is multiplied by a factor of two. Since decreasing the source resistance can have a detrimental effect on noise performance, there are usually minimum recommended source resistance values based on measurement range. [Table 4-3](#) summarizes minimum recommended source resistance values for various measurement ranges. Note that the recommended source resistance varies by measurement range because the R_F value also depends on the measurement range.

Table 4-3
Minimum recommended source resistance values

Range	Minimum recommended source resistance
pA	1 GΩ to 100 GΩ
nA	1 MΩ to 100 MΩ
μA	1 kΩ to 100 kΩ
mA	1 Ω to 100 Ω

Source capacitance

DUT source capacitance will also affect the noise performance of the Model 6517B ammeter. In general, as source capacitance increases, the noise also increases. To see how changes in source capacitance can affect noise gain, let us again refer to the simplified ammeter model in [Figure 4-9](#). The elements of interest for this discussion are the source capacitance, C_S and the feedback capacitance C_F . Taking into account the capacitive reactance of these two elements, our previous noise gain formula must be modified as follows:

$$\text{Output } V_{\text{NOISE}} = \text{Input } V_{\text{NOISE}} (Z_F / Z_S)$$

Here, Z_F represents the feedback impedance made up of C_F and R_F , while Z_S is the source impedance formed by R_S and C_S . Furthermore,

$$Z_F = \frac{R_F}{\sqrt{(2\pi f R_F C_F)^2 + 1}}$$

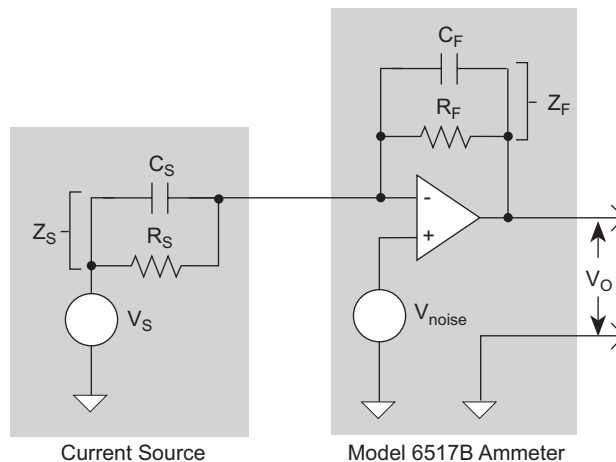
and,

$$Z_S = \frac{R_S}{\sqrt{(2\pi f R_S C_S)^2 + 1}}$$

Note that as C_S increases in value, Z_S decreases in value, thereby increasing the noise gain. Again, at the point where $Z_S = Z_F$, the input noise is amplified by a factor of two.

The maximum value of source capacitance (C_S) for the Model 6517B ammeter is 10,000pF. You can, however, usually measure at higher source capacitance values by inserting a resistor in series with the ammeter input, but remember that any series resistance will increase the voltage burden by a factor of $I_{IN} * R_{SERIES}$. For example, the range of resistance listed in [Table 4-3](#) will result in voltage burden values in the range of 1mV to 1V. A useful alternative to a series resistor is a series diode, or two diodes in parallel back-to-back. The diodes can be small-signal types and should be in a light-tight enclosure.

Figure 4-9
Source resistance and capacitance



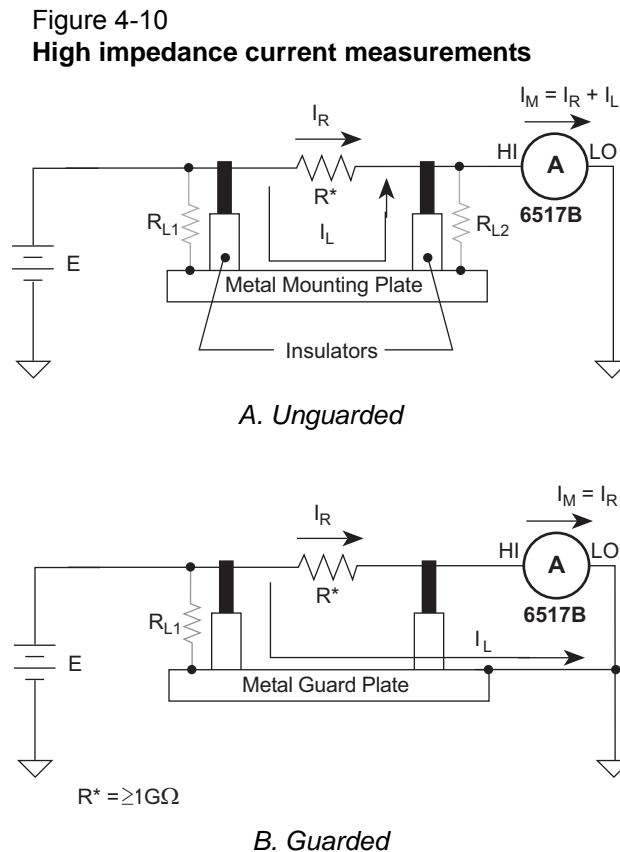
Guarding

For current measurements, guarding is used to drastically reduce leakage currents in high impedance test circuits. Ammeter input LO (inner shield of the triax cable) is used as the guard.

High impedance current measurements

Significant leakage could occur across a high impedance ($\geq 1\text{G}\Omega$) DUT through the insulators as shown in Figure 4-10A where R_{L1} and R_{L2} represent the leakage resistance. So instead of measuring just the current (I_R) through R , you are also measuring the leakage current (I_L). The current measured by the ammeter is $I_R + I_L$.

By connecting ammeter input LO to the metal mounting (guard) plate as shown in Figure 4-10B, the leakage current (I_L) is shunted to ammeter input LO and is not measured by the ammeter. Thus, the ammeter only measures I_R .



Floating current measurements

As discussed previously, guarding uses a conductor at essentially the same potential as the sensitive input to drastically reduce leakage currents in high impedance test circuits. No current can flow when there is a 0V drop across a leakage resistance.

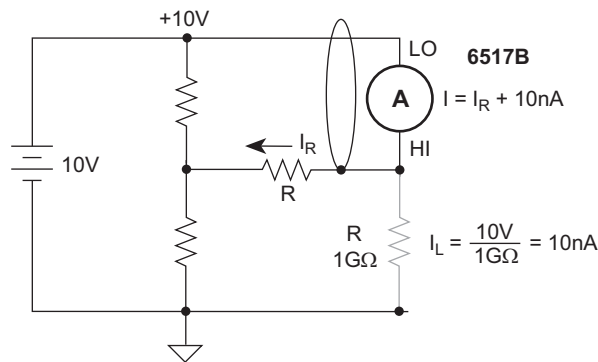
For floating current measurements, ammeter input low is used as the guard since it totally surrounds input high (through the input triax cable), and it is at nearly the same potential as input high. In reality, the ammeter drops $< 1\text{mV}$ and is known as the voltage burden.

Figure Figure 4-11A shows an unguarded floating current measurement in a high impedance circuit. The goal is to measure the current (I_R) through resistor R . However, a leakage path (R_L)

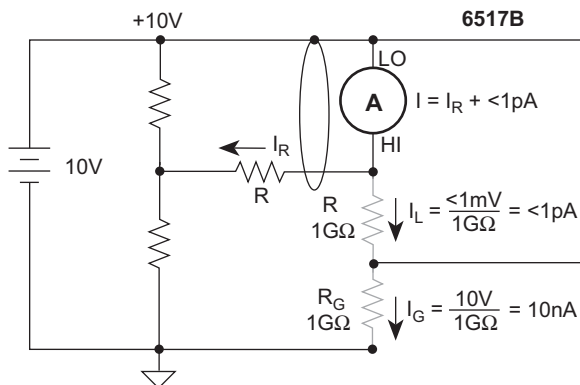
exists from ammeter input LO to test circuit common. Since the ammeter drops $<1\text{mV}$, approximately 10V is dropped by R_L . The current through R_L will be approximately 10nA ($10\text{V}/1\text{G}\Omega = 10\text{nA}$). Thus, the current that is measured by the Model 6517B is the sum of the two currents ($I = I_R + 10\text{nA}$). Obviously, if I_R is a low level current, then the 10nA leakage current will corrupt the measurement.

Figure 4-11B shows the guarded version of the same circuit. Notice that the only difference is that the connections to the electrometer are reversed. Resistor R_L now represents the leakage from ammeter input HI to ammeter input LO, and resistor R_G represents the leakage from ammeter input LO (guard) to test circuit common. As previously mentioned, the ammeter drops $<1\text{mV}$. It then follows that there is a $<1\text{mV}$ drop across R_L . Thus, the current through R_L is $<1\text{pA}$ ($<1\text{mV}/1\text{G}\Omega = <1\text{pA}$). The current that is measured by the Model 6517B is the sum of the two currents ($I = I_R + <1\text{pA}$). The use of guarding reduced the leakage current from 10nA to $<1\text{pA}$. Note that the 10nA leakage current (I_G) from ammeter input LO to test circuit low still exists, but it is of no consequence since it is not measured by the Model 6517B.

Figure 4-11
Floating current measurements



A. Unguarded



B. Guarded

Resistance and resistivity measurements

The Model 6517B can make resistance measurements and resistivity measurements (surface and volume). High resistance measurements (above $1\text{M}\Omega$) may exhibit problematic background currents and can be improved using the alternating polarity test sequence.

Overview

Auto V-source

The Model 6517B has an auto V-source mode for resistance and resistivity measurements. With AUTO V-source selected, the Model 6517B will automatically set the V-source to an optimum test voltage level; either 40V or 400V. The selected test voltage and current measurement range depends on which ohms measurement range is being used (see [Table 4-4](#)). With AUTO V-source selected, the Model 6517B will display the ohms measurement range and the V-source value. Note that with AUTO V-source selected, you will not be able to manually adjust the V-source or change the V-source range when in the ohms function.

If AUTO V-source ohms is on, the voltage limit of the V-source is $<400\text{V}$, an ohms range that requires 400V is selected, an error message will occur, and the voltage source will be turned off.

The published specifications for ohms only apply for the specified AUTO V-source test voltages. If using the MANUAL V-source setting, you must add the V-source errors to the amps measurement range errors to determine the total ohms errors.

With the MANUAL V-source setting selected, you can set the V-source to any value and change the V-source range while in the ohms function. The Model 6517B will display the amps range that is being used for the measurement and the V-source value.

WARNING *A hazardous voltage (400V) may automatically be set for the ohms function when AUTO V-source is selected. [Table 4-4](#) identifies the ohms ranges that use 400V.*

The V-source setting (AUTO or MANUAL) is selected from the VSOURCE item of CONFIGURE OHMS menu.

Ohms ranges

Each measurement range for the ohms function has a lower reading limit that is one decade below the selected range. For example, the $20\text{M}\Omega$ range has a lower reading limit of $2\text{M}\Omega$. The reading ranges for the ohms function are listed in [Table 4-4](#).

Ohms measurements are performed by sourcing voltage and measuring current. Thus, ohms ranges are actually current ranges with ohms displayed.

When the resistance of the DUT (device under test) is too low for the selected ohms range, the resultant current will exceed full scale and cause the UNDERFLOW message to be displayed. This message indicates that the measured resistance is below the lower reading limit of the selected range.

This problem can be resolved by manually selecting the next lower range or by using AUTO range.

There are three ways you can be assured of optimum range selection:

- Use AUTO range.
- Select the next lower range when UNDERFLOW is displayed.

- With the MANUAL V-source selected, use the multiple (NEXT) display that provides the actual measured current. This allows you to check that the selected amps range is the lowest range that can handle the measured current.

Note that with AUTO range selected, the instrument cannot go to the 2T Ω , 20T Ω , or 200T Ω ranges since a hazardous voltage level (400V) may be selected by the instrument. You must select these ranges manually. To speed up the auto range process, you can set upper and lower range limits. Eliminating ranges in the auto range search speeds up the measurement process.

With AUTO V-source selected, the Model 6517B will display the ohms measurement range and the V-source value. With MANUAL V-source selected, the amps range for the measurement and the V-source value will be displayed.

Since AUTO ohms uses the source V, Measure I measurement method, a current measurement overflow will result in an UNDERFLOW error. Conversely, a 0A measured current will result in an OVERFLOW error. To avoid confusion, use NEXT to show the measured current on the secondary display.

Table 4-4
Ohms reading ranges and AUTO V-source

Reading range	AUTO V-source	
	Test voltage	Amps range
200k Ω – 2M Ω	40V	200 μ A
2M Ω – 20M Ω	40V	20 μ A
20M Ω – 200M Ω	40V	2 μ A
200M Ω – 2G Ω	40V	200nA
2G Ω – 20G Ω	40V	20nA
20G Ω – 200G Ω	40V	2nA
200G Ω – 2T Ω	400V	2nA
2T Ω – 20T Ω	400V	200pA
20T Ω – 200T Ω	400V	20pA

Resistance measurements

The Model 6517B can make resistance measurements up to 10¹⁷ Ω using the force voltage measure current (FVMI) technique. From the known sourced voltage and measured current, the Model 6517B calculates and displays the resultant resistance ($R = V/I$). The V-source level can be set automatically by the Model 6517B or it can be manually set by the user.

The following procedure summarizes the basic steps to measure resistance. To ensure proper operation, always enable zero check (“ZeroCheck” displayed) before changing functions (V, I, R, or Q). The Z-CHK key controls zero check.

WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

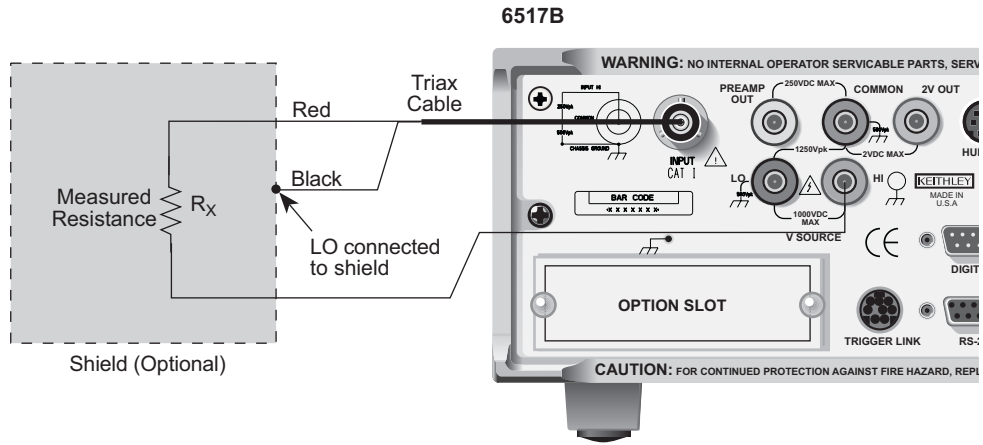
1. Enable zero check by pressing **Z-CHK**.
2. Select **RESISTANCE** from the **MEAS-TYPE** selection of the ohms configuration menu. The ohms configuration menu is accessed by pressing **CONFIG** and then **R**. This step can be skipped if the instrument is already in the resistance measurement mode.
3. Select the V-source adjustment mode. With AUTO V-source selected, the instrument will automatically select the optimum V-source value (40V or 400V) for the measurement range. With MANUAL V-source selected, you select the V-source range and value. The V-source adjustment mode is selected from the **VSOURCE** item of the **CONFIGURE OHMS** menu.
4. Connect the resistance to be measured to the Model 6517B, as shown in the typical connections in [Figure 4-12](#).
5. Select the ohms function by pressing the R key.
6. If the manual V-source adjustment mode is selected, use the cursor keys and the **VOLTAGE SOURCE** adjustment keys to set the voltage level. The V-source range can be changed from the **RANGE** item of the **CONFIGURE V-SOURCE** menu. Note that you will not be able to adjust the V-source if AUTO V-source is selected.

WARNING *To avoid a possible shock hazard, do not use a voltage level that exceeds the maximum input voltage rating of the test fixture.*

1. Use the manual **RANGE** keys (Δ and ∇) to select the resistance measurement range, or select AUTO range. Note that with AUTO range selected, the instrument will not go to the 2T Ω , 20T Ω and 200T Ω ranges. For optimum accuracy, leakage currents in the test fixture can be cancelled by performing REL on the current component of the measurement. To cancel leakage current, perform see *Cancelling test fixture leakage current* which follows Step 9 of this procedure.
2. Disable zero check by again pressing **Z-CHK** and press **OPER** to source voltage to the DUT. A flashing VOLTAGE SOURCE OPERATE LED indicates that the V-source has gone into current limit. The programmed voltage is not being applied to the load. In this situation, try using a lower voltage for the measurement.
3. Take the reading from the display.

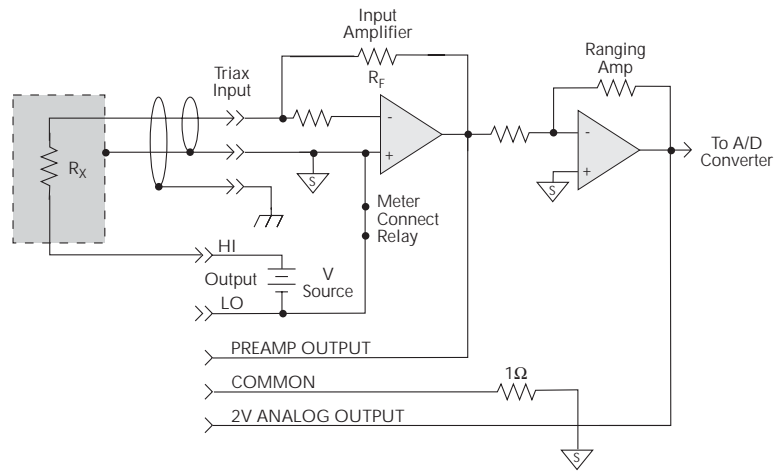
WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

Figure 4-12
Typical connections for resistance measurements



Note: V-Source low internally connected to electrometer low.

A. Connections



B) Equivalent Circuit

B. Equivalent circuit

Cancelling test fixture leakage current

Significant leakage in the test fixture can corrupt a resistance measurement. This leakage current can be cancelled by performing a REL on the current component of the resistance measurement. The following procedure assumes that steps 1 through 7 of the preceding resistance measurement procedure has been performed. Perform the following steps to cancel leakage current:

1. With the V-source in standby, remove the DUT from the test fixture.
2. Select the amps function (I) and then disable zero check; also make sure that REL is disabled (REL indicator off).
3. Press **OPER** to source the programmed V-source level to the test fixture.
4. Select the lowest possible measurement range to display the current reading; this reading is the leakage current in the test fixture.
5. Press **REL** to zero the reading; this cancels the leakage current reading.
6. Press **OPER** to place the V-source in standby and enable zero check.
7. Perform the following steps to establish the amps REL value for the ohms function:
 - a. Press **CONFIG** and then **R** to display the **CONFIGURE OHMS** menu.
 - b. Select the **AMPSREL** menu item.
 - c. Select **YES** to establish the amps REL value.
 - d. Use the **EXIT** key to back out of the menu structure.
8. Re-install the DUT in the test fixture.
9. Select the ohms function (**R**) and proceed to step 8 of the resistance measurement procedure.

Resistivity measurements

The Model 6517B can make surface resistivity measurements from 10^3 to 10^{17} ohms and volume resistivity measurements from 10^3 to 10^{18} ohm-cm.

Typical resistivity test fixtures (such as the Keithley Instruments Model 8009) use circular electrodes. In order to use these test fixtures, the insulator sample must be large enough such that all the surfaces of the electrodes make contact with the sample. When using the Model 8009 test fixture, you do not have to make any calculations. For volume resistivity, you only need to know the thickness (in mm.) of the sample. The Model 6517B will automatically perform the calculation and display the reading.

Surface resistivity

Surface resistivity is defined as the electrical resistance of the surface of an insulator material. It is measured from electrode to electrode along the surface of the insulator sample. Since the surface length is fixed, the measurement is independent of the physical dimensions (for example, thickness and diameter) of the insulator sample.

Surface resistivity is measured by applying a voltage potential across the surface of the insulator sample and measuring the resultant current as shown in [Figure 4-13](#). The Model 6517B automatically performs the following calculation and displays the surface resistivity reading:

$$\rho_s = K_s R$$

ρ_s = Surface resistivity (per square).

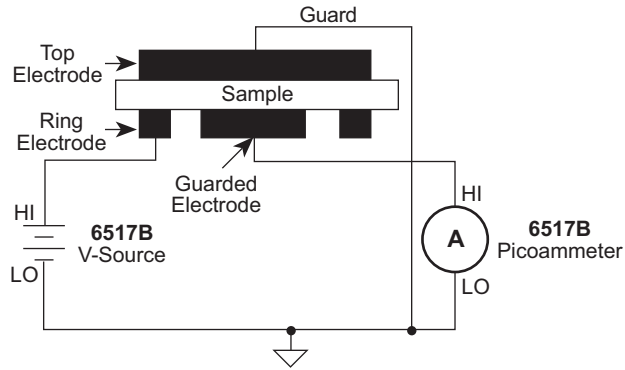
R = Measured resistance in ohms (V/I).

$K_s = P/g$

Where: P = The effective perimeter of the guarded electrode (mm).

g = Distance between the guarded electrode and the ring electrode (mm).
 Refer to [Figure 4-14](#) to determine dimension g .

Figure 4-13
Surface resistivity measurement technique

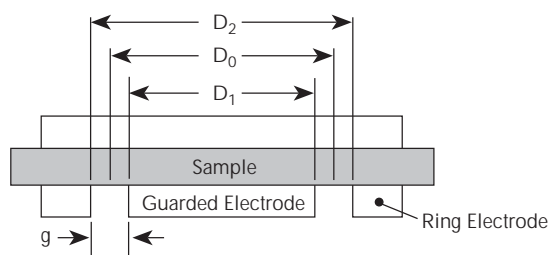
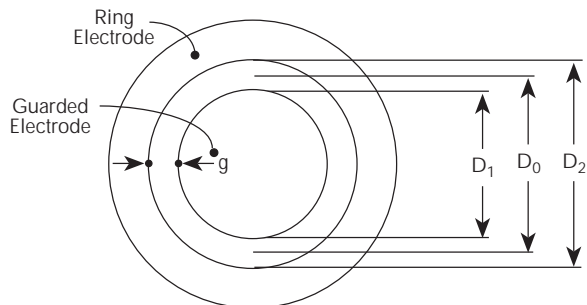


For circular electrodes:

$$P = \pi D_0$$

$D_0 = D_1 + g$ (refer to [Figure 4-14](#) to determine dimension D_0).

Figure 4-14
Circular electrode dimensions



$$g = \frac{D_1 - D_2}{2} \quad D_0 = D_1 + g$$

Test Fixture Dimensions (cm)	
Model 8009	
D ₁	2.000 in
D ₀	2.125 in
D ₂	2.250 in
g	0.125 in

Volume resistivity

Volume resistivity is defined as the electrical resistance through a cube of insulating material. When expressed in ohm-centimeters, it would be the electrical resistance through a one-centimeter cube of insulating material. If expressed in ohm-inches, it would be the electrical resistance through a one-inch cube of insulating material.

Volume resistivity is measured by applying a voltage potential across opposite sides of the insulator sample and measuring the resultant current through the sample as shown in [Figure 4-15](#). The Model 6517B automatically performs the following calculation and displays the volume resistivity reading:

$$\rho_V = \frac{K_V R}{\tau}$$

ρ_V = Volume resistivity.

K_V = The effective area of the guarded electrode for the particular electrode arrangement employed.

τ = Average thickness of the sample (mm).

R = Measured resistance in ohms (V/I).

For circular electrodes:

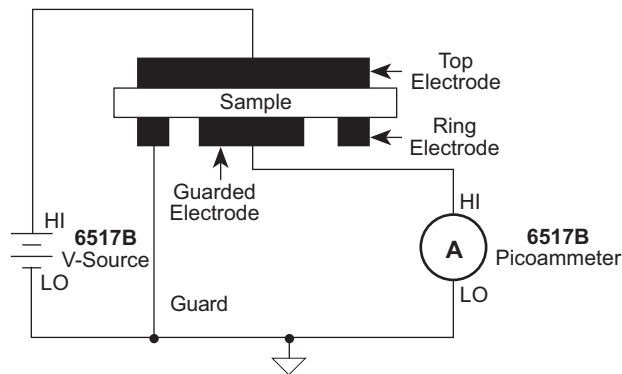
$$K_V = \pi \left(\frac{D_1}{2} + B \frac{g}{2} \right)^2$$

D_1 = Outside diameter of guarded electrode.

g = Distance between the guarded electrode and the ring electrode.

B = Effective area coefficient.

Figure 4-15
Volume resistivity measurement technique



Refer to [Figure 4-14](#) to determine dimensions D_1 and g . An effective area of coefficient (B) of 0 is typically used for volume resistivity.

General measurement procedure

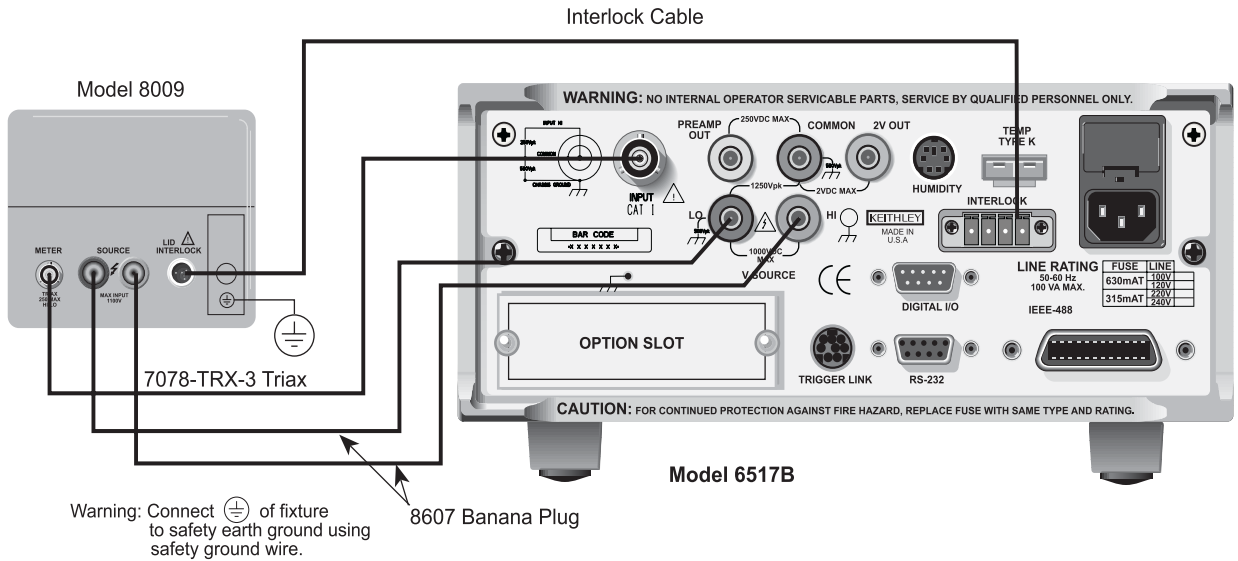
The following steps summarize the basic steps to measure resistivity. To ensure proper operation, always enable zero check (“ZeroCheck” displayed) before changing functions (V, I, R, or Q). The Z-CHK key controls zero check.

WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

1. Enable zero check by pressing **Z-CHK**.
2. Select and configure the desired resistivity measurement type from the **MEAS-TYPE (RESISTIVITY)** option of the ohms configuration menu (see *Ohms configuration* for more information).
3. Select the V-source adjustment mode. With AUTO V-source selected, the instrument will automatically select the optimum V-source value (40V or 400V) for the measurement range. With MANUAL V-source selected, you select the V-source range and value. The V-source adjustment mode is selected from the **V-SOURCE** item of the **CONFIGURE OHMS** menu.
4. Connect the sample to be measured to the Model 6517B. [Figure 4-16](#) shows the connections to the Model 8009 for surface and volume resistivity measurements.
5. Select the ohms function by pressing **R**.
6. If the manual V-source adjustment mode is selected, use the cursor and the **VOLTAGE SOURCE** adjust keys to set the voltage level. The V-source range can be changed from the **RANGE** item of the **CONFIGURE V-SOURCE** menu. Note that you will not be able to adjust the V-source if AUTO V-source is selected.
7. Use the manual **RANGE** keys (Δ and ∇) to select the ohms measurement range, or select **AUTO** range. Note that with AUTO range selected, the instrument will not go the $2T\Omega$, $20T\Omega$ and $200T\Omega$ ranges.
8. Disable zero check by again pressing **Z-CHK**.
9. Press **OPER** to place the V-source in operate and after an appropriate electrification period (bias time), note the resistivity reading. Typically, an electrification period of 60 seconds is used. A flashing VOLTAGE SOURCE OPERATE LED indicates that the V-source has gone into current limit. The programmed voltage is not being applied to the load. In this situation, try using a lower voltage for the measurement.
10. Place the V-source in standby by again pressing **OPER** and enable zero check.

WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

Figure 4-16
Connections for measurements using Model 8009 test fixture



Ohms configuration

The following information explains the various configuration options for the ohms function. The configuration menu is summarized in [Table 4-5](#). This menu is accessed by pressing **CONFIG** and then **R**.

Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 4-5
Ohms configuration menu

Menu item	Description
SPEED NORMAL FAST MEDIUM HIACCURACY SET-SPEED-EXACTLY SET-BY-RSLN	Measurement speed (integration time) menu: Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz) Select 0.01 PLC Select 0.1 PLC Select 10 PLC Set integration time in PLC (0.01-10) Default to setting appropriate for resolution
FILTER AVERAGING TYPE NONE AVERAGING ADVANCED AVERAGING-MODE MEDIAN DISABLE ENABLE	Filter menu: Configure digital averaging filter: Select type of average filter: No average filtering performed Program a simple average filter (1-100 readings) Program a simple average filter (1-100 readings) with noise tolerance window (0-100% of range) Select moving average or repeating average mode Configure median filter: Disable median filter Enable median filter and specify range (1-5)
RESOLUTION AUTO 3.5d, 4.5d, 5.5d, 6.5d	Display resolution menu: Default to resolution appropriate for integration time Select a specific resolution
AMPSREL	Enable or disable amps REL

Table 4-5 (continued)

Ohms configuration menu

Menu item	Description
AUTORNG USE-ALL-RANGES SET-LIMITS MIN-AUTO MAX-AUTO	Autorange menu: Use all ranges when autoranging Limit the ranges used in the autorange search: Specify the minimum range in the search Specify the maximum range in the search
DAMP	Enable or disable damping
MEAS-TYPE RESISTANCE RESISTIVITY SURFACE VOLUME	Resistance measurement type menu: Select the resistance measurement mode Select the resistivity measurement mode: Configure surface resistivity measurements Configure volume resistivity measurements
VSOURCE	Select AUTO or MANUAL V-source

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture).

FILTER

Use this menu item to configure the two basic filter types; averaging and median. Note that you can use either the averaging filter, the median filter, or both.

The filter menu is available from the function configuration menus (for example, press **CONFIG V**) or by pressing **CONFIG FILTER** with the desired function already selected.

RESOLUTION

The RESOLUTION parameter sets the display resolution.

AMPSREL

Leakage current in a test fixture can corrupt a resistance measurement. This leakage current can be cancelled by performing a REL on the current component of the measurement. With this menu item, you can use the established amps REL value for the resistance measurement (see *Cancelling test fixture leakage current* for more information).

ENABLED: Use this option to use the amps REL value. After this option is selected, the instrument will display the status of REL for the ohms function and for the amps function. If REL for the amps function is disabled, then no amps REL operation will be performed on the measurement.

DISABLED: Use this option if you do not wish to use the amps REL value for resistance measurements.

AUTORNG

The AUTORNG option is used to configure autorange for the ohms function. This option allows you to speed up the autoranging search process by eliminating upper and lower measurement ranges. For example, if you know that readings will not exceed 1G Ω , you can specify the 2G Ω range to be the maximum range. When the instrument autoranges (assuming AUTO range is enabled), it will not search into the ohms ranges above 2G Ω . Note that the 2T Ω , 20T Ω and 200T Ω ranges are not available for AUTO range.

USE-ALL-RANGES: With this selection, all ohms ranges (except the 2T Ω , 20T Ω and 200T Ω ranges) are used in the autoranging search process.

SET-LIMITS: This selection allows you to specify minimum and maximum ranges in the autoranging search process:

- MIN-AUTO: Use to select the lowest range to which you want the instrument to autorange.
- MAX-AUTO: Use to select the highest range to which you want the instrument to autorange.

DAMP

High capacitance seen at the input will increase reading noise. This capacitance can be attributed to a long input cable or to the capacitance of the source, or a combination of both. Enabling damping will reduce this type of noise. However, damping will also slow down the response of the measurement.

Do not confuse damping with filtering. Damping is used to reduce noise caused by input capacitance, while filtering is used to reduce noise caused by a noisy input signal.

ON: Enable current damping

OFF: Disable current damping

MEAS-TYPE

The MEAS-TYPE option is used to select and configure the measurement type for the ohms function.

RESISTANCE: Use this menu item to configure the ohms function to make normal resistance measurements.

RESISTIVITY: Use this menu item to configure the ohms function to make surface or volume resistivity measurements. If the Model 6517B is already configured to use the Model 8009 Resistivity Test Fixture (see "FIXTURE-MODEL" below) then the interlock cable **MUST** be connected to that test fixture. Measurement type (surface or volume) is automatically selected by the switch position on the test fixture. Attempts to change measurement type from the menu will be ignored. If the interlock cable is not connected, then the settings for volume or surface will not work properly, and you will not be able to change measurement type from the menu.

SURFACE: Select this option to make surface resistivity measurements. After the option is selected, the following menu items are used to configure the resistivity measurement:

MODEL-8009: Use this option if you are using the Model 8009 Resistivity Test Fixture. This option automatically sets the parameters for the surface resistivity calculation since the electrode dimensions are known.

USER: Use this option if using another manufacturer's test fixture or a custom-built test fixture. After selecting this option you will be prompted to enter the value for K_s .

VOLUME: Select this option to make volume resistivity measurements. After the option is selected, the following menu items are used to configure the resistivity measurement:

THICKNESS: Use to specify (in millimeters) the thickness of the sample.

FIXTURE-MODEL: Use this menu item to select the test fixture that you are going to use:

- MODEL-8009: Select this option if using the Model 8009 Resistivity Test Fixture. This option automatically sets the parameters for the volume resistivity calculation since the electrode dimensions are known.
- USER: Use this option if using another manufacturer's test fixture, or a custom-built test fixture. This option is also used for the Model 8009 test fixture if using an effective area coefficient less than one ($B < 1$). After selecting this option you will be prompted to enter the value for K_v .

VSOURCE

The **VSOURCE** menu item is used to select either AUTO V-source or MANUAL V-source:

- **MANUAL:** Select this option if you wish to manually set the V-source range and level for the ohms function.
- **AUTO:** Select this option if you wish the Model 6517B to automatically select the optimum V-source range and level for the ohms function; 40.000V for the 2M Ω through 200G Ω ranges, and 400.00V for the 2T Ω through 200T Ω ranges. With AUTO V-source selected, you will not be able to manually set the V-source range or level while in the ohms function.

WARNING *A hazardous voltage (400V) may automatically be set for the ohms function when AUTO V-source is selected. [Table 4-4](#) identifies the ohms ranges that use the high voltage.*

Multiple display

There is one multiple display that is unique to the ohms function.

Measure/source: When this **NEXT** display is selected, the amps measurement and V-source value are shown on the secondary display. The resistance measurement is shown on the primary display.

Ohms measurement considerations

Some considerations for making accurate resistance and resistivity measurements are summarized in the following paragraphs. High resistance measurements (above 1M Ω) may exhibit problematic background currents and can be improved by using the alternating polarity test sequence (see *Other measurement considerations* for additional information). For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley Instruments.

Leakage resistance

Even though the FVMI method for resistance measurements minimizes the effects of leakage resistance, there are some cases where leakage can affect the measurement. For example, test fixture leakage paths may appear in parallel with the device being measured, introducing errors in the measurement. These errors can be minimized by using proper insulating materials (such as Teflon) in test fixture terminals, and by keeping them clean and moisture free.

Leakage currents in the test fixture can be cancelled by performing a REL on the current component of the measurement.

Voltage coefficient

The measured value of a high-megohm resistor will often vary with the applied voltage. Such variation in resistance is known as the voltage coefficient, and is usually expressed in percent/volt or ppm/volt values. To obtain consistent test results, these resistors should always be biased at the same voltage.

The Model 6517B can be used to characterize such resistance changes by measuring the resistance with a number of different applied voltages. Once the variations are known, the voltage coefficient of the resistor being tested can be determined.

Test voltage and electrification time

Test voltage

Typically specified test voltages to be applied to the insulator sample are 100V, 250V and 1000V. Higher test voltages are sometimes used, however the maximum voltage that can be applied to the Model 8009 is 1000V, which is the maximum output of the Model 6517B V-source. Unless otherwise specified, the applied direct voltage to the insulator sample should be 500V.

Electrification time

Electrification time (also known as bias time) is the total time that the specified voltage is applied to the insulator sample when the measurement is taken. For example, for an electrification time of 60 seconds, the measurement is to be taken after the insulator sample is subjected to the applied test voltage for 60 seconds. The conventional arbitrary electrification time is 60 seconds. Keep in mind that special studies or experimentation may dictate a different electrification time.

Current measurement considerations

Ohms measurements are performed by forcing voltage and measuring current (FVMI). Thus, accurate measurements require accurate current measurements. Capacitive inputs will increase preamplifier noise, resulting in increased noise across the voltage source terminals (see *Other measurement considerations* for additional measurement considerations).

Charge measurements (Q)

The Model 6517B is equipped with four coulombs ranges to resolve charges as low as 10fC (10^{-14}C) and measure as high as $2.1\mu\text{C}$. In the coulombs function, an accurately known capacitor is placed in the feedback loop of the amplifier so that the voltage developed is proportional to the integral of the input current in accordance with the formula:

$$V = \frac{1}{C} \int i dt = \frac{Q_s}{C}$$

The voltage is scaled and displayed as charge.

Basic measurement procedure

NOTE After measuring high voltage in the volts function, it may take a number of minutes for input current to drop to within specified limits. Input current can be verified by placing the protection cap on the INPUT triax connector and then connecting a jumper between COMMON and chassis ground. With the instrument on the 20pA range and zero check disabled, allow the reading to settle until the input bias current is within specifications.

Auto discharge

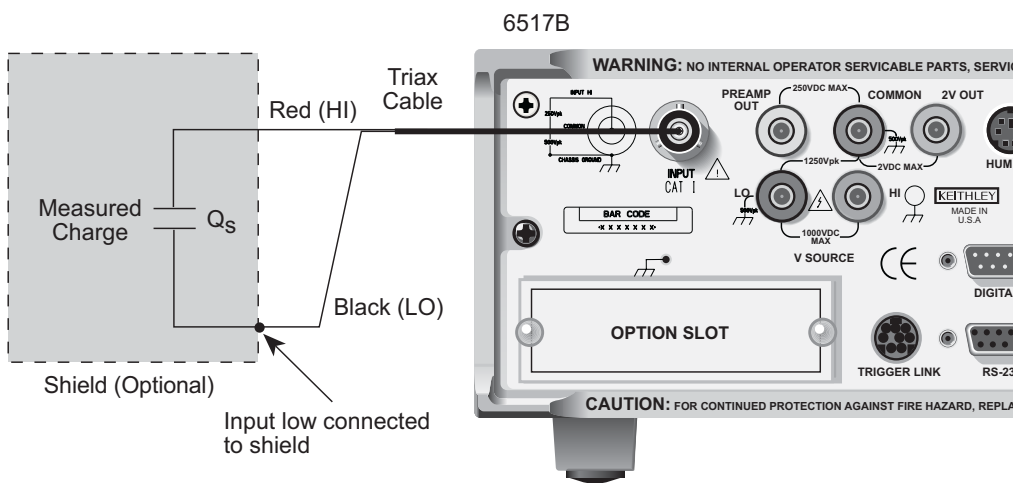
The Model 6517B has an auto discharge feature for the coulombs function. When enabled, auto discharge resets the charge reading to zero when the charge reading reaches the specified level. After the integrator resets, the charge measurement process simply restarts at zero.

Procedure

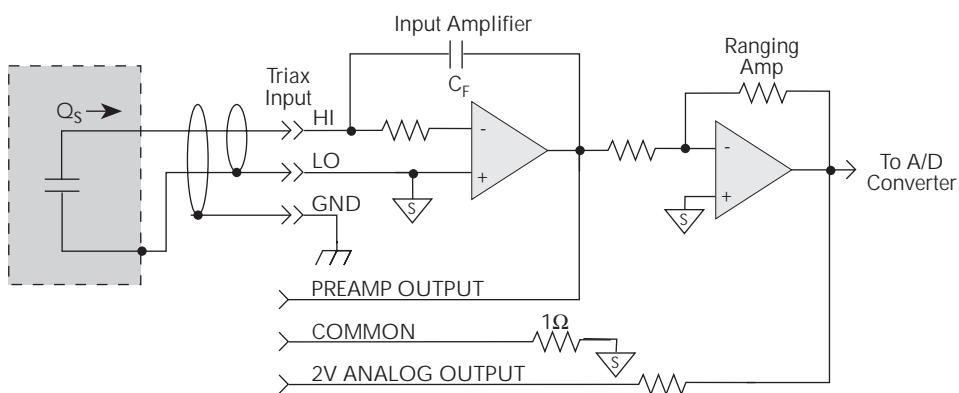
Use the following basic procedure to make charge measurements. To ensure proper operation, always enable zero check ("ZeroCheck" displayed) before changing functions (V, I, R, or Q). The **Z-CHK** key controls zero check.

1. Enable zero check by pressing **Z-CHK**.
2. Select the coulombs (**Q**) function and select the desired manual measurement range or auto range.
3. Auto discharge is configured from the Coulombs Configuration menu (see *Coulombs configuration*).
4. Connect the test cable to the Model 6517B; with the input open, disable zero check and enable REL to zero the instrument.
5. Connect the circuit to the INPUT of the Model 6517B as shown in [Figure 4-17](#); do not connect the circuit to the instrument with zero check enabled.
6. Take the charge reading from the display.

Figure 4-17
Typical connections for charge measurements



A. Connections



B) Equivalent Circuit

B. Equivalent circuit

Coulombs configuration

The following information explains the various configuration options for the coulombs function. The configuration menu is summarized in [Table 4-6](#). This menu is accessed by pressing **CONFIG** and then **Q**.

Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 4-6

Coulombs configuration menu

Menu item	Description
SPEED NORMAL FAST MEDIUM HIACCURACY SET-SPEED-EXACTLY SET-BY-RSLN	Measurement speed (integration time) menu: Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz) Select 0.01 PLC Select 0.1 PLC Select 10 PLC Set integration time in PLC (0.01-10) Default to setting appropriate for resolution
FILTER AVERAGING TYPE NONE AVERAGING ADVANCED AVERAGING-MODE MEDIAN DISABLE ENABLE	Filter menu: Configure digital averaging filter: Select type of average filter: No average filtering performed Program a simple average filter (1-100 readings) Program a simple average filter (1-100 readings) with noise tolerance window (0-100% of range) Select moving average or repeating average mode Configure median filter: Disable median filter Enable median filter and specify rank (1-5)
RESOLUTION AUTO 3.5d, 4.5d, 5.5d, 6.5d	Display resolution menu: Default to resolution appropriate for integration time Select a specific resolution
AUTO-DISCHARGE AUTORANGE	Enable (specify level) or disable auto discharge Select autorange limits (high or low)

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measure (also known as aperture).

FILTER

Use this menu item to configure the two basic filter types; averaging and median. Note that you can use either the averaging filter, the median filter, or both. The filter menu is available from the function configuration menus (for example, press **CONFIG V**) or by pressing **CONFIG FILTER** with the desired function already selected.

RESOLUTION

The RESOLUTION parameter sets the display resolution.

AUTO-DISCHARGE

The AUTO-DISCHARGE option is used to enable or disable auto discharge. When enabled, auto discharge resets the charge reading to zero at the specified level. After the integrator resets, the charge measurement process simply restarts at zero.

The AUTO-DISCHARGE selections are as follows:

OFF: Use this selection to disable auto discharge. With auto discharge disabled, you can use zero check to reset the integrator.

ON: Use this selection to enable auto discharge. After selecting ON, you will be prompted to enter the discharge level. The charge reading will reset every time the specified charge level is reached. Note that if you specify a level that exceeds the measurement range, the display will overflow before the integrator resets.

AUTORANGE

The AUTORANGE option is used to configure autorange for the coulombs function. This option allows you to speed up the autoranging search process by eliminating the low (2nC and 20nC) or high (200nC and 2 μ C) measurement ranges. For example, if you know that the readings will not exceed 10nC, you can select LO autorange limits. When the instrument autoranges (assuming AUTO range is enabled), it will not search into the high ranges.

LO (2nC-20nC): Use this option to limit the autorange search to the low measurement ranges.

HIGH (200nC-2 μ C): Use this option to limit the autorange search to the high measurement ranges.

Charge measurement considerations

Some considerations for making accurate charge measurements are summarized in the following paragraphs (see *Other measurement considerations* for additional measurement considerations). For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley Instruments.

Input bias current

A primary consideration when making charge measurements is the input bias (offset) current of the integrating amplifier. Any such current is integrated along with the input signal and reflected in the final reading. The Model 6517B has a maximum input bias of 4fA (4×10^{-15} A) for charge at 23°C. This input offset translates into a charge of 4fC per second at a temperature of 23°C. This value must be subtracted from the final reading to obtain the correct value.

Input bias current may be reduced by performing the offset adjustment procedure (**OFFSET-ADJ**).

External voltage source

When using an external voltage source, the input current should be limited to less than 1mA by placing a resistor in series with the high input lead. The value of this resistor should be at least:

$$R = 1000 \times V \text{ (ohms)}$$

Where: V is the voltage across the resistor, or the compliance of the current being integrated.

Measurement times

Long measurement times may degrade charge measurement accuracy. See the Model 6517B coulombs specifications in [Appendix B](#).

Zero check hop and auto discharge hop

Using the zero check feature (going from the enabled state to the disabled state) causes a sudden change in the charge reading and is known as zero check hop. This sudden change in charge also occurs when the auto discharge feature resets the charge reading to zero. This hop in charge can be eliminated by taking a reading the instant zero check is disabled or when an auto discharge occurs, and subtracting it from all subsequent readings. A better way to deal with this hop in charge is to enable REL immediately after zero check is disabled or when auto discharge resets the charge reading. This action nulls out the charge reading caused by the hop.

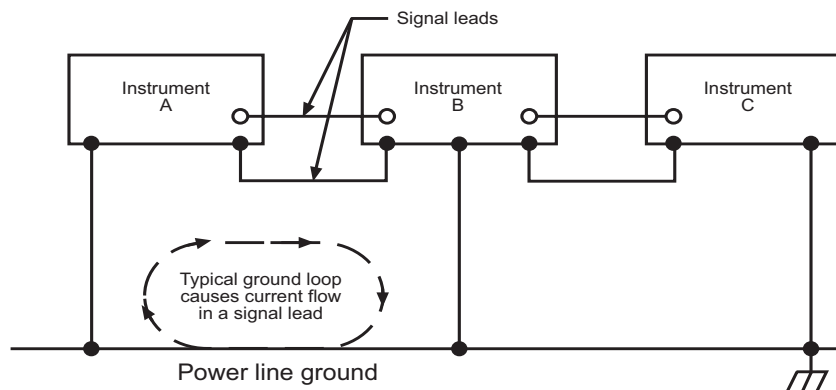
Other measurement considerations

The following measurement considerations apply to all precision measurements. For comprehensive information on all measurement considerations, refer to the Low Level Measurements handbook, which is available from Keithley Instruments.

Ground loops

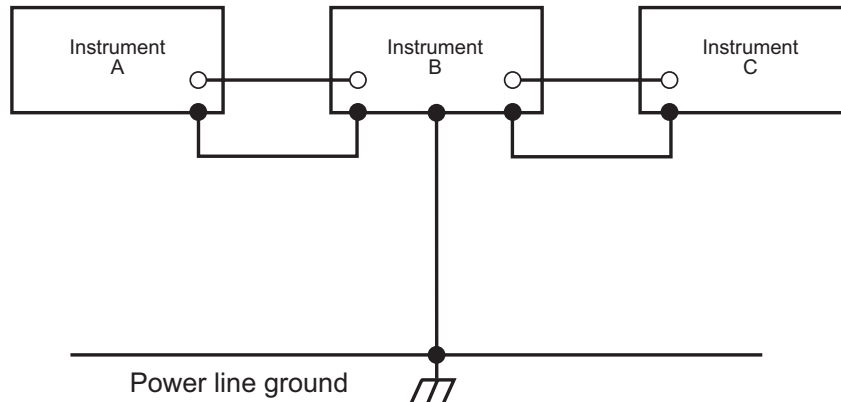
Ground loops that occur in multiple-instrument test set-ups can create error signals that cause erratic or erroneous measurements. The configuration shown in [Figure 4-18](#) introduces errors in two ways. Large ground currents flowing in one of the wires will encounter small resistances, either in the wires, or at the connecting points. This small resistance results in voltage drops that can affect the measurement. Even if the ground loop currents are small, magnetic flux cutting across the large loops formed by the ground leads can induce sufficient voltages to disturb sensitive measurements.

Figure 4-18
Multiple ground points create a ground loop



To prevent ground loops, instruments should be connected to ground at only a single point, as shown in [Figure 4-19](#). Note that only a single instrument is connected directly to power line ground. Experimentation is the best way to determine an acceptable arrangement. For this purpose, measuring instruments should be placed on their lowest ranges. The configuration that results in the lowest noise signal is the one that should be used.

Figure 4-19
Eliminating ground loops



Triboelectric effects

Triboelectric currents are generated by charges created between a conductor and an insulator due to friction. Here, free electrons rub off the conductor and create a charge imbalance that causes the current flow. For example, bending a triaxial cable causes friction between the center conductor (HI) and its surrounding insulator, resulting in triboelectric currents. Triboelectric currents can be minimized as follows:

- Use “low noise” cables. These cables are specially designed to minimize charge generation and use graphite to reduce friction. The Keithley Instruments Model 7078-TRX triax cables are low noise.
- Use the shortest cables possible, and secure them (for example, taping or tying) to a non-vibrating surface to keep them from moving.

Piezoelectric and stored charge effects

Piezoelectric currents are generated when mechanical stress is applied to certain insulating materials (for example, crystalline). In some plastics, pockets of stored charge cause the material to behave in a similar manner.

When building test fixtures, choose good insulating materials and make connecting structures as rigid as possible. Make sure there are no mechanical stresses on the insulators.

Electrochemical effects

Error currents also arise from electrochemical effects when ionic chemicals create weak batteries on a circuit board. These batteries could generate a few nanoamps of current between conductors. Ionic contamination may be the result of body oils, salts or solder flux. The problem is further enhanced by high humidity (moisture) that decreases insulation resistance.

When building test fixtures, select insulators that resist water absorption, and use the fixture in a moderate humidity environment. Also, be sure that all insulators are kept clean and free of contamination.

Humidity

Excess humidity can reduce insulation resistance on PC boards and in test connection insulators. Reduction in insulation resistance can, of course, seriously affect high-impedance measurements.

Also, humidity (moisture) can combine with contaminants to produce offset currents caused by electrochemical effects. To minimize the effects of moisture, keep humidity to a minimum (ideally <50%), and keep components and connectors in the test system clean.

Light

Some components, such as semiconductor junctions and MOS capacitors on semiconductor wafers, are excellent light detectors. Consequently, these components must be tested in a light-free environment. While many test fixtures (Keithley Instruments test fixtures, for instance) provide adequate light protection, others may allow enough light penetration to affect the test results. Areas to check for light leaks include doors and door hinges, tubing entry points, and connectors or connector panels.

Electrostatic interference

Electrostatic interference occurs when an electrically charged object is brought near an uncharged object, thus inducing a charge on the previously uncharged object. Usually, effects of such electrostatic action are not noticeable because low impedance levels allow the induced charge to dissipate quickly. However, the high impedance levels of many Model 6517B measurements do not allow these charges to decay rapidly, and erroneous or unstable readings may result. These erroneous or unstable readings may be caused in the following ways:

1. DC electrostatic field can cause undetected errors or noise in the reading.
2. AC electrostatic fields can cause errors by driving the input preamplifier into saturation, or through rectification that produces DC errors.

Electrostatic interference is first recognizable when hand or body movements near the experiment cause fluctuations in the reading. Pick-up from AC fields can also be detected by observing the electrometer preamp output on an oscilloscope. Line frequency signals on the output are an indication that electrostatic interference is present. Means of minimizing electrostatic interference include:

1. Shielding. Possibilities include: a shielded room, a shielded booth, shielding the sensitive circuit, and using shielded cable. The shield should always be connected to a solid connector that is connected to signal low. If circuit low is floated above ground, observe safety precautions, and avoid touching the shield. Meshed screen or loosely braided cable could be inadequate for high impedances, or in string fields. Note, however, that shielding can increase capacitance in the measuring circuit, possibly slowing down response time.
2. Reduction of electrostatic fields. Moving power lines or other sources away from the experiment reduces the amount of electrostatic interference seen in the measurement.

Magnetic fields

A magnetic field passing through a loop in a test circuit will generate a magnetic EMF (voltage) that is proportional to the strength of the field, the loop area, and the rate at which these factors are changing. Magnetic fields can be minimized by following these guidelines:

- Locate the test circuit as far away as possible from such magnetic field sources as motors, transformers, and magnets.
- Avoid moving any part of the test circuit within the magnetic field.
- Minimize the loop area by keeping leads as short as possible and twisting them together.

Electromagnetic interference (EMI)

The electromagnetic interference characteristics of the Model 6517B Electrometer/High Resistance Meter comply with the electromagnetic compatibility (EMC) requirements of the European Union as denoted by the CE mark. However, it is still possible for sensitive measurements to be affected by external sources. In these instances, special precautions may be required in the measurement setup.

Sources of EMI include:

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

The effect on instrument performance can be considerable if enough of the unwanted signal is present. The effects of EMI can be seen as an unusually large offset, or in the case of impulse sources, erratic variations in the displayed reading.

The instrument and experiment should be kept as far away as possible from any EMI sources. Additional shielding of the instrument, experiment and test leads will often reduce EMI to an acceptable level. In extreme cases, a specially constructed screen room may be required to sufficiently attenuate the troublesome signal.

External filtering of the input signal path may be required. In some cases, a simple one-pole filter may be sufficient. In more difficult situations, multiple notch or band-stop filters, tuned to the offending frequency range, may be required. Connecting multiple capacitors of widely different values in parallel will maintain a low impedance across a wide frequency range. Keep in mind, however, that such filtering may have detrimental effects (such as increased response time) on the measurement.

Relative humidity and external temperature readings

With the appropriate equipment connected, the Model 6517B can measure relative humidity and external temperature. Humidity and external temperature readings are provided as a multiple (NEXT) display for each function. These readings can also be included as data elements for the bus interfaces (GPIB and RS-232), and for the buffer.

Relative humidity

The Keithley Instruments Model 6517-RH option is used to measure relative humidity. This sensor plugs into the connector label "HUMIDITY" on the rear panel of the Model 6517B. Note that an extension cable (part number CA-129-1) is supplied for the humidity sensor.

Humidity measurements are controlled (enabled or disabled) from the A/D-CONTROLS (DATA-STAMP) item of the GENERAL menu (see *GENERAL* in Section 2 for more information).

External temperature

The Keithley Instruments Model 6517-TP option is a "K" type thermocouple sensor that is used to measure external temperature. This sensor plugs into the connector labeled "TEMP TYPE K" on the rear panel of the Model 6517B.

External temperature readings are controlled (enabled or disabled) from the A/D-CONTROLS (DATA-STAMP) item of the GENERAL menu. Measurement units ($^{\circ}\text{C}$, $^{\circ}\text{F}$ or K) are selected from the DISPLAY (TEMP-UNITS) item of the GENERAL menu (see *GENERAL* in Section 2 for more information).

Do not allow the exposed thermocouple sensor to come in contact with chassis ground or to a voltage. This will result in erroneous readings. The thermocouple must be electrically insulated before attaching it to a device that is at chassis ground or has a voltage on it.

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Section 5

Measurement Options

In this section:

Topic	Page
Introduction	5-2
Voltage source.....	5-2
V-Source configuration	5-2
Sourcing options.....	5-3
Setting voltage source value.....	5-6
Voltage and current limit.....	5-7
Interlock and test fixtures.....	5-7
Operate.....	5-8
Analog outputs	5-8
2 V analog output.....	5-9
Preamp out	5-11
Using external feedback.....	5-12
Electrometer input circuitry	5-12
Shielded fixture construction.....	5-13
External feedback procedure.....	5-14
Non-standard coulombs ranges.....	5-15
Logarithmic currents	5-15
Non-decade current gains	5-16
Range and resolution	5-17
Measurement range.....	5-17
Display resolution	5-17
Zero check, relative, and zero correct.....	5-18
Zero check	5-18
Relative (REL)	5-19
Zero correct	5-20

Introduction

This section contains detailed information on measurement options such as using the voltage source, analog output, and preamp output.

Voltage source

The built-in, bipolar, 1 W voltage source of the Keithley Instruments Model 6517B Electrometer can source up to ± 1000 V (the V-source may reach ± 1010 V if it is uncalibrated). The two voltage ranges of the voltage source are summarized in [Table 5-1](#).

Table 5-1: V-source ranges

Range	Maximum output		Step size
	Voltage	Current	
100 V	± 100 V	± 10 mA	5 mV
1000 V	± 1000 V	± 1 mA	50 mV

WARNING *The maximum common-mode voltage for the V-source is 750V peak. That is, the voltage between V-source LO and earth (chassis) ground must never exceed 750V peak, and the voltage between V-source HI and earth (chassis) ground must never exceed 1750V peak. Exceeding these values may create a shock hazard.*

Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.

NOTE Capacitive inputs increase preamplifier noise, resulting in noise across the voltage source terminals.

V-Source configuration

Operations to configure the V-source are performed from the V-source configuration menu which is summarized in [Table 5-2](#). The CONFIGure V-SOURCE menu is displayed by pressing **CONFIG**

and then **OPER**. The various items of this configuration menu are explained in the following sections.

Table 5-2: Configure V-Source menu structure

Menu item	Description
RANGE	Select V-source range (100 V or 1000 V)
V-LIMIT CONTROL LIMIT-VALUE	Voltage limit menu: Use to enable or disable V-Limit Set maximum absolute output limit
RESISTIVE-LIMIT	Enable or disable resistive I-Limit
METER-CONNECT	Enable or disable internal V-source LO to ammeter LO connection

Sourcing options

The voltage source can be used as an independent source or it can be internally connected to the ammeter to force voltage measure current (FVMI).

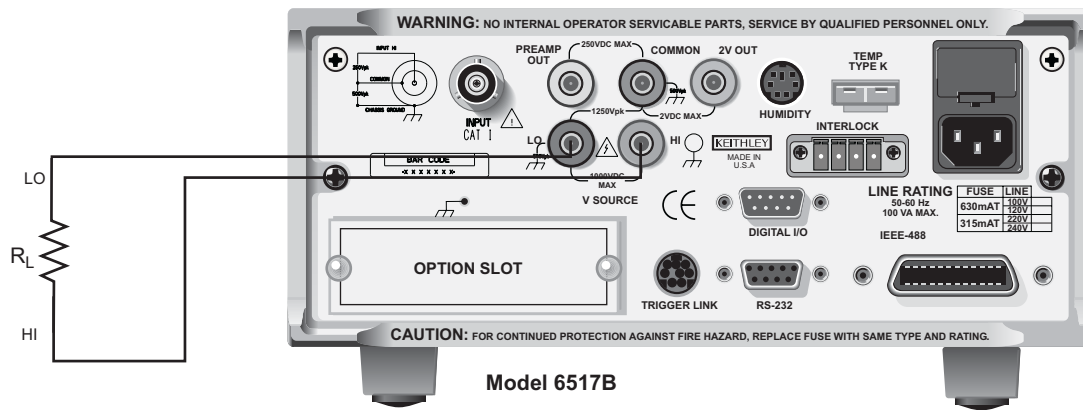
Independent source

When used as an independent source, voltage is available at the V-SOURCE HI and LO terminals on the rear panel (see [Figure 5-1](#)). In this configuration, the V-source functions as a stand-alone voltage source. The V-source is isolated ($>1\text{ G}\Omega$) from the measurement circuits of the Model 6517B when V-source LO is not internally connected to ammeter LO (See [“Ammeter LO to V-source LO connection” on page 5-5 for more information.](#)).

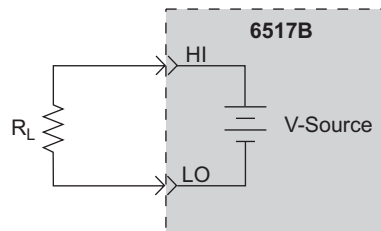
FVMI source

When used to force voltage measure current (FVMI), V-source LO is connected to ammeter LO as shown in [Figure 5-2](#). Notice that the V-SOURCE HI and INPUT HI terminals are used for this configuration. The V-source LO to ammeter LO connection can be controlled from the **METER CONNECT** option of the **CONFigure V-SOURCE** menu (See [“Ammeter LO to V-source LO connection” on page 5-5 for more information.](#)).

Figure 5-1: V-source (independent configuration)

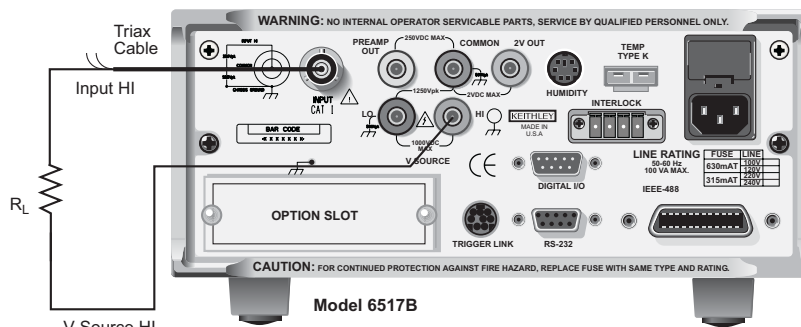


Connections

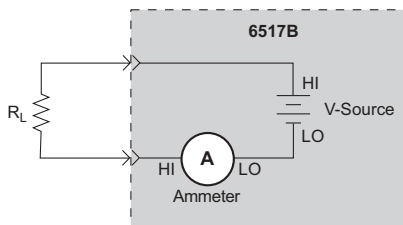


Equivalent Circuit

Figure 5-2: V-source (FVMI configuration)



Connections



Equivalent Circuit

Note: Ammeter LO internally connected to V-Source LO via METER Connect option of CONFIG V-Source menu.

When the voltage source is connected to a capacitor, the inherent noise of the preamplifier is amplified. This is expected performance. Adding a series resistance will not decrease the noise. However shunting the output of the V SOURCE (HI to LO) with a 0.1µF capacitor will recude this noise.

NOTE Ammeter LO internally connected to V-source LO through METER Connect option of CONFIG V-source menu.

When the voltage source is connected to a capacitor, the inherent noise of the preamplifier is amplified. This is expected performance. Adding a series resistance will not decrease the noise. However, shunting the output of the V-source (LI to LO) with a 0.1 µF capacitor will reduce this noise.

Ammeter LO to V-source LO connection

The **METER CONNECT** option of the **CONFIG V-SOURCE** menu (see [Table 5-2](#)) is used to make or break the internal connection between V-source LO and ammeter LO and is summarized as follows:

1. From the **CONFIG V-SOURCE** menu, select **METER CONNECT** to display the connection options (on or off).
2. To connect meter LO to V-source LO, place the cursor on the **ON** option and press **ENTER**. Conversely, to disconnect meter LO from V-source LO, place the cursor on **OFF** and press **ENTER**.
3. Use the **EXIT** key to back out of the menu structure.

Setting voltage source value

The following information covers the V-source display, and explains how to select range and set the voltage value.

Displaying voltage source value

With the instrument in the normal measurement display state, the programmed voltage source value is displayed on the right hand side of the secondary display. If in another display state, you can display the voltage source as follows:

- If a multiple (NEXT) display is currently being displayed, press and hold in the **NEXT** key (or **PREV** key) until the **NEXT** display state is cancelled.
- If you are in a menu structure, use the **EXIT** key to back out of it.

While in the multiple (NEXT) display state, you can temporarily display the voltage source value by pressing the **VOLTAGE SOURCE** Δ or ∇ key. The voltage source value will appear on the secondary display for three seconds, unless an editing operation is performed ([Adjusting voltage source value](#) below).

Selecting voltage source range

The voltage source range cannot be changed while in Auto V-source Ohms. With the voltage source value displayed, the position of the decimal point denotes the currently selected range. For example, a reading of 000.000 V is 0 V on the 100 V range, while a reading of 0000.00 V is 0 V on the 1000 V range. The **RANGE** option of the **CONFIG V-SOURCE** menu is used to change the V-source range and is summarized in [Table 5-2](#).

1. From the **CONFIG V-SOURCE** menu, select **RANGE** to display the range options (± 100 V or ± 1000 V). Note that the 100 V range provides better resolution; 5 mV vs. 50 mV for the 1000 V range.
2. Place the cursor on the desired range and press **ENTER**.
3. Use the **EXIT** key to back out of the menu structure.

Adjusting voltage source value

The voltage source value cannot be changed while in Auto V-source Ohms. The voltage source value can be changed while in operate. While in operate, the output voltage will immediately update to reflect the displayed value.

1. Select the voltage source edit mode by pressing the Δ , ∇ , \blacktriangleleft or \blacktriangleright key. The EDIT annunciator turns on and the cursor position for the voltage source value is denoted by the flashing digit. Note that the voltage source edit mode will be cancelled if no edit operations are performed within any three second period.
2. Using the keys, place the cursor on the digit to be changed use the Δ or ∇ key to increment or decrement the value.
3. Polarity changes can be made in two ways:
 - Increment or decrement the reading past 0 V to change polarity.
 - Place the cursor on the polarity sign (+ or -) and press Δ or ∇ to toggle polarity.
4. When finished, the voltage source edit mode will cancel (EDIT annunciator off) after three seconds.

Voltage and current limit

The V-source has a 1mA current limit for the 1000 V range, a 10 mA limit for the 100 V range, and an adjustable voltage limit. If the current limit is reached, the VOLTAGE SOURCE OPERATE indicator flashes. While in current limit, the programmed voltage value is not being sourced. For example, assume the voltage source is programmed to source 200V to a 100k Ω load. In this situation, current limit occurs at approximately 100 V (100 k Ω \times 1 mA = 100V). Thus, the voltage source will only output 100V.

A resistive current limit is also available for the V-source. When selected, a 20M Ω resistor is placed in series with the V-source HI lead. This allows current to be limited. For example, with a programmed voltage of 100 V, current will be limited to 5 μ A (100 V / 20 M Ω = 5 μ A).

Setting a voltage limit

While in Auto V-source Ohms, the voltage limit of the V-source can only be set to a value that is >400 V. The V-source can be set to a maximum absolute value of voltage that can be sourced. For example, setting a value of 30 V limits the voltage output from -30 V to +30 V. The V-LIMIT option of the CONFIGure V-SOURCE menu is used to set the V-source voltage limit and is summarized in [Table 5-2](#).

1. From the **CONFIGure V-SOURCE** menu, select **V-LIMIT** to display the voltage limit selections:
 - **CONTROL**: Use this selection to enable (ON) or disable (OFF) the voltage limit. When enabled, the V-source will be limited to the specified voltage limit value (see *LIMIT VALUE* below)
 - **LIMIT VALUE**: Use this selection to set the voltage limit using the Δ , ∇ , \blacktriangleleft and \blacktriangleright keys. Make sure to press **ENTER** after changing the value
2. Use the **EXIT** key to back out of the menu structure

Selecting resistive current limit

Selecting the resistive current limit places a 20M Ω resistor in series with the HI lead of the V-source. The RESISTIVE LIMIT option of the CONFIGure V-SOURCE menu is used to enable or disable resistive current limit, and is summarized in [Table 5-2](#).

1. From the **CONFIGure V-SOURCE** menu, select **RESISTIVE LIMIT** to display the options (on or off).
2. To select resistive current limiting, place the cursor on the **ON** option and press **ENTER**. Conversely, to de-select resistive current limiting, place the cursor on **OFF** and press **ENTER**.
3. Use the **EXIT** key to back out of the menu structure.

Interlock and test fixtures

The voltage source should be used with a test fixture that incorporates a safety interlock switch, such as the Keithley Instruments Model 8009 Resistivity Test Fixture. By using the interlock feature, the Model 6517B cannot source voltage when the lid of the test fixture is open or ajar.

Interlock is automatically enabled when the appropriate interlock cable is connected to the Model 6517B. It is important to note that V-source will not operate unless the interlock is activated. When interlock is used with the Model 8009, V-source will go into standby whenever the lid of the test

fixture is open or ajar. Use the Interlock Cable as shown in [Figure 4-16](#). This cable uses an extra line to detect which resistivity measurement type is selected at the test fixture (surface or volume).

WARNING *Do not connect the interlock of the Model 6517B to the interlock of another instrument. The interlock is designed to be connected to a single-pole interlock switch of a test fixture. If connecting two or more Model 6517Bs to a single test fixture, an isolated interlock switch for each instrument is required. Connecting multiple instrument interlocks to the same switch could cause the safety interlock system to fail.*

Operate

WARNING *Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, NEVER make or break connections to the Model 6517B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Model 6517B before handling cables connected to the outputs. Putting the equipment in standby mode does not guarantee that the outputs are not powered if a hardware or software fault occurs.*

The **OPER** key toggles the output between standby and operate. In standby, the voltage source is removed from the rear panel output terminals. In operate (VOLTAGE SOURCE OPERATE indicator on), the voltage source is applied to the output terminals.

A flashing VOLTAGE SOURCE OPERATE indicator denotes that the voltage source is in current limit.

CAUTION A relay switch, in series with OUTPUT HI, is opened when the voltage source is placed in standby. The transition to an open output creates a potential for noise spikes. The open output allows dielectric absorption to recharge capacitors to unexpected voltage levels.

Analog outputs

The Model 6517B has two analog outputs on the rear panel. The 2 V ANALOG OUTPUT provides a scaled 0 V to 2 [Table 5-2](#)V output with the value of 2 V corresponding to full-range input. The PREAMP OUT is especially useful in situations requiring buffering. These two analog outputs are discussed in the following sections.

WARNING *When floating input Low above 30 V RMS from earth ground, hazardous voltage will be present at the analog outputs. Hazardous voltage may also be present when the input voltage exceeds 30 V RMS in the volts function, or when input currents exceed 30 pA in the amps function.*

CAUTION Connecting PREAMP OUT, COMMON, or 2 V ANALOG OUTPUT to earth while floating the input may damage the instrument.

2 V analog output

The 2 V ANALOG OUTPUT provides a scaled 0 to 2 V output that is non-inverting in the volts mode. Connections for using this output are shown in [Figure 5-3](#). For a full-range input, the output will be 2 V; typical examples are listed in [Table 5-3](#). The 2V ANALOG OUTPUT signal is not corrected during calibration. Gain errors of up to 15% may appear at this output, depending on function and range selection.

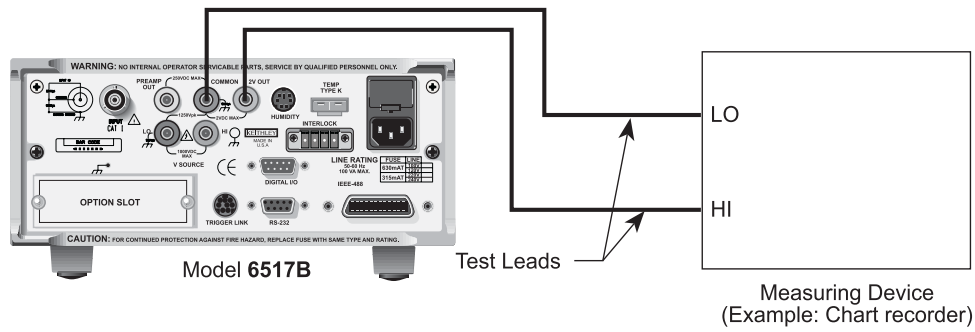
Note that the output impedance is 10 k Ω ; to minimize the effects of loading, the input impedance of the device connected to the 2 V ANALOG OUTPUT should be as high as possible. For example, with a device with an input impedance of 10 M Ω , the error due to loading will be approximately 0.1%.

Table 5-3: Typical 2 V analog output values

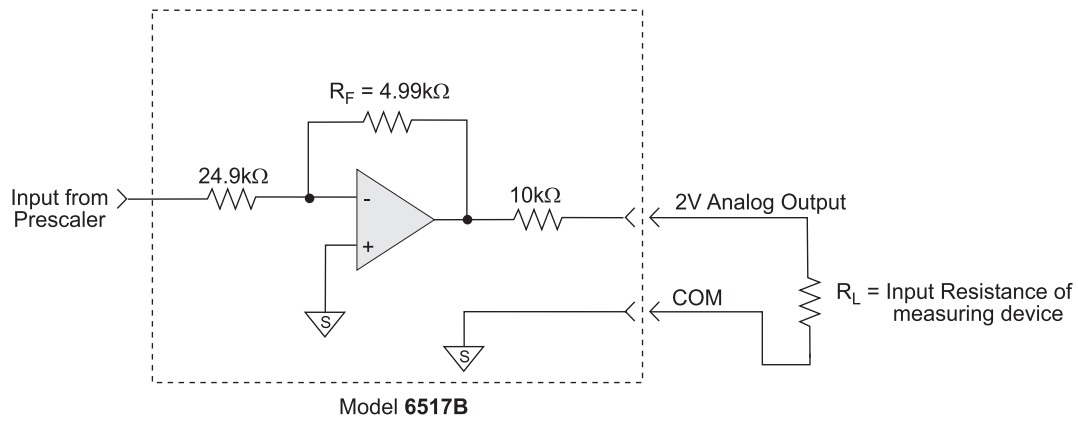
Range	Applied signal	Nominal 2V analog output value*
20 pA	10.4 pA	-1.04 V
2 μ A	1.65 μ A	-1.65 V
200 V	35 V	0.35 V
20 nC	19 nC	-1.9 V

*Output values within $\pm 15\%$ of nominal value.

Figure 5-3: Typical 2 V analog output connections



A. Connections



B. Equivalent Circuit

Preamp out

The PREAMP OUT of the Model 6517B follows the signal amplitude applied to the INPUT terminal. Some possible uses for the inverting PREAMP OUT include buffering of the input signal, as well as for guarding in the volts mode. Connections and equivalent circuits for the preamp output are shown in [Figure 5-4](#). Full-range outputs for various functions and ranges are listed in [Table 5-4](#). Since the PREAMP OUT signal is not corrected during calibration, gain error of up to 15% may appear at this output, depending on function and range selection. For all volts ranges, PREAMP OUTPUT accuracy is typically 10 ppm.

WARNING *High voltage may be present between the PREAMP OUT and COMMON terminals depending on the input signal.*

CAUTION Connecting PREAMP OUT, COMMON, or 2 V ANALOG OUTPUT to earth while floating input may damage the instrument.

NOTE The PREAMP OUTPUT accuracy is uncalibrated.

Note that the PREAMP OUT output resistance is 1 Ω. The output resistance appears between Input Low and Analog Output Low to keep the resistor out of the loop when using external feedback elements. To keep loading errors under 0.1%, the device connected to the PREAMP OUT should have a minimum input impedance of 100 kΩ.

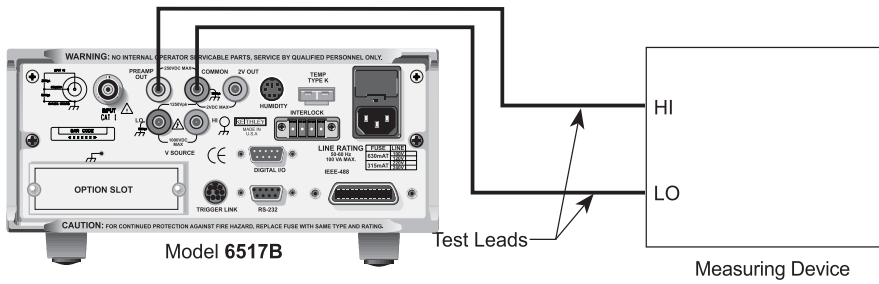
CAUTION To prevent damage to the Model 6517B, do not connect a device to PREAMP OUT that will draw more than ±10 0μA. For example, at 200 V, the impedance connected to PREAMP OUT must be at least 2 MΩ (200 V / 100 μA = 2 MΩ).

Table 5-4: Full-range PREAMP OUT values

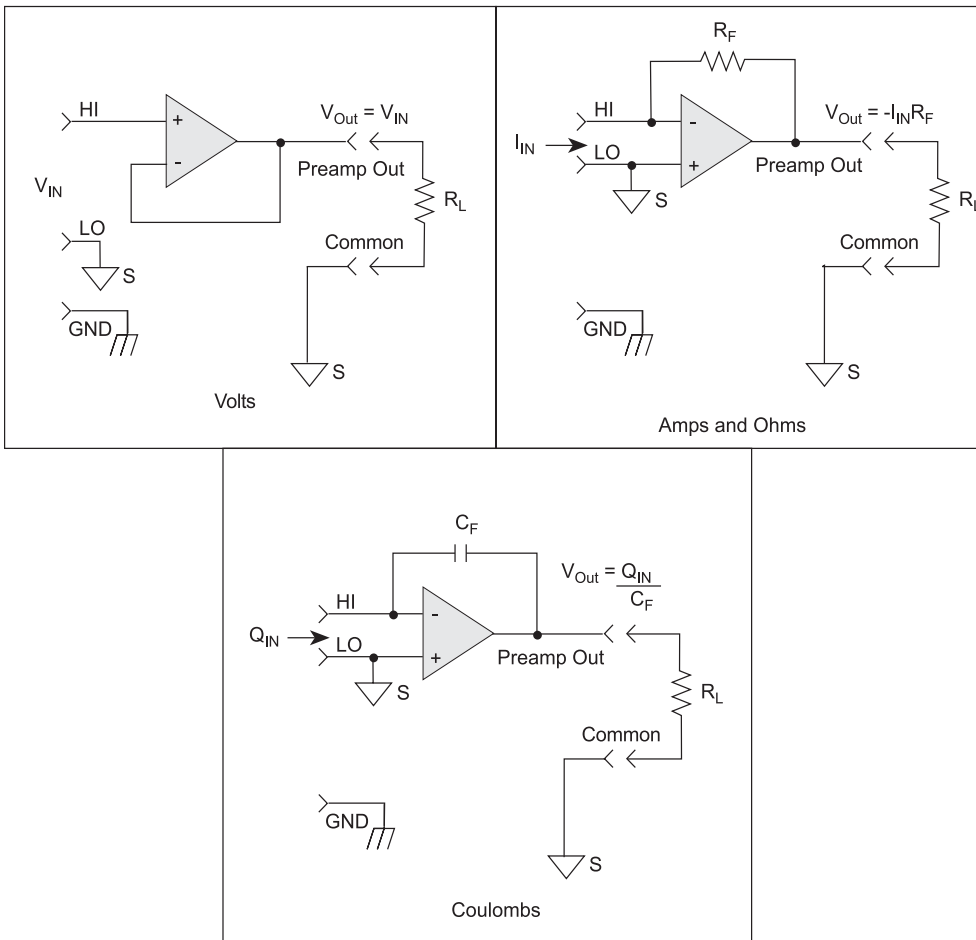
Function*	Range	Full-range value
Volts	2 V	2 V
	20 V	20 V
	200 V	200 V
Amps	2 nA, 2 μA, 2 mA	2 V
	20 pA, 20 nA, 20 μA, 20 mA	20 V
	200 pA, 200 nA, 200 μA	200 V
Coulombs	2 nC, 20 nC, 200 nC	20 V
	2 μC	200 V

*PREAMP OUT value for the Ohms function corresponds to the value for the Amps range that is being used to make the measurement.

Figure 5-4: Typical PREAMP OUT connections



A. Connections



B. Equivalent Circuits

Using external feedback

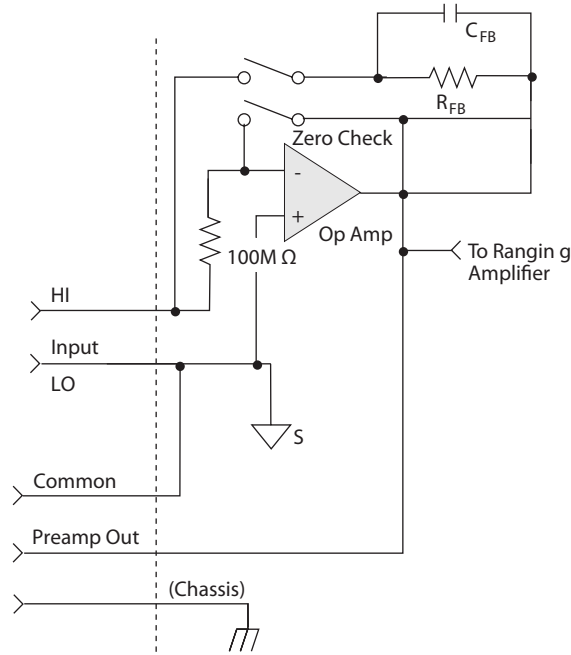
The external feedback function provides a means to extend the capabilities of the Model 6517B Electrometer to such uses as logarithmic currents, non-decade current ranges, as well as non-standard coulombs ranges. The following paragraphs discuss the basic electrometer input circuitry and methods to implement these functions.

Electrometer input circuitry

A simplified diagram of the electrometer input in the external feedback mode is shown in [Figure 5-5](#). An input current applied to the inverting (-) input of the operational amplifier (op amp) is nulled

by a current feedback through the internal feedback network made up of R_{FB} and C_{FB} . Because the output of the op amp appears at the PREAMP OUT, this internal network can be replaced by an external network connected between the preamp output and Input HI connections.

Figure 5-5: Electrometer input circuitry (external feedback mode)



When using external feedback, the following factors must be taken into account:

1. The maximum current value that can be supplied by the preamp output is 20 mA in amps and ohms (1 mA in volts). The maximum voltage span in external feedback is ± 20 V.
2. The input impedance in the external feedback mode is given by the relationship:

$$Z_{IN} = Z_{FB} / A_V,$$

where:

- Z_{FB} is the impedance of the external feedback network
- A_V is the open-loop gain of the electrometer (typically greater than 55×10^6).

Note that the input impedance is $Z_{IN} = 10 \text{ M}\Omega \parallel Z_{FB}$ when zero check is enabled.

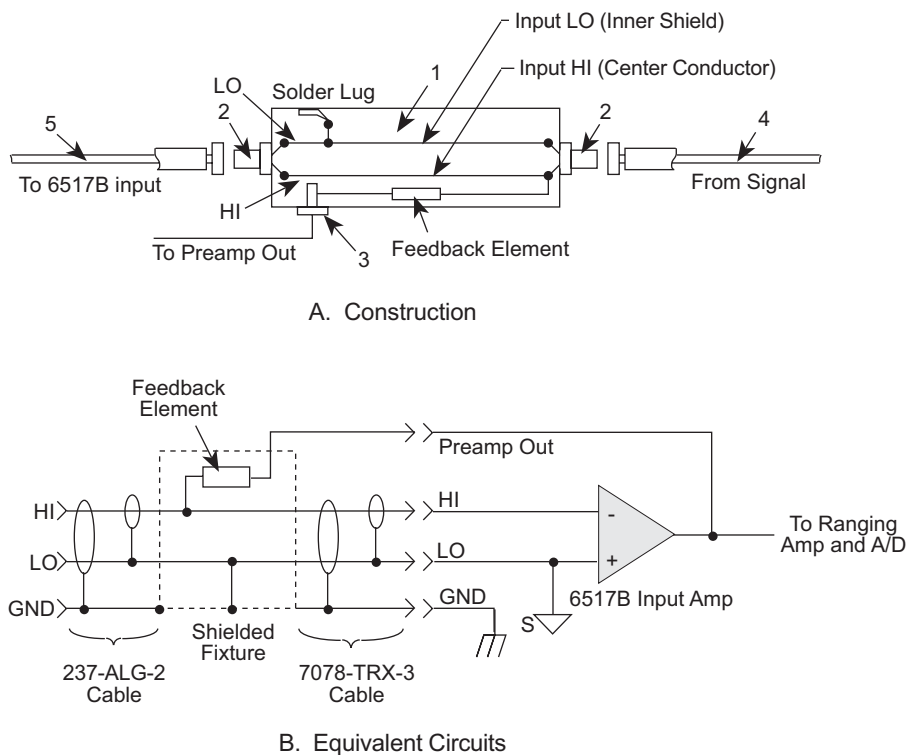
3. The voltage at the PREAMP OUT terminal is given by the formula:
 $V = -IZ_{FB}$
4. Any feedback elements should be housed in a suitable shielded enclosure ([Figure 5-6](#) below). Insulators connected to Input HI should be made of Teflon or other high-quality insulating material and should be thoroughly cleaned to maintain the high input impedance and low input current of the Model 6517B. If these insulators become contaminated, they can be cleaned with methanol and then dried with clean, pressurized air.

Shielded fixture construction

Since shielding is so critical for proper operation of external feedback, it is recommended that a shielded fixture similar to the one shown in [Figure 5-6](#) be used to house the feedback element. The fixture is constructed of a commercially available shielded fixture modified with the standard BNC connectors replaced with triaxial female connectors. For convenience, a banana jack can be mounted on the box to make the necessary PREAMP OUT connection.

Alternately, a wire could be run through a rubber grommet mounted in a hole in the side of the box. Note that input low is connected to chassis ground within the shielded box. This connection can be made by using a small solder lug secured with a screw.

Figure 5-6: Shielded fixture construction



Parts List		
Item	Description	MFR Part Number
1	Shielded Fixture	Pomona #2390
2	Female Triaxial	Keithley 7078-TRX-TBC
3	Banana Jack	Keithley BI-9-2
4	Triaxial Cable	Keithley 237-ALG-2
5	Triaxial Cable	Keithley 7078-TRX-3

External feedback procedure

Use the following procedure to operate the Model 6517B in the external feedback mode.

1. Connect the feedback element between the PREAMP OUT terminal and the Input High terminal.
2. Select the volts (**V**) function.
3. Select external feedback as follows:
 - a. Press **CONFIG V** to display the **CONFIGURE DCV** menu.
 - b. Place the cursor on **EXT-FDBK** and press **ENTER**.
 - c. Place the cursor on **ON** and press **ENTER**.
 - d. Use the **EXIT** key to back out of the menu.
4. The display will show the voltage measured at the output of the input preamplifier (PREAMP OUT).

Non-standard coulombs ranges

In its standard form, the Model 6517B has four coulombs ranges allowing it to measure charge between 10 fC and 2.1 μ C. Different charge measurement ranges can be used by placing an external feedback capacitor between the PREAMP OUT and Input HI and then placing the instrument in the external feedback mode.

Charge is related to capacitance and voltage by the formula:

$$Q = CV$$

where:

- Q is the charge in coulombs
- C is the capacitance in farads
- V is the voltage in volts

The Model 6517B display will read charge directly in units determined by the value of C. For example, a 10 μ F capacitor will show a reading of 10 μ C / V.

In practice, the feedback capacitor should be greater than 100 pF for feedback stability and of suitable dielectric material (such as polystyrene, polypropylene, or Teflon) to ensure low leakage and low dielectric absorption. The capacitor should be mounted in a shielded fixture like the one shown in [Figure 5-6](#).

To discharge the external feedback capacitor, enable zero check. The discharge time constant will be given by: $t = (10 \text{ M}\Omega) (C_{FB})$. Allow five time constants for discharge to within 1% of final value.

Logarithmic currents

The use of a diode junction in the external feedback path permits a logarithmic current-to-voltage conversion. This relationship for a junction diode is given by the equation:

$$V = mkT / q \ln(I/I_0) + I_{RB}$$

Where:

- q = unit of charge (1.6022×10^{-19})
- k = Boltzmann's constant (1.3806×10^{-23})
- T = temperature (K).

The limitations in this equation center on the factors I_0 , m, and R_B . I_0 is the extrapolated current for V_0 . An empirical proportional constant, m, accounts for the different character current conduction (recombination and diffusion mechanisms) within the junction, typically varying between 1 and 2. Finally, R_B constitutes the ohmic bulk resistance of the diode junction material. I_0 and R_B limit the usefulness of the junction diode at low and high currents respectively. The factor m introduces nonlinearities between those two extremes. Because of these limitations, most diodes have a limited range of logarithmic behavior.

A solution to these constraints is to use a transistor configured as a "transdiode" in the feedback path, as shown in [Figure 5-7](#). Analyzing the transistor in this configuration leads to the relationship:

$$V = kT/q[\ln(I/I_0) - \ln(h_{FE}/(1 + h_{FE}))]$$

where:

- h_{FE} is the current gain of the transistor

From this equation, proper selection of Q1 would require a device with high current gain (h_{FE}), which is maintained over a wide range of emitter currents. Suitable devices for this application include Analog Devices AD812 and Precision Monolithics MAT-01. Use the enclosure in [Figure 5-6](#) to shield the device.

Frequency compensation/stabilization is accomplished by adding a feedback capacitor, C_{FB} . The value of this capacitor depends on the particular transistor being used and the maximum current level expected. Compensation at maximum current is required because the dynamic impedance will be minimal at this point. It should be noted that the response speed at lower currents will be compromised due to the increasing dynamic impedance, which is given by the following formula:

$$Z = \frac{dV}{dI} = kT/qI = 0.026 / I (@25^{\circ}\text{C})$$

Using the above transistors, a minimum RC time constant of 100 μs at maximum input current would be used. At $I_{IN}(\text{max})$ of 100 μA , this value would correspond to 0.4 μF . Note that at 100 nA, this value would increase the RC response time constant to 100 ms. A minimum capacitance of 100 pF is recommended.

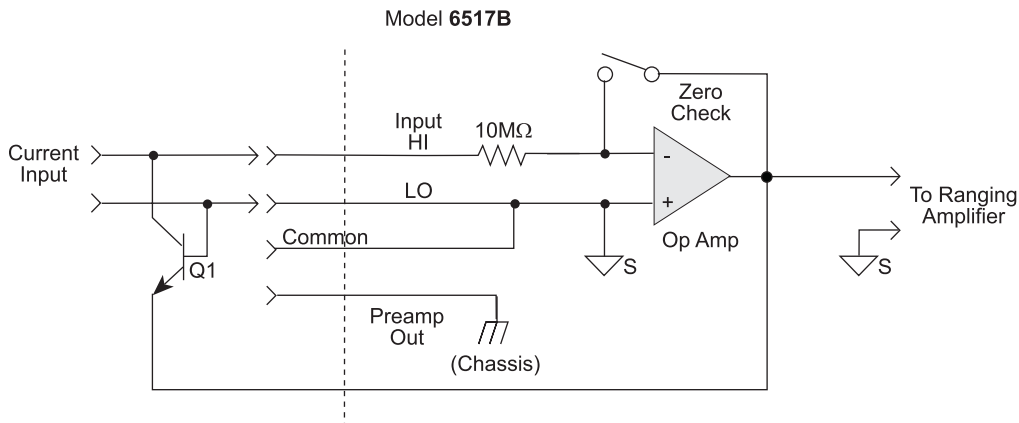
Although the input signal to this particular circuit is assumed to be a current, conversion to voltage input could be performed by placing a shunt resistor across the input. However, the nominal voltage burden of 1 mV must be considered as an error signal that must be taken into account.

Further processing of the current response can be achieved by using the suppress feature. For example, REL could be enabled with a reference input current applied. For all subsequent currents, the natural logarithm of the ratio of the measured current to the suppressed current would then be displayed:

$$\begin{aligned} V_{\text{DISP}} &= V_{\text{REL}} kT/q (\ln (I_{\text{READ}}/I_{\text{O}}) - \ln (I_{\text{REL}}/I_{\text{O}})) \\ &= kT/q (\ln (I_{\text{READ}}/I_{\text{REL}})) \\ &= 0.26/I (\ln (I_{\text{READ}}/I_{\text{REL}})) @ 25^{\circ}\text{C} \end{aligned}$$

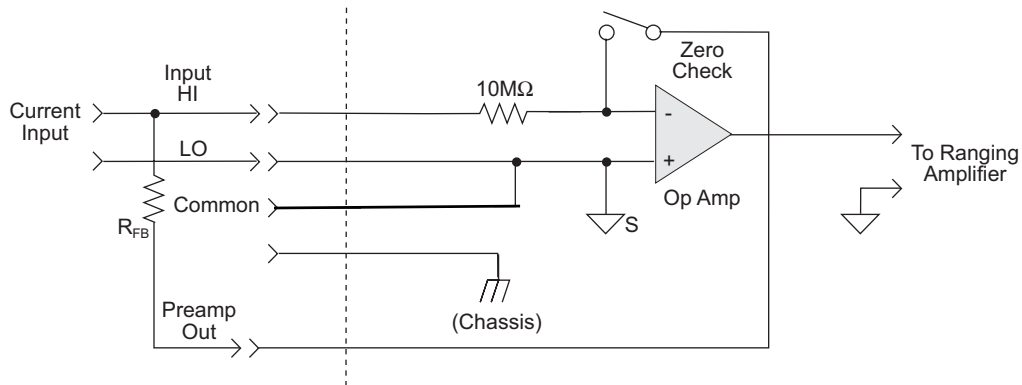
The circuit topology of [Figure 5-7](#) works for positive input currents only. For bipolar input signals, an external offset bias must be applied, or use a PNP transistor for Q1.

Figure 5-7: Transdiode logarithmic current configuration



Non-decade current gains

The Model 6517B electrometer input uses internal decade resistance feedback networks for the current ranges. In some applications, non-decade current gains may be desirable. As shown in [Figure 5-8](#), an external feedback resistor, R_{FB} , can be used to serve this purpose. Limitations on the magnitude of the feedback current require that the value of R_{FB} be greater than 100 Ω .

Figure 5-8: Non-decade current gains

Range and resolution

The range and resolution setting (fixed or auto) for each measurement function are saved when changing functions.

Measurement range

The measurement range affects the accuracy of the measurement as well as the maximum signal that can be measured. The measurement ranges for each function are listed in the specifications. The maximum input signal level for voltage, current, and charge measurements is 105% of the measurement range. For example, the maximum signal level on the 2 V range is 2.1 V ($2\text{ V} \times 1.05 = 2.1\text{ V}$). When the integrated (average) input level exceeds the selected range, the OVERFLOW message will be displayed. However, if a stray out of range transient (such as a noise spike) occurs, the message OUT OF LIMIT will be displayed (assuming the integrated signal level is still within the selected range).

For the ohms function, each measurement range has a lower reading limit that is one decade below the selected range. For example, the 20 M Ω range has a lower reading limit of 2 M Ω . Measuring a device that is less than 2 M Ω will cause the UNDERFLOW message to be displayed.

With AUTO range selected, the instrument will automatically go to the most sensitive (optimum) range to make the measurement. Note that with AUTO range selected for the ohms function, the instrument cannot go to the 2 T Ω , 20 T Ω or 200 T Ω ranges since a hazardous voltage level (400 V) may be selected by the instrument. You must select these ohms ranges manually.

For the amps, ohms and coulombs function, you can set autorange limits to speed up the autoranging process. Setting limits eliminates upper and lower ranges from the autorange search. This speeds up the measurement process. These limits are set from the AUTORANGE option of the appropriate function configuration menu.

Display resolution

The Model 6517B can display readings at 3.5, 4.5, 5.5, or 6.5 digit resolution. The display resolution of a reading depends on the selected resolution setting (fixed or auto). The default display resolution for every function is 5.5 digits. [Table 5-5](#) summarizes the relationship between speed (SET-BY-RSLN setting) and the selected resolution setting. With auto resolution selected, the instrument selects the optimum resolution for the present speed (integration period setting). See [Table 5-6](#).

The display resolution for ohms readings may be less than what was selected. For example, assume for an ohms measurement that the measured current is 00.100 pA (20 pA range, 4½ digit

resolution). If you discount the leading zeroes, the amps reading actually has a usable resolution of 2½ digits (0.100 pA). Since the current measurement only uses 2½ digits, the resolution of the ohms display will also be limited to 2½ digits.

Table 5-5: Integration times set-by-resolution (all functions)

Resolution	Integration time
Auto*	1.00 PLC
3.5d	0.01 PLC
4.5d	0.02 PLC
5.5d	0.20 PLC
6.5d	2.00 PLC

*With AUTO resolution selected, display resolution is set to 6.5 digits.

Table 5-6: Auto resolution (all functions)

Resolution	Integration time
3.5d	0.01 to <0.02 PLC
4.5d	0.02 to <0.20 PLC
5.5d	0.20 to <2.00 PLC
6.5d	2.00 to 10.00 PLC

NOTE: If SET-BY-RSLN integration is selected, display resolution will be 6.5 digits and the integration time 1.0 PLC.

Zero check, relative, and zero correct

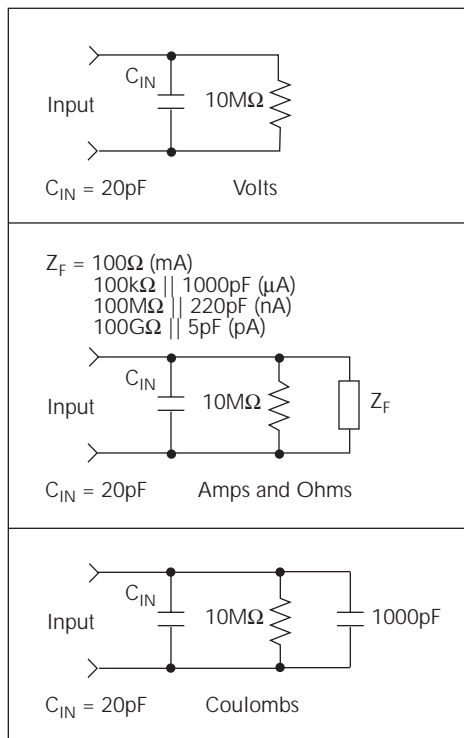
Zero check

When zero check is enabled (on), the input amplifier is reconfigured to shunt the input signal to low as shown in [Figure 5-9](#). When you enable or disable zero check, that state is assumed regardless of which function you select. In other words, you cannot set a unique zero check state (on or off) for each function.

Zero check is enabled by pressing the Z-CHK key. When enabled, the “Zerocheck” message is displayed. Pressing Z-CHK a second time disables zero check. To ensure proper operation, always enable zero check before changing functions (V, I, R, or Q).

In coulombs, enabling zero check dissipates the charge. That is, the charge reading is reset to zero. When zero check is disabled, a sudden change in the charge reading (zero check hop) occurs. This effect can be cancelled by enabling REL immediately after zero check is disabled.

For voltage, current and resistance measurements, leave zero check enabled when connecting or disconnecting input signals. For charge measurements, disable zero check before connecting the input signal. If zero check is left enabled when you connect the input signal, the charge will dissipate through the 10MΩ resistor (see [Figure 5-9](#)).

Figure 5-9: Equivalent input impedance with zero check enabled

Relative (REL)

The REL (relative) operation subtracts a reference value from actual readings. When REL is enabled by the **REL** key, the instrument uses the present reading as a relative value. Subsequent readings will be the difference between the actual input value and the REL value. You can also enter and enable a relative value from the **CONFIG-REL** display.

A REL value can be established for each measurement function. The state and value of REL for each measurement function are saved when changing functions.

Once a REL value is established for a measurement function, the value is the same for all ranges. For example, if 15 V is set as a REL value on the 20 V range, then REL is also 15 V on the 200 V and 2 V ranges.

A relative value can be as large as the highest allowable reading for the particular function.

Selecting a range that cannot accommodate the REL value does not cause an overflow condition, but it also does not increase the maximum allowable input for that range. For example, on the 2 mA range, the Model 6517B still overflows for a 2.1 mA input.

Configuring REL

Pressing **CONFigure REL** displays the REL value for the present measurement function. You can change the REL value using the cursor keys (**◀** and **▶**) and the manual **RANGE** keys (**△** and **▽**). When **ENTER** is pressed, the instrument returns to the measurement display state with that value of REL enabled. If you try to enter an invalid REL value, a message indicating the REL limit will be displayed and the REL operation will be cancelled.

Note that a bench or GPIB reset clears any stored REL values and disables REL for all functions.

Enabling REL

From the normal reading display, the **REL** key toggles the REL operation on and off. Each time REL is enabled by the REL key, the present reading becomes the new REL value for that function. You cannot REL an overflow reading. To make a new reading the REL value, REL must first be disabled and then enabled again. Disabling REL does not clear any stored REL value.

When REL is enabled, the resulting reading is the algebraic difference between the actual input value and the REL value:

$$\text{REL'd reading} = \text{actual value} - \text{relative value}$$

With math enabled, the REL'd reading is acted on by the math operation:

$$\text{displayed reading} = \text{math operation (REL'd reading)}$$

WARNING *With REL enabled, the voltage on the input may be significantly larger than the displayed value. For example, if a 150 V REL value is stored, an applied voltage of +175 V will result in a displayed value of only +25 V.*

Multiple display of REL

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One of the “multiple displays” allows you to view the reading without REL applied on the bottom line of the display and the REL'd reading on the top line. The display is available by repeatedly pressing either the **PREV** or **NEXT DISPLAY** key to scroll through the multiple displays of the particular function. The following is a typical message for a REL multiple display:

+000.012 mA
Actual = +001.012 (without REL)

Zero correct

The **Z-CHK** and **REL** keys work together to cancel (zero correct) any internal offsets that might upset accuracy for volts and amps measurements.

Perform the following steps to zero correct the volts or amps function:

1. Select the **V** or **I** function.
2. Press **Z-CHK** to enable Zero Check.
3. Select the range that will be used for the measurement.
4. Press **REL** to zero correct the instrument (REL indicator will be lit and “Zcor” displayed). Note that for the volts function, the “Zcor” message will not be displayed if guard was already enabled (“Grd” displayed).
5. Press **Z-CHK** to disable zero check.
6. Readings can now be taken in the normal manner.

Note that the instrument will remain zeroed even if the instrument is upranged. If downranged, press **REL** to zero the instrument again.

To disable zero correct, press **REL** with zero check enabled.

Specification considerations

For taking measurements “when properly zeroed”, per instrument specifications:

1. Perform the zero correct procedure described above.

2. Provide a zero input from a calibration source, or short leads in V function, open leads in I function.
3. Press **REL** to null remaining measurement offsets.
4. Readings can now be taken in the normal manner. (REL indicator will remain on.)

Repeat steps 1 through 4 whenever the measurement range is changed. To disable REL mode, press **REL** with zero check not enabled.

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In this section:

Topic	Page
Introduction	6-2
Test sequences	6-2
Test descriptions	6-2
Diode leakage current test	6-2
Capacitor leakage current test	6-4
Cable insulation resistance test	6-4
Resistor voltage coefficient test	6-5
Standard method resistivity tests	
Alternating polarity resistance/resistivity test	6-7
Surface insulation resistance (SIR) test	6-8
Sweep tests (square wave and staircase)	6-9
Configuring test sequences	6-11
Configure sequence menu	6-11
Menu sections	6-12
Running the selected test	6-14

Introduction

This section contains detailed information on built-in test sequences available with the Keithley Instruments Model 6517B Electrometer.

Test sequences

The Model 6517B has the following built-in test sequences:

- Device characterization tests:
 - Diode leakage current
 - Capacitor leakage
 - Cable insulation resistance
 - Resistor voltage coefficient
- Resistivity tests:
 - Normal (surface and volume)
 - Alternating polarity
- Surface insulation resistance (SIR) test
- Sweep tests:
 - Square wave
 - Staircase

Test descriptions

The following information describes each test, shows the connections to the Model 6517B, and explains how to set up the Model 6517B for the measurements.

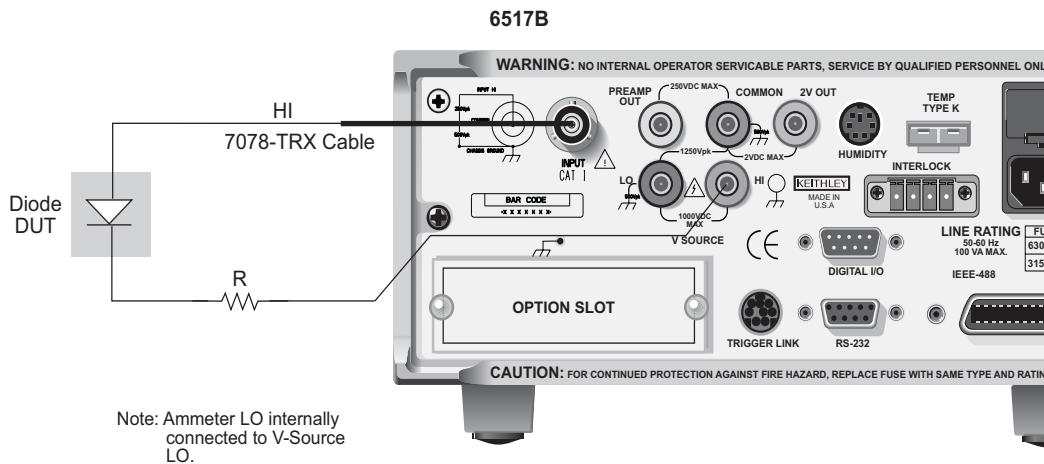
The results of a test are stored in the buffer. If, for example, a test performs 10 measurements, those 10 readings will be stored in the buffer at locations 0 through 9. If a test only performs one measurement, then that single reading will be stored at memory location 0. Note that when a test is performed, previous data stored in the buffer will be lost.

Diode leakage current test

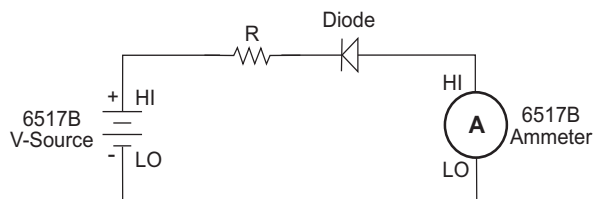
This test is used to measure the leakage current for a diode. [Figure 6-1](#) shows the connections and the simplified schematic. By sourcing a positive voltage, the leakage current through the diode will be measured. Note that if you source a negative voltage, you will forward bias the diode. Resistor R is used to limit current in the event that the diode shorts out or it becomes forward biased. Select a value of R that will limit current to 20mA or less.

This test allows you to measure the current at various voltage levels. When the test is configured, you specify the start voltage (START V), the step voltage (STEP V), the stop voltage (STOP V) and the DELAY between steps. [Figure 6-2](#) shows an example using the default test parameters. When the test is run, 10 current measurements will be performed (one at each voltage step) and stored in the buffer. This test is selected and configured from the **CONFIGURE SEQUENCE** menu (DEV-CHAR; DIODE).

Figure 6-1
Connections; diode leakage current test

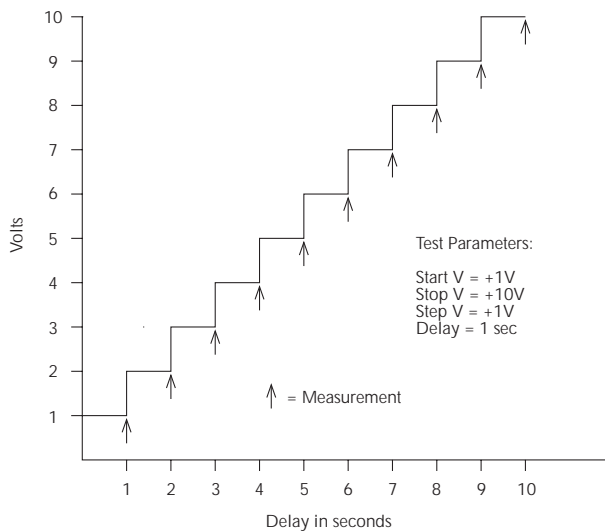


A) Connections



B) Equivalent Circuit

Figure 6-2
Default measurement points; diode leakage current test

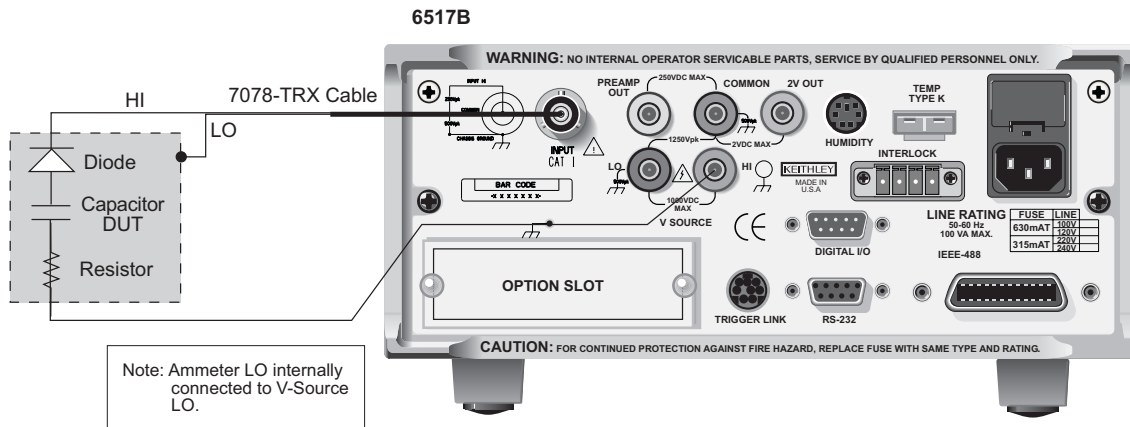


Capacitor leakage current test

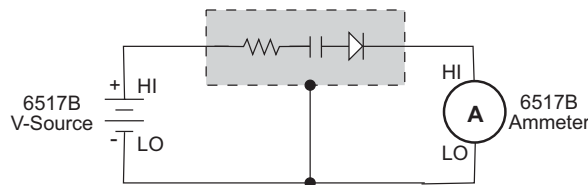
This test is used to measure the leakage current for a capacitor. The magnitude of the leakage is dependent on the type of dielectric and the applied voltage. Figure 6-3 shows the connections for this test. A resistor and a diode are used to limit noise for the measurement.

For this test, a fixed voltage (BIAS V) is applied to the capacitor for specified time intervals to allow the capacitor to charge (current decays exponentially with time). The leakage current is measured at each interval and stored in the buffer. This test is selected and configured from the **CONF SEQUENCE** menu (DEV-CHAR; CAPACITOR).

Figure 6-3
Connections; capacitor leakage current test



A) Connections



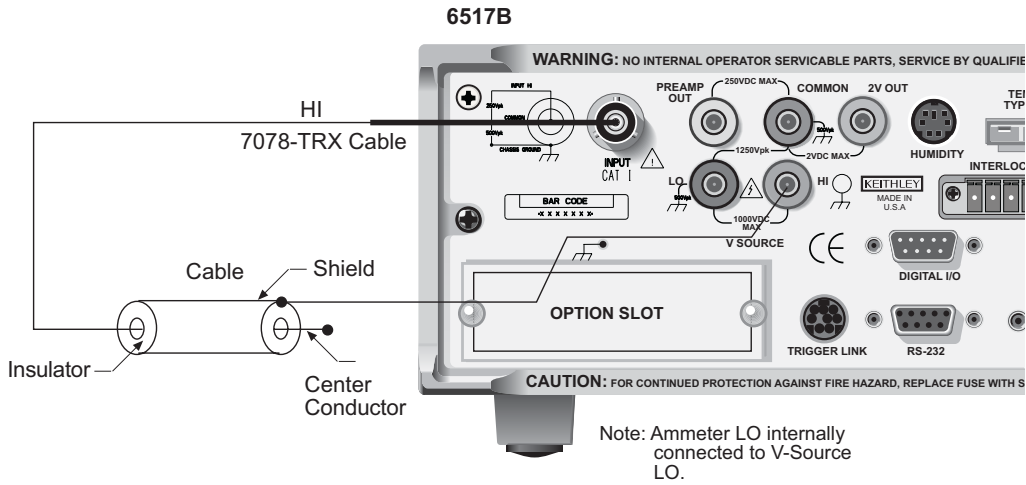
B) Equivalent Circuit

Cable insulation resistance test

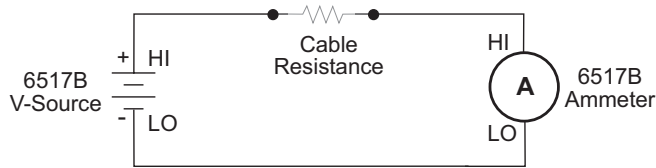
This test is used to measure the insulation resistance of a cable. Figure 6-4 shows the connections for this test. The resistance of the insulator between the shield and the inner conductor is being measured. The cable sample should be kept as short as possible to minimize input capacitance to the ammeter.

For this test a fixed voltage (BIAS V) is applied across the insulator for a specified time to allow the charging effects of cable capacitance to stabilize. The resistance is then measured and stored in the buffer. This test is selected and configured from the **CONF** menu (DEV-CHAR; CABLE).

Figure 6-4
Connections; cable insulation resistance test



A) Connections



B) Equivalent Circuit

Resistor voltage coefficient test

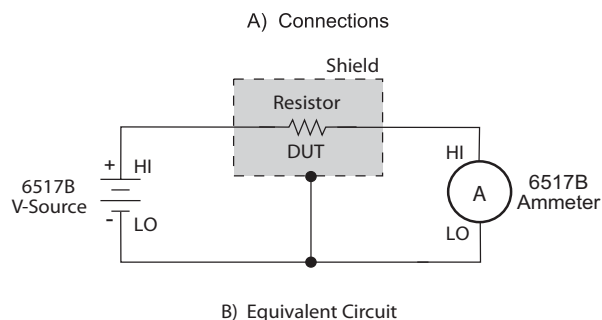
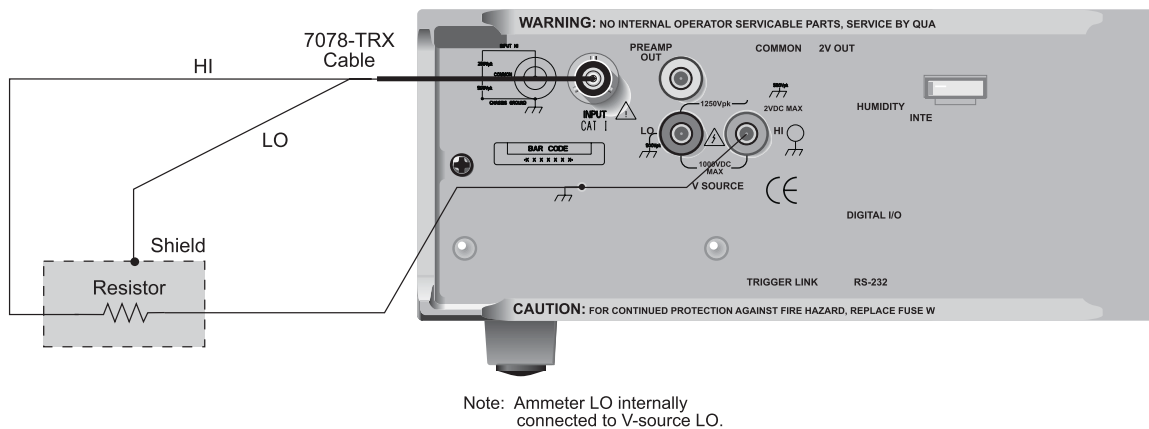
High valued resistors often have a change in resistance with applied voltage. This change in resistance is characterized as the voltage coefficient. Voltage coefficient is defined as the percent change in resistance per unit change in applied voltage:

$$\text{Voltage Coefficient} = \frac{R1 - R2}{R1} \times \frac{1}{V2 - V1}$$

This test makes two resistance measurements at two different voltage levels, and calculates the voltage coefficient. The test circuit is shown in Figure 6-5. The resistor should be placed in a shielded test fixture that is designed to minimize leakage resistance.

For this test, the first specified voltage (SOURCE V1) is applied to the resistor and, after the specified delay (DELAY 1), a resistance measurement is made. The second voltage (SOURCE V2) is then applied and, after the next delay (DELAY 2), a second resistance measurement is made. The Model 6517B then automatically calculates the voltage coefficient and stores it in the buffer. This test is selected and configured from the **CONF**igure **SEQUENCE** menu (DEV-CHAR; RESISTOR).

Figure 6-5
Test circuit; resistor voltage coefficient test



Standard method resistivity tests

This test is used to measure the resistivity (surface or volume) of an insulator sample. When used with the Keithley Instruments Model 8009 Resistivity Test Fixture, the test conforms to the ASTM D-257 standard (see *Resistance and resistivity measurements* for more information). [Figure 4-14](#) and [Figure 4-15](#) show the test circuits for the respective measurement, and [Figure 4-16](#) shows the connections to the Model 8009. Refer to the instruction manual for the Model 8009 to install the insulator sample in the test fixture.

When this test is run, the V-source will initially be set to source 0V for a specified time (PRE-DISCH time) to allow any charge to dissipate. The V-source will then apply a specified voltage (BIAS V) to the electrodes of the test fixture for a specified time (BIAS-TIME). This “bias” period allows currents in the test circuit to stabilize. The V-source then applies the test voltage (MEAS-V) and, after a specified delay (MEAS-TIME), the Model 6517B measures the resistivity of the sample and stores the reading in the buffer. Note that the test voltage (MEAS-V) is typically at the same level as the bias voltage (BIAS V).

The surface resistivity test and the volume resistivity test are selected and configured from the **CONFIGURE SEQUENCE** menu (R/RESISTIVITY; NORMAL; SURFACE and VOLUME).

Alternating polarity resistance/resistivity test

The alternating polarity resistance/resistivity test is designed to improve high resistance/resistivity measurements. These measurements are prone to large errors due to background currents. By using an alternating stimulus voltage, it is possible to eliminate the effects of these background currents. This test will measure surface or volume resistivity or resistance, as selected in the **CONFIGURE RESISTANCE** menu (see *Resistance and resistivity measurements* for more information). [Figure 4-14](#) and [Figure 4-15](#) show the test circuits for the respective measurement, and [Figure 4-16](#) shows the connections to the Model 8009. Refer to the Model 8009 Instruction Manual for information on installing the sample in the test fixture.

When this test is run, the V-source will alternate between two voltages (V-OFS + V-ALT) and (V-OFS - V-ALT) at timed intervals (MEAS-TIME). Current measurements are taken at the end of each of these alternations and after calculation of I_{calc} resistance values are computed. I_{calc} is a weighted average of the latest four current measurements, each at the end of a separate alternation. The resistance value is then converted to a resistivity value if the meter has been configured for resistivity measurements. The first few readings can be rejected (DISCARD XXX RDGS) as the sample or resistance achieves a steady-state response to the alternating voltage. After this, the alternation will continue until a specified number of readings (STORE XXX RDGS) have been stored in the buffer. The time required to complete a sequence is (STORE + DISCARD + 4) * MEAS-TIME. For example, a sequence alternating at 15 second intervals, discarding 3 readings, and storing 3 readings will take 2.5 minutes.

[Figure 6-6](#) shows an example of the alternating polarity test using the test parameters shown and the resulting sample current from a typical high resistance sample. Note that the sample currents shown exhibit some capacitive decay, as many high resistance samples also tend to have significant capacitance.

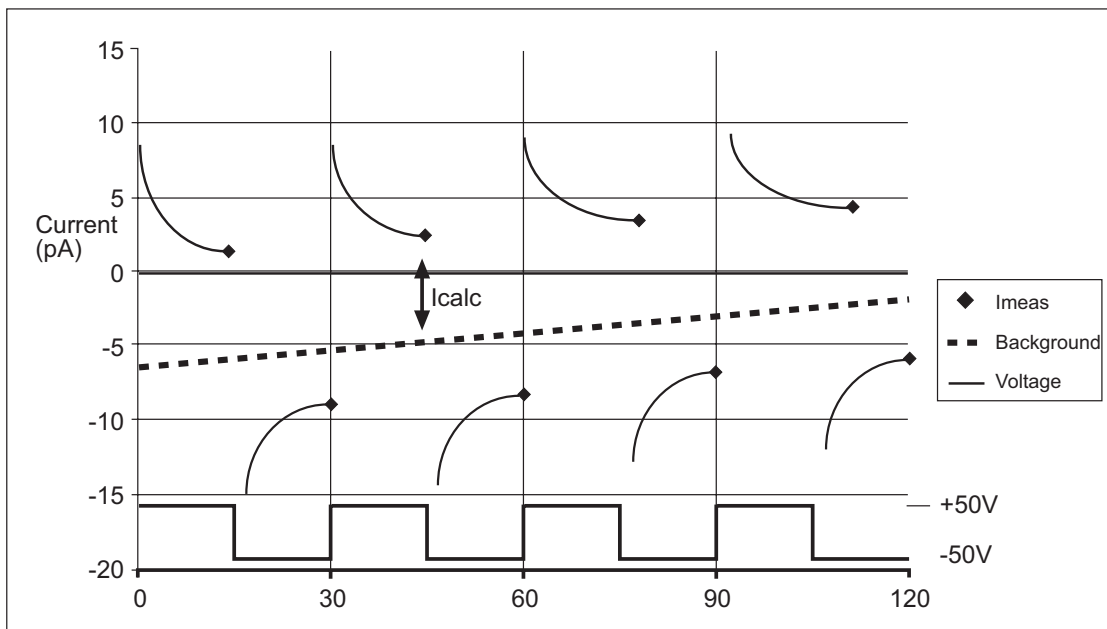
When the alternating polarity sequence is first armed by pressing **SEQUENCE** and then **ENTER**, the settings for the current measurements made internally to the sequence are preset to the settings for the amps function. If the amps function is set to a specific range, the sequence defaults to that range. If the amps function is autoranging, the sequence will default to autoranging. The range can be changed after the sequence is armed by pressing the **manual** or **AUTO range keys**. The alternating polarity sequence will not autorange past the 2nA range. If the resistance/resistivity to be measured is high and a more sensitive range is required, the user must set this range manually using the manual **RANGE** keys (Δ and ∇). (For the 20pA and 200pA ranges, use a measure time of at least 15 seconds).

While in the armed condition, the sequence parameters may be changed (**CONFIG-SEQ**), the range may be changed, the output result type may be changed (resistance, surface or volume resistivity), and the resistivity parameters edited. To run the sequence, press **TRIG** after arming. Pressing **EXIT** after arming disarms the sequence, and returns the Model 6517B to the function in use when it was armed.

During execution, the sequence will show “-----” until the first reading becomes available and is sent to the buffer. After this, the latest calculated value will be displayed. If, at the end of any alteration the current exceeds the amps range in use, the error +618 Resistivity Out Of Limit will occur and the sequence will abort, returning it to the function in use before it was last armed. If the alternating polarity sequence calculates a current of zero, “<Infinity>” will be displayed, but the sequence will continue. A lower current range should be selected.

The alternating polarity test is selected and configured from the **CONFIGURE SEQUENCE** menu (APPLICATIONS; R/RESISTIVITY; ALT-POLARITY).

Figure 6-6
Alternating polarity test example



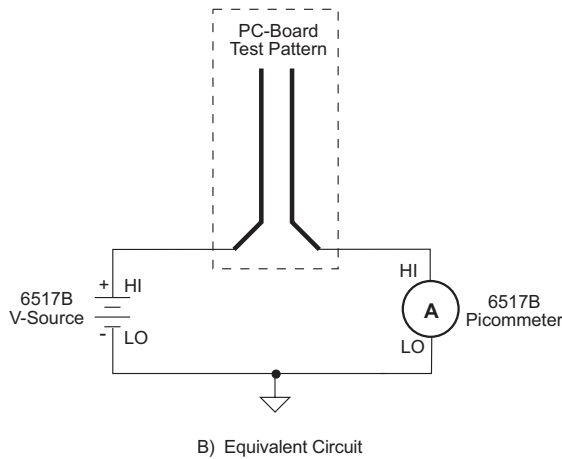
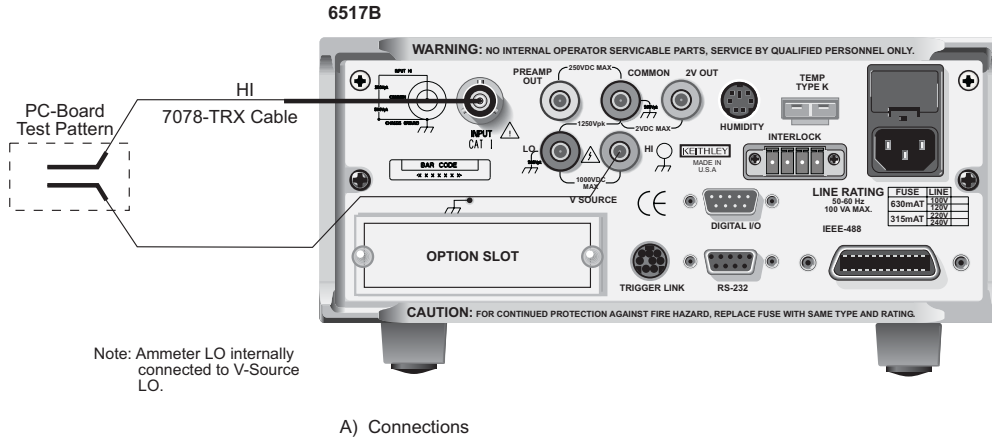
Surface insulation resistance (SIR) test

This test is used to measure the insulation resistance between PC-board traces. [Figure 6-7](#) shows the connections and the equivalent circuit. Note that the drawing shows a “Y” test pattern for the measurement. This is a typical test pattern for SIR tests.

When this test is run, a specified voltage (BIAS V) is applied to the test pattern for a specified time (BIAS-TIME). This “bias” period is used to polarize the test pattern. The test voltage (MEAS-V) is then applied and, after a specified time (MEAS-TIME), the Model 6517B measures the resistance and stores the reading in the buffer.

This test is selected and configured from the **CONFIGURE SEQUENCE** menu (SIR).

Figure 6-7
Surface insulation test connections



Sweep tests (square wave and staircase)

The sweep tests are not geared to any specific application. These voltage/measure sweeps can be used for any type of measurement; volts, amps, ohms or coulombs. Thus, make sure to select the measurement function before running one of these tests.

The square wave sweep test allows you to make a series of measurements at an alternating high and low voltage level. When the test is configured, you specify the high voltage level (HI-LEVEL), the time spent at the high level (HI-TIME), the low level voltage (LO-LEVEL), the time spent at the low level (LO-TIME), and the number of cycles to repeat (CYCLE COUNT). [Figure 6-8](#) shows an example using the default test parameters. When the test is run, 20 measurements will be performed (at each high and low level) and stored in the buffer. This test is selected and configured from the **CONFIGURE SEQUENCE** menu (SWEEP; STAIRCASE).

The staircase sweep test allows you to make measurements at staircased voltage levels. When the test is configured, you specify the START voltage, the STEP voltage, the STOP voltage and the delay (STEP TIME) between steps. [Figure 6-9](#) shows an example using the default test parameters.

When the test is run, 10 measurements will be performed (one at each voltage step) and stored in the buffer. This test is selected and configured from the **CONFIGURE SEQUENCE** menu (SWEEP; STAIRCASE).

Figure 6-8
Default measurement points; square wave sweep test

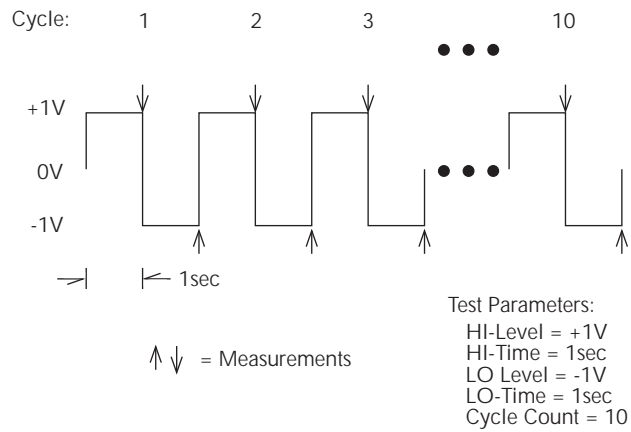
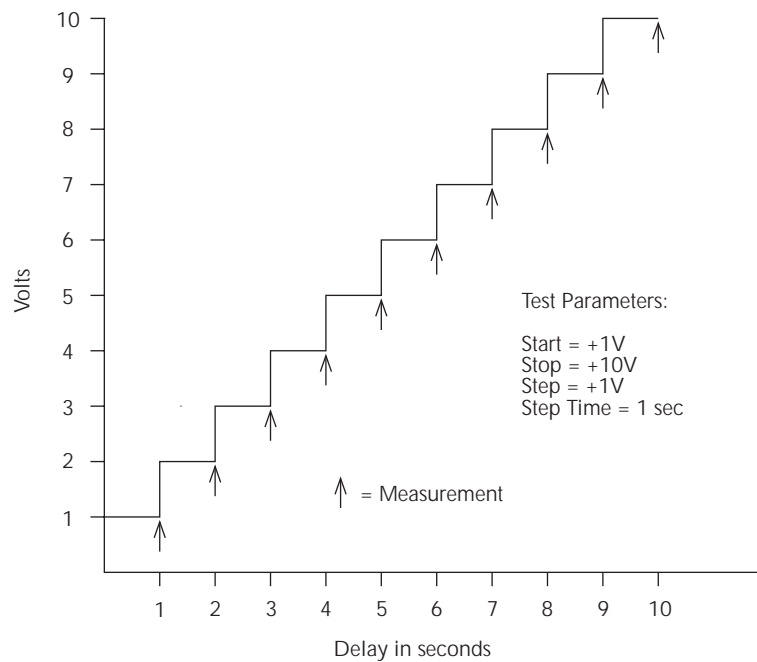


Figure 6-9
Default measurement points; staircase sweep test



Configuring test sequences

Configure sequence menu

The **CONFIGURE SEQUENCE** menu is used to select and configure a test sequences and is summarized in [Table 6-1](#). The top level of the menu is displayed by pressing **CONFIG** and then **SEQ**.

Table 6-1
Configure sequence menu

Menu item	Description	Default parameter
APPLICATIONS	Select type of test:	
DEV-CHAR	Device characterization tests:	
DIODE		
LEAKAGE-CURRENT	Diode leakage current test:	
START V	Specify start voltage	+1 V
STOP V	Specify stop voltage	+10 V
STEP V	Specify step voltage	+1 V
DELAY	Specify delay	1 s
CAPACITOR		
LEAKAGE-CURRENT	Capacitor leakage current test:	
BIAS V	Specify bias voltage	+1 V
STORE nnnnn READINGS	Specify number of readings	10
INTERVAL	Specify time interval	1 s
CABLE		
INSULATION-RESISTANCE	Cable insulation resistance test:	
BIAS V	Specify bias voltage	+1 V
STORE READINGS	Specify number of readings	5
INTERVAL	Specify time interval	1 sec
RESISTOR		
VOLTAGE-COEFFICIENT	Resistor voltage coefficient test:	
SOURCE V1	Specify 1st test voltage	+1V
DELAY 1	Specify 1st delay	1sec
SOURCE V2	Specify 2nd test voltage	+2V
DELAY 2	Specify 2nd delay	1 sec
R/RESISTIVITY	Resistance/resistivity tests:	
NORMAL	Standard method resistivity tests:	
SURFACE	Surface resistivity test:	
PRE-DISCH	Specify pre-discharge time	0.2 sec
BIAS V	Specify bias voltage	+500V
BIAS-TIME	Specify bias time	1 sec
MEAS-V	Specify measurement voltage	+500V
MEAS-TIME	Specify measurement time	0 sec
DISCHARGE	Specify discharge time	2 sec
VOLUME	Volume resistivity test:	
PRE-DISCH	Specify pre-discharge time	10 sec
BIAS V	Specify bias voltage	+500V
BIAS-TIME	Specify bias time	1 sec
MEAS-V	Specify measurement voltage	+500V
MEAS-TIME	Specify measurement time	0 sec
DISCHARGE	Specify discharge time	2 sec

Table 6-1 (continued)
Configure sequence menu

Menu item	Description	Default parameter
ALT-POLARITY V-OFS V-ALT MEAS-TIME DISCARD RDGS STORE RDGS SIR SUR-INSUL-RES-TEST BIAS V BIAS-TIME MEAS-V MEAS-TIME	Alternate polarity test: Specify offset voltage Specify alternating voltage Specify measurement time Specify discarded readings Specify readings to store Surface insulation resistance test: Specify bias voltage Specify bias time Specify measurement voltage Specify measurement time	0V 10V 15 sec 3 1 +50V 1 sec +100V 1sec
SWEEP SQUARE-WAVE HI-LEVEL HI-TIME LO-LEVEL LO-TIME CYCLE COUNT STAIRCASE START STOP STEP STEP TIME	Sweep tests: Square wave sweep test: Specify high level voltage Specify time at high level Specify low level voltage Specify time at low level Specify number of cycles Staircase sweep test: Specify start voltage Specify stop voltage Specify step voltage Specify step time	+1V 1sec -1V 1sec 10 +1V +10V +1V 1sec
CONTROL MANUAL IMMEDIATE LID-CLOSURE GPIB EXTERNAL TRIGLINK	Select trigger source to start test: Start when TRIG key pressed Start immediately Start when test fixture lid closed Start on GPIB trigger (GET or *TRG) Start when external trigger received Start when trigger is received through the specified trigger link line	Manual Line #1

Menu sections

APPLICATIONS

This menu item is used to select the application:

DEV-CHAR: Use this menu item to select and configure one of the device characterization tests:

DIODE: Use this option to select and configure the diode leakage current test. After selecting **LEAKAGE-CURRENT**, you will be prompted to enter the start voltage, stop voltage, step voltage and the delay. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

CAPACITOR: Use this option to select and configure the capacitor leakage current test. After selecting **LEAKAGE-CURRENT**, you will be prompted to enter the bias voltage, number of readings, and the time interval. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

CABLE: Use this option to select and configure the cable insulation resistance test. After selecting **INSULATION-RESISTANCE**, you will be prompted to enter the bias voltage, number

of readings, and time interval. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

RESISTOR: Use this option to select and configure the resistor voltage coefficient test. After selecting **VOLTAGE-COEFFICIENT**, you will be prompted to enter the first voltage, first delay, second voltage, and second delay. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

RESISTIVITY: Use this menu item to select and configure one of the standard method resistivity tests or the alternating polarity test:

NORMAL: Use this menu item to select and configure one of the standard method resistivity tests:

SURFACE: Use this option to select and configure the surface resistivity test. You will be prompted to enter the pre-discharge time, bias voltage, bias time, measure voltage, measure time, and discharge time. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

VOLUME: Use this option to select and configure the volume resistivity test. You will be prompted to enter the pre-discharge time, bias voltage, bias time, measure voltage, measure time, and discharge time. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

ALT POLARITY: Use this menu to select and configure the alternating polarity resistance/resistivity test. You will be prompted to enter the offset voltage, alternating voltage, measure time, readings to discard, and readings to store. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

SIR: Use this menu item to select and configure the surface insulation resistance test. After selecting **SUR-INSUL-RES-TEST**, you will be prompted to enter the bias voltage, bias time, measure voltage, and measure time. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

SWEEP: Use this menu item to select and configure one of the sweep tests:

SQUARE-WAVE: Use this option to select and configure the square wave sweep test. You will be prompted to enter the high level voltage, time at the high level, low level voltage, and time at the low level. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

STAIRCASE: Use this option to select and configure the staircase sweep test. You will be prompted to enter the start voltage, stop voltage, step voltage, and the step time. After entering these test parameters, use the **EXIT** key to back out of the menu structure.

CONTROL

This menu item is used to select the trigger source that will start the armed test. The **SEQ** key is used to arm the selected test.

MANUAL: Use this option to select the manual trigger source. Once the test is armed, it will start when the **TRIG** key is pressed.

IMMEDIATE: Use this option to select the immediate trigger source. The test will start as soon as it is armed.

LID-CLOSURE: Use this option to select the lid test fixture as the trigger source. Once the test is armed, it will start when the lid of the test fixture is closed.

GPIB: Use this option to select the GPIB trigger source. Once the test is armed, it will start when the Model 6517B receives a bus trigger (**GET** or ***TRG**). Note that the **TRIG** key can instead be used to start the test.

EXTERNAL: Use this option to select the external trigger source. Once the test is armed, it will start when the Model 6517B receives an external trigger through the **EXT TRIG IN** connector. Note that the **TRIG** key can instead be used to start the test.

TRIGLINK: Use this option to select the trigger link trigger source. After selecting **TRIGLINK** you will be prompted to select the trigger link line. Once the test is armed, it will start when the Model 6517B receives a trigger through the selected trigger link line. Note that the **TRIG** key can instead be used to start the test.

Running the selected test

Perform the following steps to run the selected test:

1. Enable zero check and make sure the V-source is in standby (**OPERATE LED** off).
2. Connect and configure the Model 6517B for the desired test (see *Configure sequence menu* for more information).
3. Select and configure the desired test.
4. Press the **SEQ** key. The selected test will be displayed.
5. Press **ENTER** to arm the test. When the selected trigger source event occurs, zero check will disable and the test will run.
6. When the test is finished, zero check will stay disabled and the V-source will go into standby.
7. The measured readings for the test are stored in the buffer. To access these readings, press **RECALL**.

Test notes

1. If the IMMEDIATE trigger source is selected, the test will start immediately after it is armed. With any other trigger source (except LID CLOSURE) selected, the test can be started by pressing **TRIG**.
2. While a test is armed or running, the flashing “**SEQ**” message is displayed on the Model 6517B.
3. Readings are automatically stored in the buffer starting at memory location (reading #) zero.
4. The alternating polarity test will be re-armed upon completion of a sequence. When the selected trigger source event occurs, the test will re-run. Readings may be recalled, or the sequence re-configured while the 6517B awaits the trigger. When the sequence is armed the first time, trigger source is set to manual but can be re-configured to any other trigger source. To end the sequences, press **EXIT** to return to normal operation.

In this section:

Topic	Page
Introduction	7-2
Trigger configuration menu	7-2
Trigger models	7-4
Basic trigger model	7-4
Advanced trigger model	7-5
Trigger model layers	7-7
Trigger configuration	7-8
Basic trigger configuration	7-8
Advanced trigger configuration	7-9
External triggering	7-14
Trigger link connector	7-14
Asynchronous operation	7-14
Semi-synchronous operation	7-18

Introduction

This section discusses front panel triggering, trigger configuration, and external triggering, including example setups.

Trigger configuration menu

The Keithley Instruments Model 6517B Electrometer triggers are set up from the **CONFIGURE TRIGGER** menu. The menu structure is shown and summarized in [Table 7-1](#).

Notice in [Table 7-1](#) that there are two trigger configuration structures: BASIC and ADVANCED. The basic menu structure can be used when simple trigger operations will suffice. The advanced menu structure must be used when more sophisticated trigger operations (such as scanning) are required. The differences between basic and advanced triggering are explained below.

Table 7-1

Trigger configuration menu

Menu item	Description
BASIC MODE CONTINUOUS ONE-SHOT SOURCE IMMEDIATE MANUAL GPIB EXT TIMER	Select and configure basic triggering: Select trigger mode: Use for continuous triggering Use for one-shot triggering Select source of triggers: Use to make measurements immediately Use TRIG key to control measuring Use bus triggers to control measuring Use external triggers to control measuring Use a timer to control measuring; enter trigger interval (0.001 - 999999.999 seconds)
ADVANCED MEASURE SOURCE IMMEDIATE EXTERNAL MANUAL GPIB TRIGLINK TIMER HOLD DELAY COUNT INFINITE ENTER-CHAN-COUNT CONTROL SOURCE ACCEPTOR	Select and configure advanced triggering: Measure layer menu: Select measure source: Use to make measurements immediately Use external trigger to control measuring Use TRIG key to control measuring Use bus triggers to control measuring Use trigger link triggers to control measuring; enter trigger link mode and lines Use a timer to control measuring and enter interval between triggers (0.001 - 999999.999 seconds) Use to hold up the measurement in the measure layer Use to delay measurement in the measure layer (0.001 - 999999.999 seconds) Define number of measurements to make: Repeat measuring indefinitely Specify count (1 - 99999) Select trigger control mode: Enable source Bypass Disable source Bypass

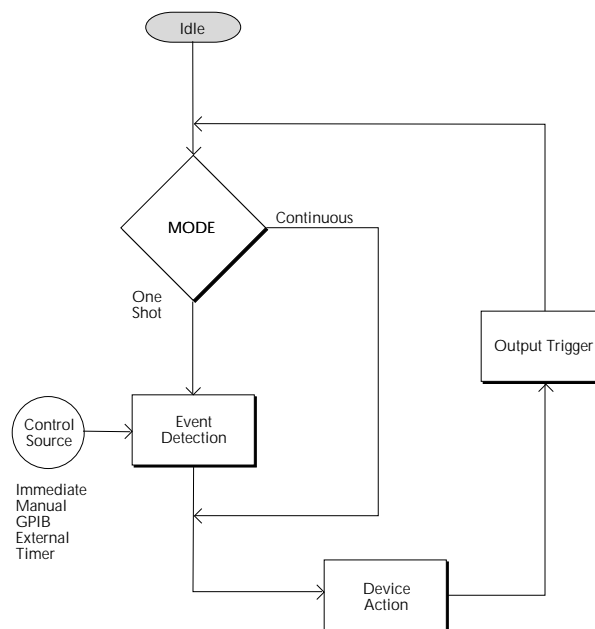
Table 7-1 (continued)
Trigger configuration menu

Menu item	Description
SCAN SOURCE IMMEDIATE EXTERNAL MANUAL GPIB TRIGLINK TIMER HOLD DELAY COUNT INFINITE ENTER-SCAN-COUNT CONTROL SOURCE ACCEPTOR	Scan layer menu: Select scan source: Use to pass operation immediately into the measure layer Use external triggers to control scanning Use TRIG key to control scanning Use bus triggers to control scanning Use trigger link triggers to control scanning Enter trigger link lines Use a timer to control scanning and enter interval between scans (0.001 - 999999.999 seconds) Use to hold up the measurement in the scan layer Use to delay scan in the layer (0.001 - 999999.999 seconds) Define number of scans to be performed: Repeat scanning indefinitely Specify count (1 - 99999) Select trigger control mode: Enable source bypass Disable source bypass
ARM SOURCE IMMEDIATE EXTERNAL MANUAL GPIB TRIGLINK RT-CLOCK HOLD COUNT INFINITE ENTER-ARM-COUNT CONTROL SOURCE ACCEPTOR	Arm layer menu: Select arm source: Use to arm meter immediately and pass operation into the scan layer Use external triggers to arm meter Use TRIG key to arm meter Use bus triggers to arm meter Use trigger link triggers to arm meter; enter trigger link lines Use clock to arm instrument; enter time and date Use to hold up the measurement in the arm layer Define number of times to arm meter: Continuously re-arm meter Specify count (1 - 99999) Select trigger control mode: Enable source bypass Disable source bypass
INIT HALT	Enable or disable continuous initiation Use to halt triggers; press TRIG key to resume triggering

Trigger models

The following information describes triggering of the Model 6517B from the front panel. The flowchart of [Figure 7-1](#) which is the simplified trigger model, summarizes basic front panel triggering. The flowchart of [Figure 7-2](#), which is the complete trigger model, summarizes advanced front panel triggering.

Figure 7-1
Basic trigger model



Basic trigger model

As shown in [Figure 7-1](#), the basic trigger model provides the fundamental trigger options needed for many instrument operations.

Basic triggering is selected and configured from the BASIC menu item of the CONFIGURE TRIGGER menu. Refer to [Figure 7-1](#) for the following explanation of the basic trigger model.

Idle

While in the idle state, the instrument cannot perform measurements. The front panel ARM indicator is off when the instrument is in idle. Pressing **TRIG** takes the instrument out of idle (ARM indicator turns on).

Trigger mode

With the continuous trigger mode selected, operation continuously loops around the control source to make measurements (device action). This trigger mode provides continuous reading conversions.

With the one-shot trigger mode selected, operation waits for the selected control source event to occur before making a measurement (device action). A measurement occurs every time the source event is detected (see *Control sources* below).

The trigger mode is selected from the BASIC (MODE) option of the CONFIGURE TRIGGER menu.

Control sources

With the one-shot trigger mode selected, a measurement (device action) does not occur until the selected control source event is detected. The control sources are explained as follows:

- Immediate: With this control source selected, event detection is immediately satisfied allowing operation to continue. Using this selection is effectively the same as using the continuous trigger mode.
- Manual: Event detection is satisfied by pressing the **TRIG** key. Note that the Model 6517B must be taken out of remote before it will respond to the TRIG key. Pressing **LOCAL** takes the instrument out of remote.
- GPIB: Event detection is satisfied when a bus trigger (GET or *TRG) is received by the Model 6517B.
- External: Event detection is satisfied when an input trigger through the EXTERNAL TRIGGER connector is received by the Model 6517B.
- Timer: Event detection is immediately satisfied on the initial pass through the layer. Each subsequent detection is satisfied when the programmed timer interval (1 to 999999.999 seconds) elapses.

Output triggers

After every measurement (device action) a trigger pulse is applied to the trigger link connector on the rear panel of the instrument. This out-going trigger pulse can be used to trigger another instrument to perform an operation.

Advanced trigger model

As shown in [Figure 7-2](#), the advanced trigger model provides more triggering options, which are programmed from the ADVANCED menu item of the CONFIGURE TRIGGER menu. Note that scanning operations use this trigger model.

Advanced triggering is selected and configured from the ADVANCED menu item of the CONFIGURE TRIGGER menu. Refer to [Figure 7-2](#) for the following explanation of the advanced trigger model.

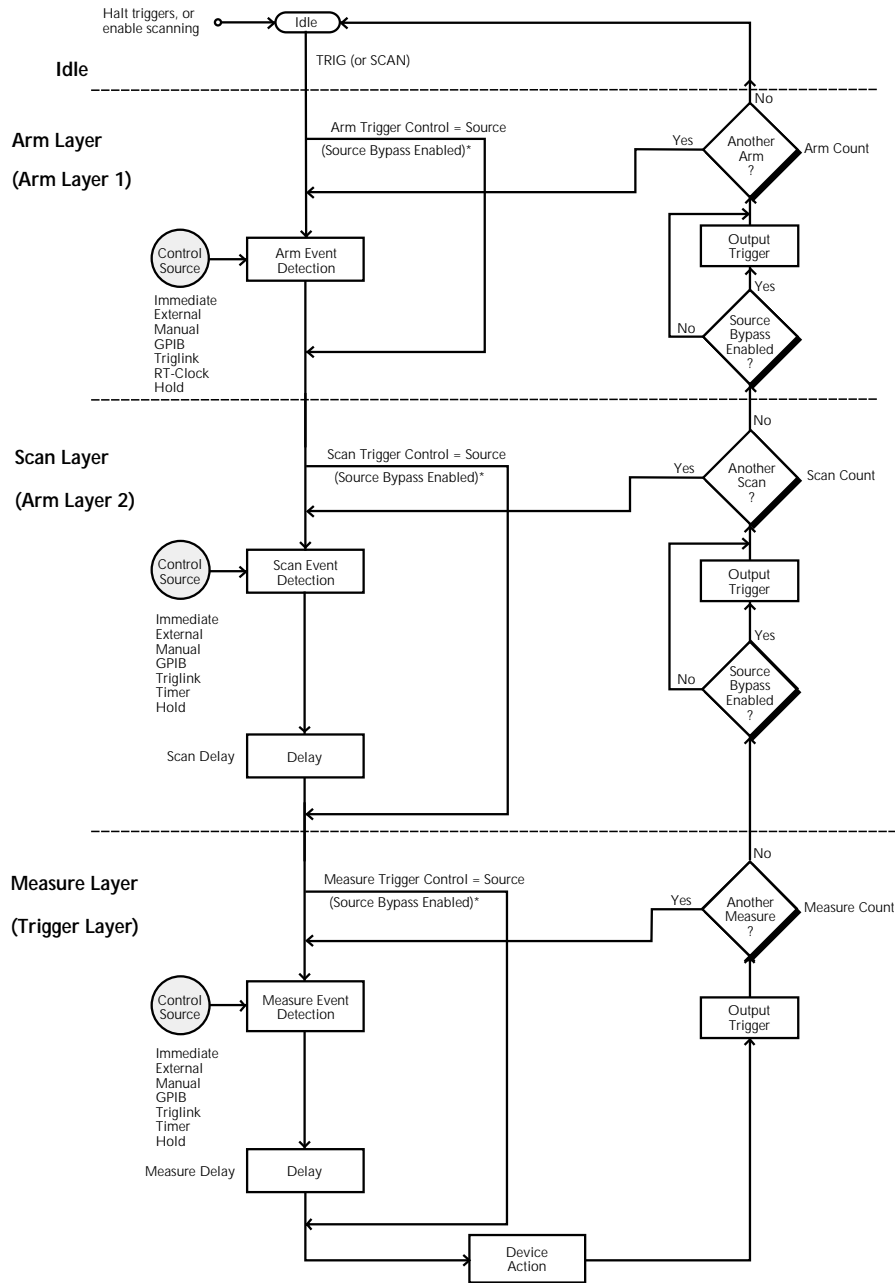
Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the three layers of the trigger model. The front panel **ARM** indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any measurement or scanning functions.

From the front panel there are three ways to put the instrument into idle:

- Select **RESET GPIB** from the **SAVESETUP** option of the main menu. Press the **TRIG** key to take a reading. After each reading, the instrument returns to the idle state.
- Select **HALT** from the **ADVANCED** item of **CONFIGURE TRIGGER** menu. Press the **TRIG** key to resume triggering. The **INIT (ON)** option of the **ADVANCED** trigger menu structure will also take the instrument out of idle.
- Press the **OPTION CARD** key to place the Model 6517B in the scan mode. Triggering will resume when the scan is started or if the scan is aborted by pressing **EXIT**.

Figure 7-2
Advanced trigger model



* Take bypass path the first time a layer is entered

Trigger model layers

As can be seen in [Figure 7-2](#), the trigger model uses three layers: the arm layer, scan layer and measure layer. For IEEE-488 bus operation, these layers are known as Arm Layer 1, Arm Layer 2 and the trigger layer.

Once the Model 6517B is taken out of the idle state, operation proceeds through the layers of the trigger model down to the device action where a measurement occurs.

Control sources: In general, each layer contains a control source which holds up operation until the programmed event occurs. The control sources are described as follows:

- Immediate: With this control source selected, event detection is immediately satisfied allowing operation to continue.
- Manual: Event detection is satisfied by pressing the **TRIG** key. Note that the Model 6517B must be taken out of remote before it will respond to the **TRIG** key. Pressing **LOCAL** takes the instrument out of remote.
- GPIB: Event detection is satisfied when a bus trigger (GET or *TRG) is received by the Model 6517B.
- RT-Clock: Event detection in the arm layer is satisfied when the programmed time and date occurs. The real-time clock control source is not available in the scan layer and measure layer.
- Timer: Event detection is immediately satisfied on the initial pass through the layer. Each subsequent detection is satisfied when the programmed timer interval (1 to 999999.999 seconds) elapses. A timer resets to its initial state when operation loops back to a higher layer (or idle). Note that a timer is not available in the arm layer.
- External: Event detection is satisfied when an input trigger through the EXTERNAL TRIGGER connector is received by the Model 6517B.
- Triglink: Event detection is satisfied when an input trigger through the trigger link is received by the Model 6517B.
- Hold: With this selection, event detection is not satisfied by any of the above control source events and operation is held up.

Source bypasses: As can be seen in the flowchart in [Figure 7-2](#), each layer has a path that allows operation to loop around the control source. Each path is called a source bypass.

When a source bypass is enabled, and the external or trigger link (triglink) control source is selected, operation loops around the control source on the initial pass through the layer. If programmed for another event detection in the layer, the bypass loop will not be in effect though it is still enabled. The bypass loop resets (be in effect) if operation loops back to a higher layer (or idle).

In the arm layer and scan layer, enabling a source bypass also enables the respective output trigger. In the trigger layer, its output trigger is always enabled and occurs after every device action. See output triggers (below) for more information.

Delays: The scan layer and the measure layer have a programmable delay (0 to 999999.999 seconds) that is enforced after an event detection.

Device action: The primary device action is a measurement. However, the device action could include a function change and a channel scan (if scanner is enabled). A channel is scanned (closed) before a measurement is made. When scanning internal channels, the previous channel opens and the next channel closes (break-before-make). Also included in the device action is the internal settling time delay for the relay.

Output triggers: In the arm layer and scan layer the output triggers are enabled only if their respective source bypasses are also enabled. If a trigger link (triglink) control source is selected, the output trigger pulse is available on the selected trigger link output line.

In the measure layer, the output trigger is always enabled and occurs after every device action. If the control source is set for external, immediate, manual, GPIB or timer, the output trigger pulse is available at the trigger link connector. If the trigger link (triglink) control source is selected, output trigger action occurs on the selected trigger link output line as follows:

- If the asynchronous trigger link mode is selected, the output trigger pulse is available on the programmed output line.
- If the semi-synchronous trigger link mode is selected and the source bypass is disabled, the trigger link line is released (goes high).
- If the semi-synchronous trigger link mode is selected and the source bypass is enabled, the trigger link line is pulled down low and then released.

Counters: All three layers use programmable counters which allow operation to return to or stay in the respective layer. For example, programming the measure layer counter for infinity keeps operation in the measure layer. After each device action and subsequent output trigger, operation loops back to the trigger layer control source. A counter resets when operation loops back to a higher layer (or idle).

Trigger configuration

Basic trigger configuration

The following information explains how to configure the Model 6517B for basic triggering. If you instead wish to use advance triggering, see *Advanced trigger configuration* below. Basic triggering is configured from the BASIC item of the CONFIGURE TRIGGER menu (see [Table 7-1](#)), which is displayed by pressing the **CONFIG** key and then the **TRIG** key.

The BASIC TRIGGERING menu items are explained as follows:

MODE

Use this menu item to select the trigger mode for basic triggering.

CONTINUOUS: Use this trigger mode to place the instrument in the continuous measurement mode.

ONE-SHOT: Use this trigger mode to place the instrument in the one-shot measurement mode. In this mode, the instrument waits for the selected control source event to occur before making a measurement (see *SOURCE* below).

SOURCE

Use this menu item to select the control source event for one-shot triggering:

IMMEDIATE: With this selection, events (such as **TIMER** and **EXTERNAL** triggers) do not control the measurement interval. Once the Model 6517B starts measuring, it will take readings as fast as its measurement configuration allows.

MANUAL: With this selection, the front panel **TRIG** key controls the measure source. A device action is performed when the **TRIG** key is pressed. The front panel **TRIG** key is active when **EXT**, **GPIB**, or **TIMER** is selected.

GPIB: With this selection, bus triggers control the measurement interval. When the Model 6517B receives a bus trigger (**GET** or ***TRG**), it performs a measurement. The front panel **TRIG** key (see *MANUAL* above) is active with bus triggering selected. Pressing the **TRIG** key performs a measurement.

EXT: With this selection, external triggers are used to control the measurement interval. Each trigger stimulus applied to the Model 6517B results in a measurement. The external trigger is applied to the rear panel trigger link connector. The front panel **TRIG** key (see *MANUAL* above) is active with external triggering selected. Pressing the **TRIG** key performs a device action.

TIMER: Use the timer to control the time interval between measurements. The timer can be set for an interval from 0.001 seconds (1ms) to 999999.999 seconds with 1ms resolution. The first measurement occurs immediately, while all subsequent measurements occur at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single measurement, the next measurement will not start until the previous one is done. The front panel **TRIG** key (see *MANUAL* above) is active with the time selected. Pressing the **TRIG** key after the completion of a measurement starts the next measurement.

Advanced trigger configuration

The following information explains how to configure the Model 6517B for advanced triggering. If you instead wish to use basic triggering, see *Basic trigger configuration* above. Advanced triggering is configured from the **ADVANCED** item of the **CONFIGURE TRIGGER** menu (see [Table 7-1](#)), which is displayed by pressing the **CONFIG** key and then the **TRIG** key.

Configuring measure layer

The measure layer is used for the following operations:

- To select the measuring event (**SOURCE**) for the instrument
- To delay operation in the measure layer
- To designate the number of measurements the instrument will make (**COUNT**)
- To enable or disable the source Bypass

The measure layer is configured from the **MEASURE** item of the **ADVANCED TRIGGERING** menu.

SOURCE

This menu item selects the event that controls the measure source.

IMMEDIATE: With this selection, events (such as **TIMER** and **EXTERNAL** triggers) do not control the measurement interval. Once the Model 6517B starts measuring, it will take readings as fast as its measurement configuration allows.

EXTERNAL: With this selection, external triggers are used to control the measure source. Each trigger stimulus applied to the Model 6517B performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning, and other operations. The external trigger is applied to the rear panel trigger link connector. The front panel **TRIG** key (see *MANUAL* below) is active with external triggering selected. Pressing the **TRIG** key performs a device action.

MANUAL: With this selection, the front panel **TRIG** key controls the measure source. A device action is performed when the **TRIG** key is pressed. The front panel **TRIG** key is active when **EXTERNAL**, **GPIB**, **TRIGLINK**, or **TIMER** is selected.

GPIB: With this selection, bus triggers control the measure source. When the Model 6517B receives a bus trigger (**GET** or ***TRG**), it performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning and other operations. See [Section 11](#) for detailed information on bus triggers. The front panel **TRIG** key (see *MANUAL* above) is active with bus triggering selected. Pressing the **TRIG** key performs a device action.

TRIGLINK: With this selection, the measure source is controlled by the trigger link of the Model 6517B. trigger link is an enhanced trigger system that uses up to six lines to direct trigger pulses to an from other instruments. When the Model 6517B receives a trigger over the trigger link, it performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning, and other operations. The front panel TRIG key (see *MANUAL* above) is active with the trigger link selected, Pressing the **TRIG** key performs a device action.

After selecting TRIGLINK as the measurement event, select one of the following trigger link modes:

- **ASYNCHRONOUS:** The asynchronous trigger link mode is used for trigger configurations that require input and output triggers to be routed on separate lines. After selecting this trigger link mode, you will be prompted to select an input line and then an output line. Note that you cannot use the same trigger line for both input and output.
- **SEMI-SYNCHRONOUS:** In this mode, the input and output triggers for the Model 6517B are assigned to the same line. After selecting this trigger link mode, you will be prompted to select the trigger line.

TIMER: Use the timer to control the time interval between measurements. The timer can be set for an interval from 0.001 seconds (1msec) to 999999.999 seconds with 1ms resolution.

The first measurement occurs immediately, while all subsequent measurements occur at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single measurement, the next measurement will not start until the previous one is done.

The front panel **TRIG** key (see *MANUAL* above) is active with the time selected. Pressing the TRIG key after the completion of a measurement starts the next measurement (assuming the Model 6517B is programmed for another measurement; see *COUNT* below).

HOLD: When HOLD is selected, the measure source is suppressed. As a result, measuring is stopped and does not continue until HOLD is cancelled by selecting one of the other measure source selections. Select HOLD from the SELECT MEASURE SRC menu by pressing the cursor on **HOLD** and pressing **ENTER**. The instrument returns to the SETUP measure layer menu.

DELAY

This delay is used to hold up operation in the measure layer. After the measure event occurs, the instrument waits until the delay period times out (0 - 999999.999 seconds) before performing a device action.

COUNT

With this selection, you determine the number (count) of measurements per scan sequence. The user programmed count can be smaller, equal to, or larger than the number of channels in the scan list. For example, if the scan list is made up of four channels, you can program a count of 12. With this count value, the instrument repeats the scan three times. An advantage of repeating channels (rather than scans) is that delays in the scan layer of operation are avoided. The measure layer delays among all 12 channels are the same.

INFINITE: Use this selection to continuously repeat measurements (and looping in the measure layer).

ENTER-CHAN-COUNT: With this selection, the user determines the number of readings per scan. You can program the Model 6517B to measure up to 99,999 times.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the measure event on the first pass through the measure layer.

SOURCE: With this selection, the source bypass is enabled. The measure event will be bypassed on the first pass through the scan layer. This allows operation to proceed to the delay and device action without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

Configuring scan layer

The scan layer is used for the following operations:

- To select the scanning event (SOURCE) for the instrument
- To delay operation in the scan layer
- To designate the number of scan sequences the instrument will perform (COUNT)
- To enable or disable the source bypass

The scan layer is configured from the SCAN item of the ADVANCED menu.

SOURCE: This menu item selects the event that controls the scan source.

IMMEDIATE: With this selection, operation passes immediately into the measure layer.

EXTERNAL: With this selection, external triggers are used to control the scan source. A trigger stimulus applied to the Model 6517B passes operation into the measure layer. The external trigger is applied to the rear panel trigger link connector. The front panel TRIG key (see *MANUAL* below) is active with external triggering selected. Pressing the **TRIG** key passes operation into the measure layer.

MANUAL: With this selection, the front panel TRIG key controls the scan source. Operation passes into the measure layer when the TRIG key is pressed. The front panel TRIG key is active when EXTERNAL, GPIB, TRIGLINK, or TIMER is selected.

GPIB: With this selection, bus triggers control the scan source. Operation passes immediately into the measure layer when a bus trigger (GET or *TRG) is received by the Model 6517B. The front panel TRIG key (see *MANUAL* above) is active with bus triggering selected. Pressing the **TRIG** key passes operation into the measure layer.

TRIGLINK: With this selection, the scan source is controlled by the trigger link of the Model 6517B. trigger link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the measure layer when the Model 6517B receives a trigger over the trigger link. The front panel TRIG key (see *MANUAL* above) is active with the trigger link selected. Pressing the **TRIG** key passes operation into the measure layer.

After selecting TRIGLINK, you will be prompted to select an input line and then an output line. Note that you cannot use the same trigger line for both input and output.

TIMER: Use the timer feature to control the time interval between scan sequences when scanning. The timer can be set for an interval from 0.001 seconds (1ms) to 999999.999 seconds with 1ms resolution.

The first scan sequence occurs immediately, while all subsequent scans start at the end of the programmed timer interval. If, however, the programmed timer interval is shorter than the time it takes to complete a single scan, the next scan will not start until the previous one is done. The front panel TRIG key (see *MANUAL* above) is active with the timer selected. Pressing the **TRIG** key after the completion of a scan sequence starts the next scan sequence (assuming the Model 6517B is programmed for another scan sequence; see "*COUNT*" below).

HOLD: When HOLD is selected, the scan source is suppressed. As a result, operation does not pass into the measure layer until HOLD is cancelled by selecting one of the other scan source selections. Select **HOLD** from the SELECT SCAN SOURCE menu by placing the cursor on **HOLD** and pressing **ENTER**. The instrument returns to the SETUP SCAN LAYER menu.

DELAY

This delay is used to hold up operation in the scan layer. After the scan event occurs, the instrument waits until the delay period times out (0 to 999999.999 seconds) before proceeding to the measure layer.

COUNT

This menu item defines the number of times operation returns to the scan layer.

INFINITE: Use this selection to continuously return operation to the scan layer.

ENTER-CHAN-COUNT: With this selection, the user determines the number of times operation returns to the scan layer. You can program the Model 6517B to scan up to 99999 times.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the scan event on the first pass through the scan layer.

SOURCE: With this selection, the source bypass is enabled. The scan event will be bypassed on the first pass through the scan layer. This allows operation to proceed into the measure layer without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

Configuring arm layer

The arm layer is used for the following operations:

- To select the arming event (**SOURCE**) for the instrument
- To designate the number of times the instrument is to be armed (**COUNT**)
- To enable or disable the source Bypass

The arm layer is configured from the ARM item of the ADVANCED menu.

SOURCE

This menu item selects the event that controls the arm source.

IMMEDIATE: With this selection, operation passes immediately into the scan layer.

EXTERNAL: With this selection, external triggers are used to control the arm source. A trigger stimulus applied to the Model 6517B passes operation into the scan layer. The external trigger is applied to the rear panel trigger link connector. The front panel TRIG key (see *MANUAL* below) is active with external triggering selected. Pressing the **TRIG** key passes operation into the scan layer.

MANUAL: With this selection, the front panel TRIG key controls the arm source. Operation passes into the scan layer when the TRIG key is pressed. The front panel TRIG key is active when **EXTERNAL**, **GPIB** or **TRIGLINK** is selected.

GPIB: With this selection, bus triggers control the arm source. Operation passes immediately into the scan layer when a bus trigger (**GET** or ***TRG**) is received by the Model 6517B. See [Section 11](#) for detailed information on bus triggers. The front panel TRIG key (see *MANUAL* above) is active with bus triggering selected. Pressing the **TRIG** key passes operation into the scan layer.

TRIGLINK: With this selection, the arm source is controlled by the trigger link of the Model 6517B. Trigger link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the scan layer when the Model 6517B receives a trigger over the trigger link. The front panel TRIG key (see *MANUAL* above) is active with the trigger link selected. Pressing the **TRIG** key passes operation into the scan layer.

After selecting TRIGLINK, you will be prompted to select an input line and then an output line. Note that you cannot use the same trigger line for both input and output.

RT-Clock: With this selection, the arm source is controlled by the real-time clock. When the programmed time and data occurs, the Model 6517B passes operation into the scan layer.

- **SET-TIME:** Use this selection to set the time (hour, minute and second) for the arm event. Set the time using the 12-hour format if “AM” or “PM” is displayed. Otherwise, set the time using the 24-hour format.
- **SET-DATE:** Use this selection to set the date (month, day, and year) for the arm event.

HOLD: When HOLD is selected, the arm source is suppressed. As a result, operation does not pass into the scan layer until HOLD is cancelled by selecting one of the other arm source selections. Select **HOLD** from the SELECT ARM SOURCE menu by placing the cursor on **HOLD** and pressing **ENTER**. The instrument returns to the SETUP arm layer menu.

COUNT

This menu item defines the number of times operation returns to the arm layer.

INFINITE: Use this selection to continuously return operation to the arm layer.

ENTER-ARM-COUNT: With this selection, the user determines the number of times operation returns to the arm layer. You can program the Model 6517B to arm up to 99999 times.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the arm event on the first pass through the arm layer.

SOURCE: With this selection, the source bypass is enabled. The arm event will be bypassed on the first pass through the arm layer. This allows operation to proceed into the scan layer without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

Continuous initiation

The INIT item of the ADVANCED TRIGGERING menu is used to enable or disable continuous initiation.

ON: Use this option to enable continuous initiation. The instrument will not go into idle when all trigger model operations are done. Operation will instead start over from the top of the advanced trigger model.

OFF: Use this option to disable continuous initiation. After all advanced trigger model operations are done, the instrument will go into idle.

Halting triggers

The HALT option of the ADVANCED TRIGGERING menu is used to disarm the instrument and place it in the idle state. You can press the **TRIG** key to resume front panel triggers. Enabling (ON) continuous initiation will also take the instrument out of idle.

External triggering

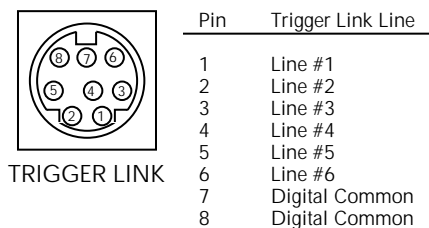
The Model 6517B has enhanced external triggering capabilities using the trigger link. In general, trigger link input triggers to the Model 6517B are used to control the measure operation. For the Model 6517B to respond to trigger link compatible triggers, the appropriate layers of the trigger model must be programmed for it. For example, if you want trigger link input triggers to control the measuring process, you must program measure source for TRIGLINK trigger events. Typically, a trigger link output trigger from the Model 6517B would be used to trigger a scanner to close the next channel.

There are two modes of operation for trigger link: asynchronous and semi-synchronous. In the asynchronous mode, separate lines are used for input and output triggers; in the semi-synchronous mode, the same line is used for both input and output triggers.

Trigger link connector

The trigger link has six lines allowing up to six instruments to be controlled over this trigger bus. The pin layout of the 8-pin micro-DIN sockets used for the trigger link is shown in [Figure 7-3](#).

Figure 7-3
Trigger link connector



Asynchronous operation

The asynchronous mode uses separate lines for input and output triggers. The specifications for the input and output trigger signals of asynchronous mode are shown in [Figure 7-4](#) and [Figure 7-5](#), respectively.

Figure 7-4
Asynchronous trigger link input pulse specifications

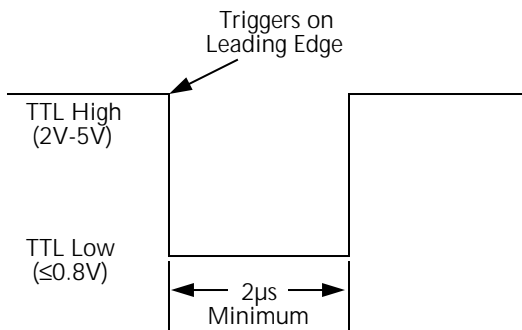
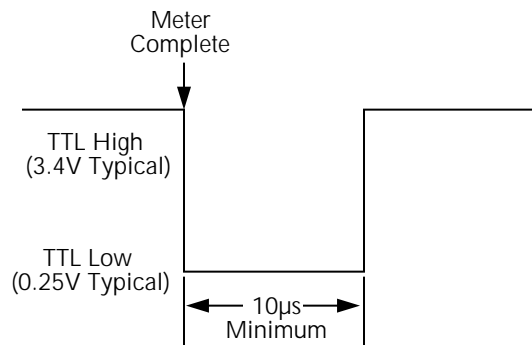


Figure 7-5
Asynchronous trigger link output pulse specifications



For typical asynchronous trigger link operation, the measure layer is configured with measure source set to TRIGLINK and Trigger link mode set to ASYNCHRONOUS. You must also select input and output lines for the measure layer. Input and output triggers can be set to any of the six lines, but they cannot use the same line. For example, if you select line #1 for input triggers, then output triggers must use one of the other five lines (#2 through #6).

During operation in the measure layer, each trigger link input trigger makes a measurement. After the user-programmed DELAY and the measurement settling time, the Model 6517B outputs a trigger link completion pulse (typically to a scanner to close the next channel). The measure layer is configured using the CONFIGURE TRIGGER menu (see *Trigger configuration menu* for more information).

The scan layer and arm layer can also be programmed for trigger link, where scan source is set to TRIGLINK, and Arm source is set to TRIGLINK. When using trigger link in these layers, you must also select input and output lines as you did in the measure layer. Keep in mind that you can use the same lines in the scan and arm layers as selected in the measure layer.

Asynchronous trigger link example

In a typical test system, you may want to close a channel and then measure the DUT connected to the channel with a meter. Such a test system is shown in [Figure 7-6](#), which uses a Model 6517B Electrometer to measure ten DUTs switched by a 10-channel multiplexer card in a Model 7001/7002 Switch System.

The trigger link connections for this test system are shown in [Figure 7-7](#), trigger link of the Model 6517B is connected to trigger link of the Model 7001/7002 Switch System. Notice that only one trigger link cable is needed. For this example, the Models 6517B and 7001/7002 are configured as follows:

Model 6517B:

Idle State:

Bench reset = :INIT:CONT ON*

Arm layer:

Arm source = Immediate*

Arm count = 1*

Arm trigger control = Acceptor*

Scan layer:

Scan source = Immediate*

Scan count = Infinite*

Scan trigger control = Acceptor*

Measure layer:
 Measure source = TrigLink
 Trigger link mode = Asynchronous
 Input line = #3
 Output line = #4
 Measure count = 20
 Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Figure 7-6
DUT test system

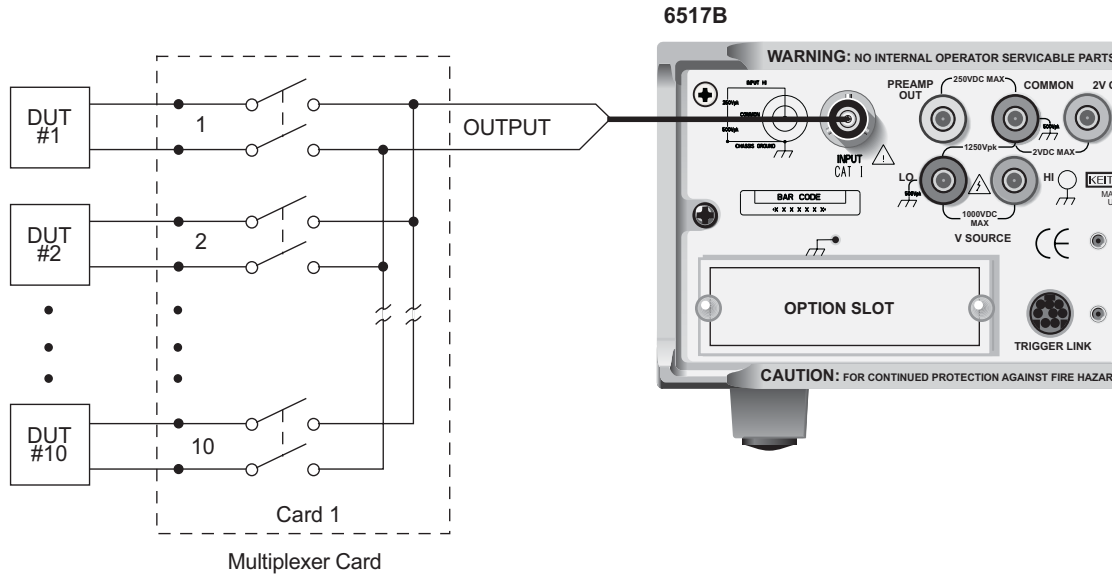
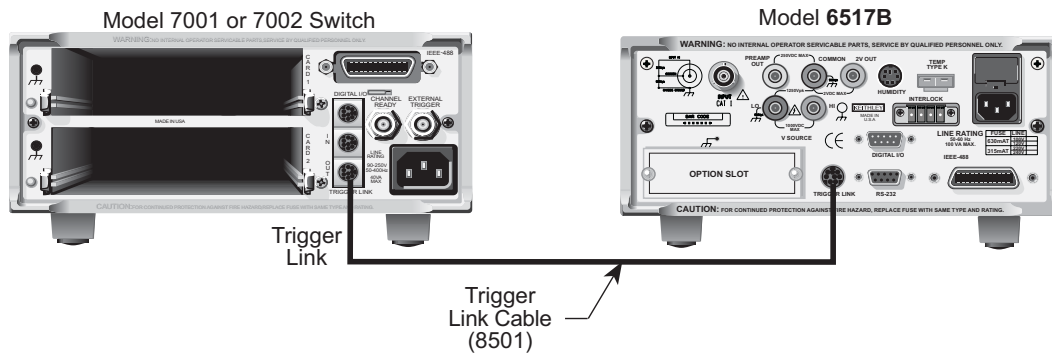


Figure 7-7
Trigger link connections (asynchronous example)



Model 7001 or 7002:

Idle State:
 Reset = :INIT:CONT OFF*
 Scan List = !11-!10,
 Arm layer:
 Arm spacing = Immediate*
 Arm count = 1*
 Arm trigger control = Acceptor*

Scan layer:

Scan spacing = Immediate*
 Number of scans = 1
 Scan trigger control = Acceptor*

Channel Layer:

Channel spacing = TrigLink
 Trigger link mode = Asynchronous
 Input line = #4
 Output line = #3
 Number of channels = 20
 Channel trigger control = source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 6517B is reset to BENCH defaults. With this selection, the electrometer stays armed. Since the arm source and scan source are set to immediate, the Model 6517B waits in the measure layer for a trigger.

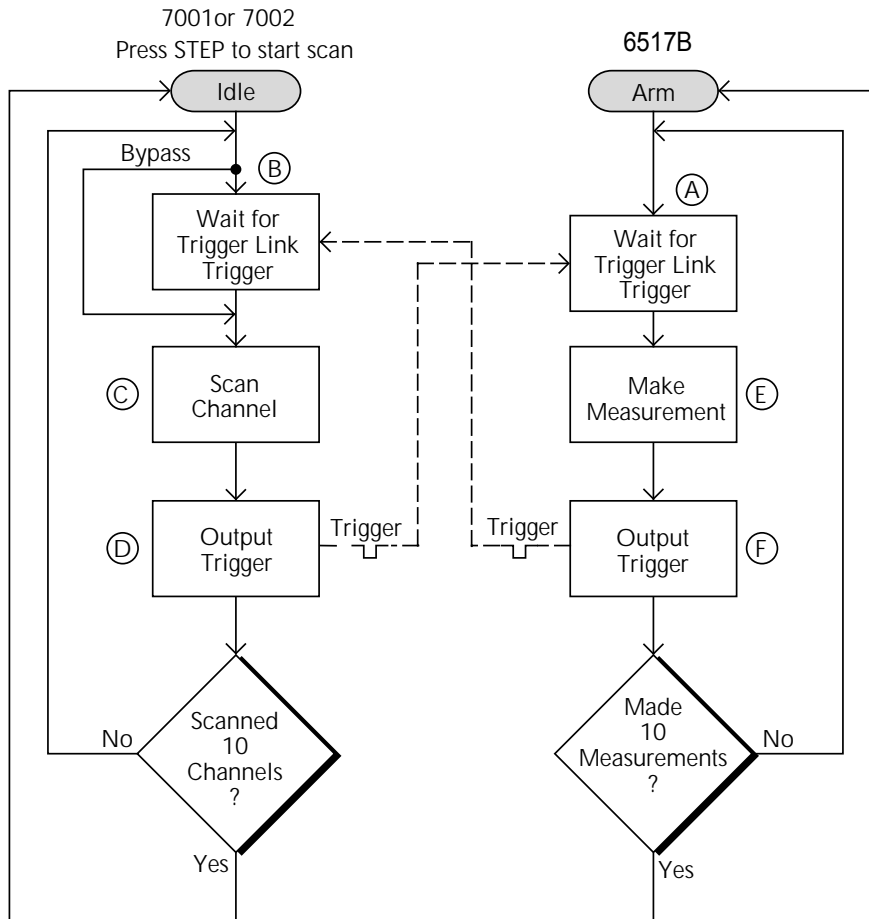
With the channel trigger control of the Model 7001/7002 set for source, scan operation initially bypasses the need for a trigger link trigger to close the first channel. Since arm spacing and scan spacing are set to Immediate, the scan starts as soon as the scanner is taken out of the idle state by pressing the **STEP** key.

To run the test and store the readings in the Model 6517B, press **STORE** on the electrometer, enter the desired number of readings (ten), and press **ENTER**. The Model 6517B waits (with the asterisk annunciator lit) for a trigger link trigger from the Model 7001/7002.

Press **STEP** on the Model/7002 to start the scan. The scanner's output pulse triggers the Model 6517B to take a reading, store it, and send a trigger pulse. The following explanation on operation is referenced to the operation model shown in [Figure 7-8](#).

- Ⓐ The BENCH RESET condition arms the Model 6517B and places electrometer operation at point A in the flowchart, where it is waiting for a trigger link trigger. Note that since both the arm layer and scan layer are programmed for immediate source, operation immediately drops down to the measure layer at point A.
- Ⓑ Pressing STEP takes the Model 7001/7002 out of the idle state and places operation at point B in the flowchart. Since both the arm layer and scan layers are programmed for immediate spacing, operation drops down to the channel layer at point B.
- Ⓒ Since channel trigger source is set to source, the scan does not wait at point B for a trigger. Instead, it bypasses "Wait for trigger link Trigger" and closes the first channel (point C). Note that the bypass is in effect only on the first pass through the model.
- Ⓓ After the relay settles, the Model 7001/7002 outputs a channel ready pulse (point D). Since the instrument is programmed to scan ten channels, operation loops back up to point B, where it waits for an input trigger. Note that bypass is no longer in effect.
- Ⓔ and Ⓕ Remember that the Model 6517B operation is at point A waiting for a trigger. The output channel ready pulse from the Model 7001/7002 triggers the electrometer to measure DUT #1 (point E). After the measurement is complete, the Model 6517B outputs a completion pulse (point F) and then loops back to point A, where it waits for another input trigger. The trigger applied to the Model 7001/7002 from the Model 6517B closes the next channel in the scan. This triggers the electrometer to measure the next DUT. The process continues until all ten channels are scanned and measured.

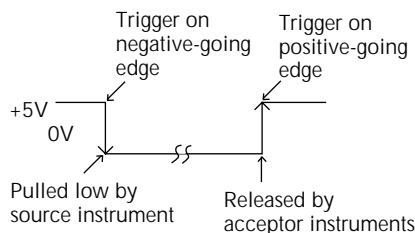
Figure 7-8
Operation model for asynchronous trigger link example



Semi-synchronous operation

In the Semi-synchronous trigger link mode, all triggering (input and output) is controlled by a single line. When the normally high (+5V) trigger line is pulled low (0V), a trigger occurs on the negative-going edge. When the trigger line is released, a trigger occurs on the positive-going edge (see Figure 7-9). The advantage of this single line trigger is that as long as one of the instruments in the system holds the line low, the trigger is suppressed. In other words, the trigger does not occur until all instruments in the system are ready.

Figure 7-9
Semi-synchronous trigger link specifications



For example, assume that a Model 6517B is connected to two Model 7001 or 7002 Switch Systems for semi-synchronous operation, as shown in Figure 7-10. All three instruments are programmed to use trigger line #1. The two Model 7001s/7002s have relay settling times of 10ms and 50ms, respectively. The Model 6517B is designated as the trigger control source and the two Model 7001/7002 units as trigger control acceptors.

Assume that the Model 6517B initially performs a measurement. After the reading is done, the Model 6517B drives the trigger line low. The negative-going edge triggers both Model 7001s/7002s to close a channel. While the Model 7001s/7002s are in the process of closing a channel, they hold the trigger line low. Ten milliseconds after switch closure, the first Model 7001/7002 releases the trigger line. However, the second Model 7001/7002 continues to hold the line low since it is not finished. Fifty milliseconds after switch closure, the second Model 7001/7002 releases the trigger line. The positive-going edge triggers the Model 6517B to make a measurement and subsequently pull the trigger line back down to close the next channels. This process continues until all channels are scanned and measured.

Semi-synchronous trigger link example

This example uses the same test system (Figure 7-6) that was used for the Asynchronous trigger link example #1. However, triggering is done using the semi-synchronous mode. Trigger link connections are shown in Figure 7-11.

Figure 7-10
Typical semi-synchronous mode connections

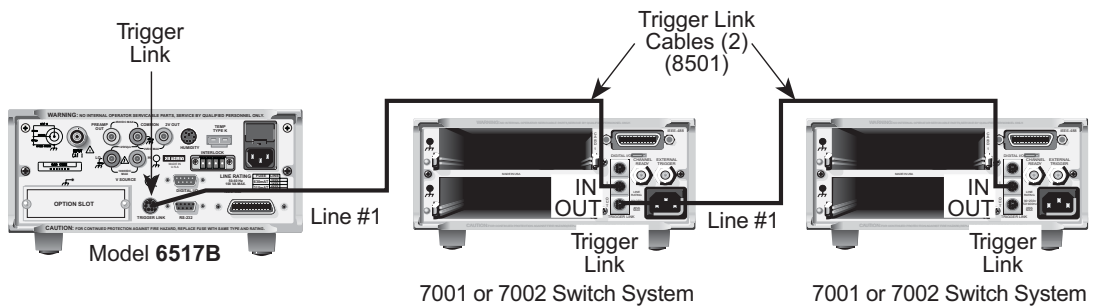
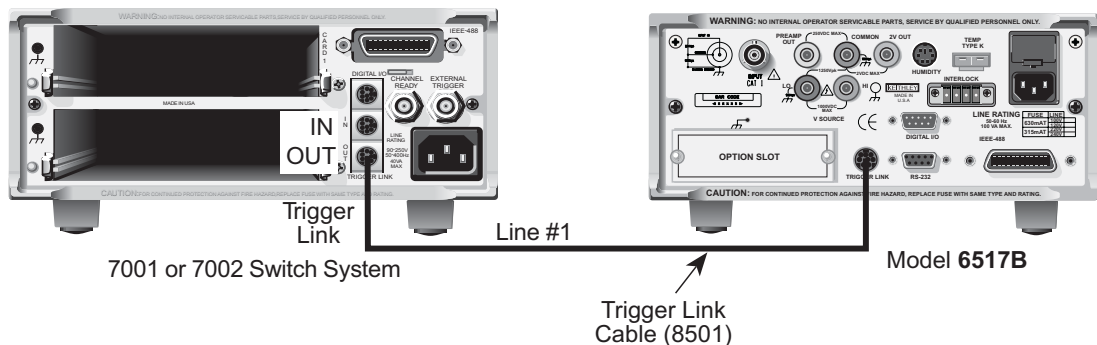


Figure 7-11
Trigger link connections (semi-synchronous example)



The two instruments are configured as follows:

Model 6517B:

Idle state:

Bench reset = :INIT:CONT ON*

Arm layer:

Arm source = Immediate*

Arm count = 1*

Arm trigger control = Acceptor*

Scan layer:

Scan source = Immediate*

Scan count = Infinite*

Scan trigger control = Acceptor*

Measure layer:

Measure source = TrigLink

Trigger link mode = Semi-synchronous

Semi-sync line = #1*

Measure count = 10

Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Model 7001 or 7002:

Idle state:

Reset = :INIT:CONT OFF*

Scan list = 1!1-1!10,

Arm layer:

Arm spacing = Immediate*

Arm count = 1*

Arm trigger control = Acceptor*

Scan layer:

Scan spacing = Immediate*

Number of scans = 1

Scan trigger control = Acceptor*

Channel layer:

Channel spacing = TrigLink

Trigger link mode = Semi-synchronous

Semi-sync line = #1

Number of channels = Use Scanlist length*

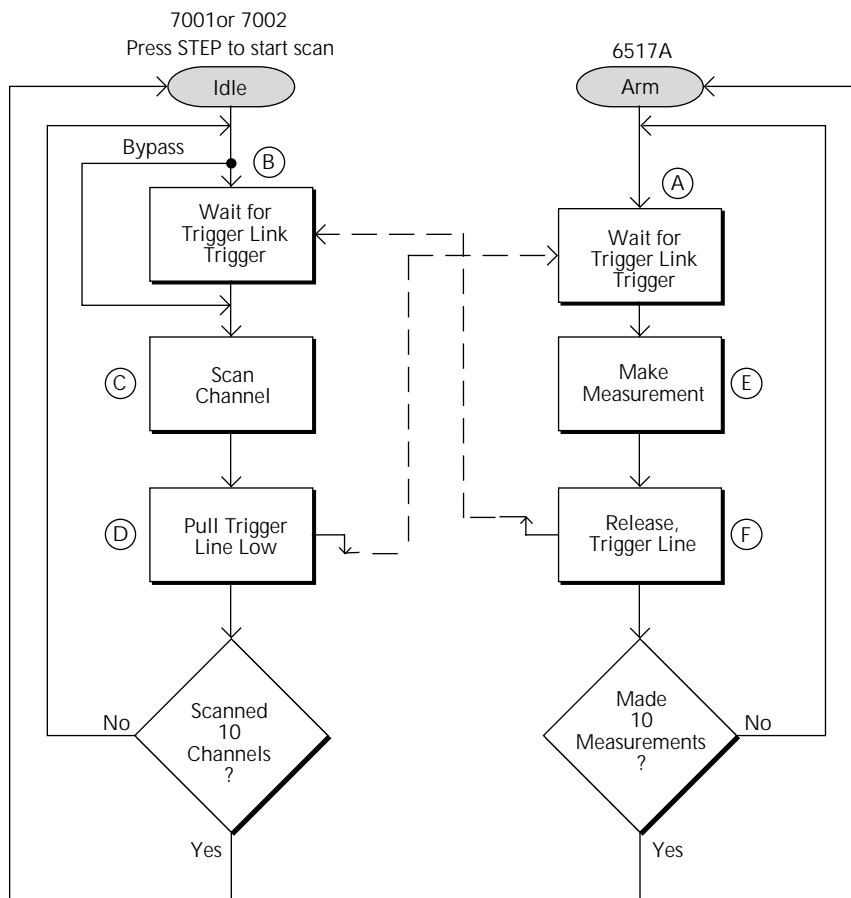
Channel trigger control = source*

* Indicates that the setting is the RESET (and factory) default condition.

To run the test and store the readings in the Model 6517B, press **STORE** on the electrometer, enter the desired number of readings (ten), and press **ENTER**. The Model 6517B waits (with the asterisk annunciator lit) for a trigger link trigger from the Model 7001/7002. Press **STEP** on the Model 7001/7002 to start the scan.

The following explanation on operation is referenced to the operation model shown in [Figure 7-12](#).

Figure 7-12
Operation model for semi-synchronous trigger link example



- (A)** The BENCH RESET condition arms the Model 6517B and places electrometer operation at point A in the flowchart, where it is waiting for a trigger link trigger. Note that since both the arm layer and scan layer are programmed for immediate source, operation immediately drops down to the measure layer at point A.
- (B)** Pressing STEP takes the Model 7001/7002 out of the idle state and places operation at point B in the flowchart. Since both the arm layer and scan layers are programmed for Immediate Spacing, operation drops down to the Channel Layer at point B.
- (C)** Since Channel Trigger source is set to source, the scan does not wait at point B for a trigger. Instead, it bypasses “Wait for Trigger Link Trigger” and closes the first channel (point C). Note that the Bypass is in effect only on the first pass through the model.
- (D)** After the relay settles, the Model 7001/7002 pulls down the trigger link trigger line (point D). Since the instrument is programmed to scan ten channels, operation loops back up to point B, where it waits for an input trigger. Note that Bypass is no longer in effect.
- (E)** and **(F)** Remember that the Model 6517B operation is at point A waiting for a trigger. When the trigger line is pulled low by the Model 7001/7002, the leading negative-going edge triggers the Model 6517B to measure DUT #1 (point E). Note that the electrometer holds the trigger line low. After the measurement is complete, The Model 6517B releases the trigger line (point F) and then loops back to point A where it waits for another input trigger.

When the Model 6517B releases the trigger line, the leading positive-going edge triggers the Model 7001/7002 to close the next channel in the scan. This pulls the trigger line low, triggering the Model 6517B to measure the next DUT. The process continues until all ten channels are scanned and measured.

In this section:

Topic	Page
Introduction	8-2
Buffer overview	8-2
Maximum readings	8-2
Data elements	8-2
Configuring data storage	8-3
Data store configuration menu	8-4
Storing and recalling readings	8-6
Buffer multiple displays	8-7

Introduction

This section discusses the buffer (data store), which can be used to store a number of readings. The following paragraphs discuss configuration of the buffer as well as recalling buffered data.

Buffer overview

Maximum readings

The Keithley Instruments Model 6517B Electrometer has a buffer to store up to 50,000 data readings.

For compatibility with the 6517A, the maximum buffer data points available when using the `:TRACe:POINts MAX` command will vary with the reading elements stored as shown in [Table 8-1](#). The Model 6517B will always allow 50,000 to be specified when using this command regardless of what elements are stored. The number of data points can be set using the front panel.

Data elements

The basic data elements include the reading, units, reading# and status (overflow or underflow). The reading# indicates the location of the reading in the buffer. In addition to these items, recalled data also includes statistical information, such as minimum, maximum, average, and standard deviation, which are part of the NEXT displays).

Optional data elements include time stamp, humidity, external temperature and channel number (for scanning). When selected, the time stamp is available on the primary display along with the reading. If a scan was performed, the channel number will also be displayed along with the reading if it was selected as a data element. Humidity and external temperature are available as a NEXT display.

Table 8-1
Maximum buffer readings

Buffer Elements					Max Buffer Size
CHANNEL	TIMESTAMP	TEMPerature	HUMIDITY	VSOURCE	
0	0	0	0	0	15847
0	0	0	1	0	11885
0	0	1	0	0	11885
0	0	1	1	0	9507
0	1	0	0	0	10564
0	1	0	1	0	8643
0	1	1	0	0	8643
0	1	1	1	0	7313
1	0	0	0	0	13583
1	0	0	1	0	10564
1	0	1	0	0	10564
1	0	1	1	0	8643
1	1	0	0	0	9507
1	1	0	1	0	7923
1	1	1	0	0	7923
1	1	1	1	0	6791
0	0	0	0	1	11885
0	0	0	1	1	9507
0	0	1	0	1	9507
0	0	1	1	1	7923
0	1	0	0	1	8643
0	1	0	1	1	7313
0	1	1	0	1	7313
0	1	1	1	1	6338
1	0	0	0	1	10564
1	0	0	1	1	8643
1	0	1	0	1	8643
1	0	1	1	1	7313
1	1	0	0	1	7923
1	1	0	1	1	6791
1	1	1	0	1	6791
1	1	1	1	1	5942

0 = N (not included)
 1 = Y (included)

NOTE These values are for compatibility with the Model 6517A when using the :TRACe:POINt:s MAXimum command. The Model 6517B always allows up to 50,000 data points to be stored in the buffer.

Configuring data storage

The data storage configuration menu is used for the following operations:

- To select the buffer control
- To clear the buffer of readings and statistics
- To specify the number of readings to store
- To specify the source of readings to be stored
- To select optional data elements

Data store configuration menu

The buffer is configured from the **CONFIG DATA STORE** menu. This menu is displayed by pressing **CONFIG** and then **STORE**.

Table 8-2
CONFIGURE DATA STORE menu structure

Menu item	Description
COUNT	Select buffer size
ENTER-COUNT	Enter number of readings to store
USE-TRIGGER-MODEL	Use (finite) measure count from trigger model
CONTROL	Select type of buffer control
FILL-AND-STOP	Fill buffer with readings and stop
PRETRIGGER	Wait for pretrigger event; store before and after readings
PERCENTAGE	Enter percentage of stored readings before trigger
READING-COUNT	Enter count of stored readings before trigger
EVENT	Select source for pretrigger event
CONTINUOUS	Store readings in buffer continuously
NEVER	Readings are not stored
CLEAR-ALL	Clear all stored readings and buffer statistics
TIMESTAMP	Configure time stamp:
TYPE	Check or change type:
RELATIVE-TIME	Reference time stamp to relative time
REAL-TIME	Reference time stamp to real-time
FORMAT	Select time stamp format:
ABSOLUTE	Reference each time stamp to the first buffer reading (relative),
DELTA	or to the time and date (real)
ELEMENTS	Reference each time stamp to the previous buffer reading
DISPLAY	Enable/disable optional data elements; time stamp, humidity, external temperature, channel and V-source
	Enable/disable storage display

COUNT

With this menu selection, you specify the number of readings to store.

ENTER-COUNT: This item allows you to specify the buffer size. The maximum buffer size is 50,000 readings.

The minimum buffer size is one reading. Note that with only one reading stored in the buffer, the buffer math operations (MIN, MAX, StdDev) may not be useful or may not return valid data.

USE-TRIGGER-MODEL: This selection lets you default to the measure count in the present trigger configuration, as long as the measure count is a finite value.

CONTROL

This menu item controls the type of data storage.

FILL-AND-STOP: This control selection fills the buffer then stops. The readings can be recalled following testing.

PRETRIGGER: This selection continuously stores readings until a user-programmed trigger event occurs. It then stores post-trigger readings. For example, with a buffer size of 100 readings, there can be 50 readings stored before the trigger event and 50 readings stored after the trigger. The

first reading after the trigger is reading zero. Pretrigger readings have reading numbers and relative time-stamps with a minus sign; post-trigger readings have reading numbers and relative time-stamps with a plus sign. After selecting PRETRIGGER, configure pretrigger control further as follows:

- **PERCENTAGE** or **READING-COUNT**: Specify the number of readings to store before the trigger event as a percentage of the total number of stored readings, or as a number of pretrigger readings. You will be prompted to enter the percentage or count value.
- **EVENT**: Selects the source of the pretrigger or “mark-point” event. This can be a Manual, GPIB, trigger link or External trigger.

CONTINUOUS: With this control selection, readings are always stored in the buffer. The process continues, with the oldest readings being overwritten in a circular manner, until storage is interrupted with the **EXIT** key.

NEVER: Gets set to this if data storage has been interrupted. Pressing the **STORE** key changes NEVER to FILL-AND-STOP.

CLEAR-ALL

This action (yes or no) can be used at any time to clear the data buffer of all stored readings and buffer statistics.

TIMESTAMP

A time stamp is included with each buffer reading if it is selected as a data element (see ELEMENTS). This menu selection is used to check and change the time stamp type and format.

TYPE: This menu item is used to check and change the time stamp type. Note that changing the time stamp type clears the buffer.

- **RELATIVE-TIME**: With this selection, time stamps are oriented to a timer with the first buffer reading time stamped at 0.000000 seconds. Each following time stamp is then based on the currently selected format (see FORMAT). With the ABSOLUTE format selected, the time stamp for each reading is referenced (in seconds) to the first buffer reading. With the DELTA format selected, each time stamp is referenced (in seconds) to the previous time stamp.
- **REAL-TIME**: With this selection, time stamps are oriented to the real-time clock and are based on the currently selected format (see FORMAT). With the ABSOLUTE format selected, each reading is simply time stamped with the actual time and date. Time can be expressed in the 12-hour (AM, PM) format or the 24-hour format.

With the DELTA format selected, the first buffer reading is time stamped at 00000d 00h 00m 00.00s (zero days, hours, minutes and seconds). Each subsequent time stamp is referenced (in days, hours, minutes and seconds) to the previous time stamp.

Time stamp type for buffer readings is coupled to time stamp type for bus readings. Thus, if you change time stamp type from this menu structure, it also changes in the MAIN MENU structure.

FORMAT: This menu item is used to check and change the time stamp format. Note that if format is changed after readings are stored in the buffer, the time stamps will change to reflect the alternate format.

ABSOLUTE: With this selection, each time stamp provides the time and date that the reading was taken (see REAL-TIME time stamp type), or the number of seconds from the first buffer reading that the reading was taken (see RELATIVE-TIME time stamp type).

DELTA: With this selection, each time stamp is referenced to the time stamp for the previous reading. This provides the time between buffer readings. Time stamps are provided in days, hours, minutes and seconds (see REAL-TIME time stamp type) or in seconds (see RELATIVE-TIME time stamp type).

ELEMENTS

Optional data elements can be included for each reading stored in the buffer. After selecting ELEMENTS, the status of each optional data element will be displayed. A “y” indicates that the element is included, while a “n” indicates that the data element is not included. To change the status of a data element, place the cursor on the data element status and press either manual RANGE key.

The optional data elements are described as follows:

Timestamp: When selected, the time stamp will be displayed on the primary display for each stored reading. The form that time stamp is displayed depends on the selected TYPE and FORMAT (see **TIMESTAMP**).

Humidity and External Temperature: When selected, these readings are included in a NEXT display. Note that the appropriate sensor has to be connected to the instrument, and it has to be enabled through the **DATA-STAMP** item of **GENERAL** menu.

Channel: When selected, the scanned channel number will be displayed on the primary display for each stored reading. Note that if a scan was not performed, a channel number will not be displayed even though it is a selected data element.

V-source: When selected, the sourced voltage level will be available as a multiple (NEXT) display.

DISPLAY

This menu item is used to enable or disable the display during the storage process.

YES: This option enables the display. When enabled, readings are displayed along with the message that indicates that readings are being stored.

NO: With this option selected, the display and front panel are disabled (“FRONT PANEL DISABLED” message displayed). This option optimizes speed and provides a more uniform interval between readings. Pressing **LOCAL** during the storage process, will return the display and front panel back to normal.

Storing and recalling readings

Table 8-3, Table 8-4, and Table 8-5 detail the sequence of steps for the various modes of buffer control. The tables assume the buffer is configured as explained previously. Note that during data storage, the reading number on the bottom line of the display is one ahead of the reading on the top line.

There are “multiple displays” available when recalling buffered readings. These are explained below.

Table 8-3
Fill-and-stop sequence

Action	Result	Annunciator
STORE ENTER	STORE 00100 READINGS Storing reading #xx of 100 Storage complete; press RECALL	(* on) (* off)
RECALL	Rdg#+00000 @Time=+000.000000 sec ...	
EXIT	Rdg#+00099 @Time=+002.700473 sec (normal reading display)	

Table 8-4
Continuous sequence

Action	Result	Annunciator
STORE ENTER	STORE 00100 READINGS Storing reading #xx of 100 100 rdgs stored; continuous ON	(* on)
RECALL	Rdg#+00000 @Time=+003.903546 sec ...	
EXIT RECALL	100 rdgs stored; continuous ON Rdg#+00000 @Time=+067.709331 sec ...	
EXIT EXIT	100 rdgs stored; continuous ON STORAGE INTERRUPTED Acquired 100 of 100 readings (normal reading display)	(* off)

Table 8-5
Pretrigger sequence

Action	Result	Annunciator
STORE ENTER TRIG	STORE 00100 READINGS Waiting for pretrigger event Storing reading #xx of 50	(* on)
RECALL	Storage complete; press RECALL Rdg#-00050 @Time=-004.999990 sec ... Rdg#+00000 @Time=+000.000000 sec ... Rdg#+00049 @Time=+004.899996 sec	(* off)
EXIT	(normal reading display)	

Note: A manual trigger is used as an example.
 Other pretrigger events include GPIB and trigger link.

Buffer multiple displays

Math operations performed on buffered readings are available when readings are recalled. Just press **NEXT DISPLAY** to view the math operation on the bottom line of front panel display, in the following order. Note that the appropriate data store element has to be selected in order to get the reading.

1. RH and ET: relative humidity and external temperature, for example:

Rdg#+00000 RH=35% ET= 23°C

Note: In order to get these readings, the appropriate sensor has to be connected to the Model 6517B, and it has to be enabled

2. V-source: V-source output, for example:

Vsource = +0001.000V

3. MAX: maximum reading in buffer, for example:

MAX=+1.635968e+00 at RDG# +00090

Notes:

- a. Display response may be slow due to calculation of statistics for large buffers
 - b. Exponents are in terms of primary units of function on top line (for example, volts, not millivolts)
4. MIN: minimum reading in buffer, for example:
MIN=+1.627611e+00 at RDG# +00012
5. Average: This math operation displays the mean value of the buffered readings, for example:

Average = +1.6345e+00

The equation used to calculate the mean is:

$$y = \frac{\sum_{i=1}^n X_i}{n}$$

Where: x_i is a stored reading, and n is the number of stored readings. Note that if $n = 0$, the result is NAN (not a number).

6. StdDev: This operation displays the standard deviation of the stored readings, for example:
StdDev = 1.4944e-03

The equation used to calculate the standard deviation is:

$$y = \sqrt{\frac{\sum_{i=1}^n X_i^2 - \frac{1}{n} \left(\sum_{i=1}^n X_i \right)^2}{n-1}}$$

Where: x_i is a stored reading, and n is the number of stored readings.

Note that if $n \leq 1$, the result is NAN (not a number). These statistics are invalid if the measurement function changed during data store (for example, when scanning different functions). The Model 6517B uses IEEE-754 floating point format for math calculations.

The last display in this series allows you to send the buffered readings to a printer.

In this section:

Topic	Page
Introduction	9-2
Filters	9-2
Digital filters	9-2
Median filter	9-3
Configuring the filters	9-5
Math	9-7
Polynomial	9-7
Percent	9-7
Percent deviation	9-8
Deviation	9-8
Ratio	9-8
Logarithmic	9-8
Selecting and configuring math	9-9
Math multiple display	9-10

Introduction

This section discusses the digital and median filters, as well as the available math functions such as polynomial and ratio.

Filters

Filtering stabilizes noisy measurements caused by noisy input signals.

The Keithley Instruments Model 6517B Electrometer uses two types of filters: digital and median. The displayed, stored, or transmitted reading is simply the result of the filtering processes. Note that both the digital and median filters can be in effect at the same time.

When FILTER is enabled, the selected filter configuration for that measurement function is in effect. Filtering is enabled by pressing the **FILTER** key (FILT annunciator turns on). Pressing **FILTER** a second time disables filter.

When FILTER is enabled, the status of the two filters will be briefly displayed. For example,

Filter Enabled

Digital = ADV(10) Median ON

The above display message indicates that the advanced filter (average 10 readings) is in effect and the median filter is on. If no digital filter is selected (NONE) and the median filter is off, the message "No Filters Selected" will be displayed. In this case, enabling FILTER has no effect on the input signal.

Filtering is performed only on primary display measurements; it has no effect on multiple displays.

NOTE When the median filter is enabled, readings from the analog to digital converter have the median filter applied first, then the results of the median filter are fed into the digital filter.

Digital filters

Digital filter types

The Model 6517B has two types of digital filters: averaging and advanced. Both types are a simple average of one to 100 reading conversions. The difference between them is the user-programmable noise "window" of the advanced filter.

The noise window, which is expressed as a percentage of range (0-100%), allows a faster response time to large signal step changes (for example, scanned readings). A reading conversion outside the plus or minus noise window fills the filter "stack" immediately.

If the noise does not exceed the selected percentage of range, the reading is based on an average of reading conversions. In this case, the advanced filter works the same as the averaging filter. If the noise does exceed the selected percentage, the reading is a single reading conversion, and new averaging starts from this point. The two filter types are compared in [Figure 9-1](#).

Digital filter modes

An additional filter parameter is the mode, either moving or repeating. A moving filter is a first-in, first-out stack, where the newest reading conversion replaces the oldest. An average of the stacked reading conversions yields a reading. Therefore, after a selected number of conversions, a moving filter gives a new reading for every new conversion.

A repeating filter takes a selected number of reading conversions, averages them, and yields a reading. It then flushes its stack and starts over. This characteristic is useful when scanning channels.

Filter modes are compared in [Figure 9-2](#).

Response time

The various filter parameters have the following effects on the time needed to display, store, or output a filtered reading:

- Filter type: The time to the first reading is the same for all filters; moving mode yields a faster reading than repeating mode. Also, advanced mode has a faster response to changes in the input signal than averaging.
- Number of reading conversions: Speed and accuracy are inversely dependent (for example, greater speed results in reduced accuracy).
- Noise window: For the advanced type, speed, accuracy, and response to input signal changes are related in the same way as speed and accuracy in the number of reading conversions.

Median filter

The median filter is used to determine the “middle-most” reading from a group of readings that are arranged according to size. For example, assume the following readings:

20V, 1V, 3V

The readings are re-arranged in an ascending order as follows:

1V, 3V, 20V

From the above readings, it can be plainly seen that 3V is the median (middle-most) reading.

The number of sample readings used for the median calculation is determined by the selected rank (1 to 5) as follows:

$$\text{Sample readings} = (2 \times R) + 1$$

Where: R is the selected rank (1 to 5)

For example, a rank of 5 will use the last 11 readings to determine the median; $(2 \times 5) + 1 = 11$.

Each new reading replaces the oldest reading, and the median is then determined from the updated sample of readings.

NOTE Because of the median filter operation, a sudden change in signal level may not immediately appear in the readings. To ensure the signal is reported correctly, at least $2 \times R$ readings need to be taken to make the reading consistent with the signal level when the median filter is enabled.

Figure 9-1
Digital filter types

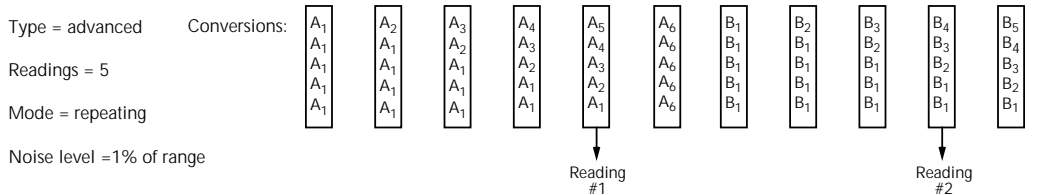
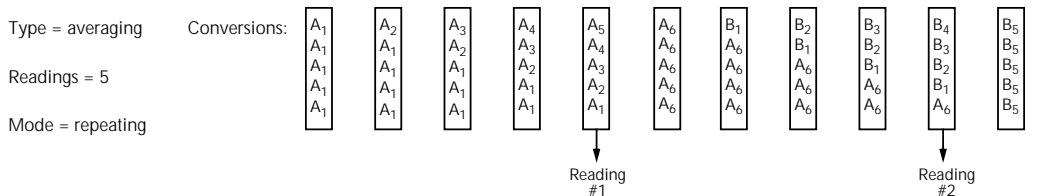
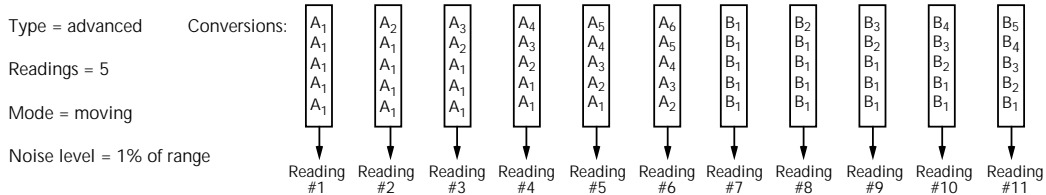
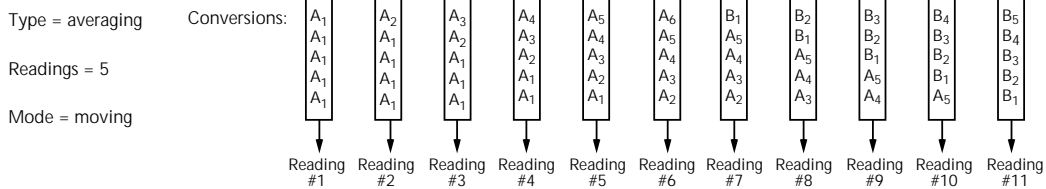
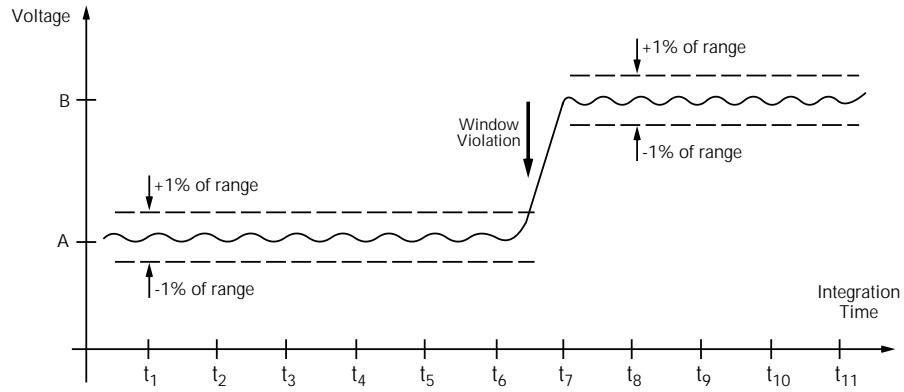
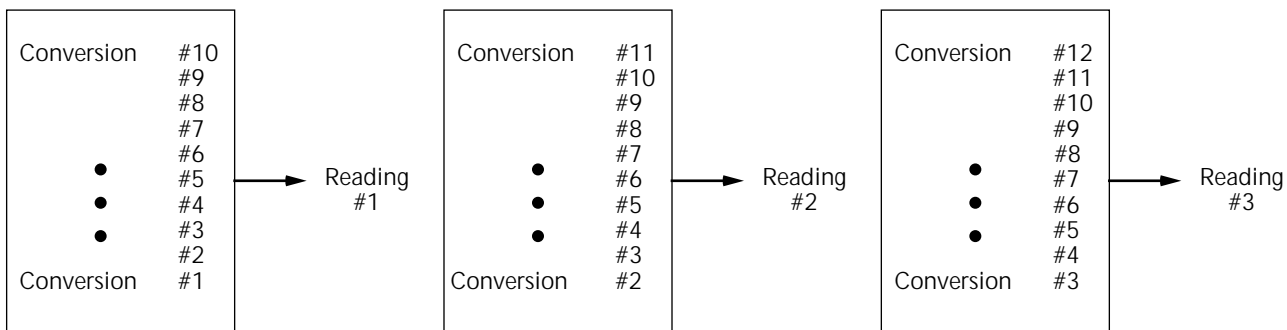
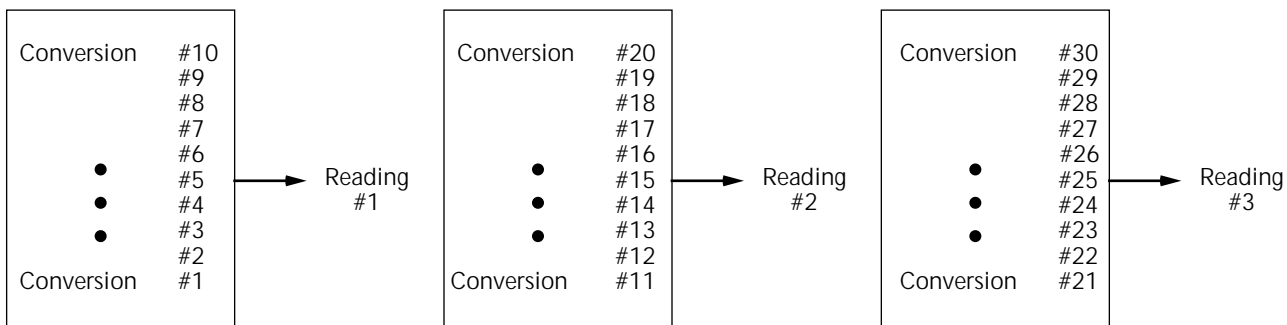


Figure 9-2
Digital filter; moving and repeating filter modes



A. Type - Average, Readings = 10, Mode - Moving



B. Type - Average, Readings = 10, Mode - Repeating

Configuring the filters

Each measurement function has its own filter configuration and is summarized in [Table 9-1](#).

Table 9-1
Filter configuration menu

Menu item	Description
FILTER	Filter menu:
AVERAGING	Configure digital averaging filter:
TYPE	Select type of average filter:
NONE	No average filtering performed
AVERAGING	Program a simple average filter (1-100 rdgs.)
ADVANCED	Program a simple average filter (1-100 rdgs.) with noise tolerance window (0-100% of range)
AVERAGING-MODE	Select moving average or repeating average mode
MEDIAN	Configure median filter:
DISABLE	Disable median filter
ENABLE	Enable median filter and specify range (1-5)

Choosing the filter parameters for each function follows the same procedure. There are three ways to display a filter configuration menu:

- To configure the filter of the present function, press **CONFIG**, then **FILTER**.
- To configure the filter of another function and remain in the present function, press **CONFIG**, then the appropriate function key, then select **FILTER** from its menu.
- To configure the filter of another function and change to that function, press **CONFIG**, then the appropriate function key, then **FILTER**.

AVERAGING

Select this menu item to configure the digital filter:

TYPE: Use to select the type of digital filter:

- **NONE**: Use this selection for no digital filtering.
- **AVERAGING**: Use this selection for a non-windowed averaging filter. A message indicating the presently set number of reading conversions to average (the “stack” size) is displayed. If you change the filter value, be sure to press **ENTER**. Note that the number of reading conversions selected for the averaging filter type is also coupled to that for the advanced filter type.
- **ADVANCED**: This selection is for an averaging filter with a noise window. A message indicating the presently set number of reading conversions to average (the “stack” size) is displayed.

You can retain the present filter value or you can key in another value. In either case, press **ENTER** to display the maximum noise window.

The displayed level is the plus or minus percentage of range window around the first reading conversion in the stack. Be sure to press **ENTER** if you key in a different percentage. Note that the number of reading conversions (filter value) selected for the advanced filter is also coupled to that for the averaging filter.

AVERAGING-MODE: This selection determines the mode of an average filter for a measurement function, either a moving or repeating average:

- **MOVING**: This item selects a moving filter, where a new reading conversion is shifted into a stack as the oldest conversion is shifted out (FIFO). When the stack is full, a simple average is taken to yield a reading.
- **REPEAT**: This menu item selects a repeating filter, where an average of a selected number of reading conversions is taken for each reading.

MEDIAN

Use this selection to enable or disable the median filter.

DISABLE: Use this selection to disable the median filter.

ENABLE: Use this selection to enable the median filter and specify the rank. If you change the rank, be sure to press **ENTER**.

Math

Model 6517B math operations are divided into three categories:

- Math performed on single readings (polynomial, percent, percent deviation ratio and logarithmic).
- Math performed on buffered readings (maximum and minimum values, average, and standard deviation).
- Math performed on single readings as a part of a pass/fail limits test.

The first category is configured from the CONFIGURE MATH menu and is described in this paragraph. Math operations on buffered readings are available in multiple displays of recalled data.

Note that once enabled for a function, the CONFIGURE MATH calculations are in effect across function changes. The Model 6517B uses IEEE-754 floating-point format for math calculations.

Polynomial

This math operation allows you to mathematically manipulate normal display readings (X) according to the following polynomial calculation:

$$Y = (a2)X^2 + (a1)X + (a0)$$

Where: X is the normal display reading
 a2, a1, and a0 are user-entered constants
 Y is the displayed result

The value of the a2, a1, and a0 constants can be changed through the CONFIGURE MATH menu. The before and after calculation can be viewed with one of the multiple displays. When necessary, the resulting Y value is displayed in scientific notation.

Percent

This operation lets you specify a target reading value. The displayed reading will be expressed as a percentage of the target value, often in scientific notation. The percentage calculation is performed as follows:

$$\text{Percent} = \frac{\text{Input Reading}}{\text{Target Value}} \times 100$$

As an example, consider the default target value for percentage calculations, where:

$$100\% = +1.000000e+00$$

Therefore, a 1V input would be 100% of the target value and a typical reading would be displayed as follows:

+100.000 V%

With the calculate multiple display selected, the display would be:

+100.000 V%

Reading = +1.00000

The bottom line displays the reading (in the units and multiplier prefix of the top line) before the percentage calculation is performed.

Percent deviation

The following math calculation provides the percent deviation between the normal display reading and the user specified reference value:

$$\%Dev = \frac{(X-Y)}{Y} \times 100$$

Where: X is the normal display reading
Y is the specified reference value

Percent Deviation is enabled through the CONFIGURE MATH menu.

Deviation

The following math calculation provides the deviation between the normal display reading and the user specified reference value:

$$Deviation = \frac{(X-Y)}{Y}$$

Where: X is the normal display reading
Y is the specified reference value

Deviation is enabled through the CONFIGURE MATH menu.

Ratio

The following calculation divides the normal display reading by the user specified reference value:

$$Ratio = \frac{X}{Y}$$

Where: X is the normal display reading
Y is the specified reference value

Ratio is enabled through the CONFIGURE MATH menu.

Logarithmic

This calculation converts input readings to logarithmic base 10 values. The calculation is shown as follows:

$$\log_{10} X = Y$$

Where: X is the input reading
Y is the logarithmic result

Example: Assume that exactly 1mA is being measured by the Model 6517B.

$$\log_{10} 1.000000mA = -3$$

Note that this calculation uses the absolute value of the normal input reading since you cannot compute the log of a negative number.

Selecting and configuring math

The polynomial, percent ratio, percent deviation, or logarithmic calculation is selected and configured from the CONFIGURE MATH menu (see [Table 9-2](#)). The selected calculation is enabled by pressing the **MATH** key (MATH annunciator turns on). The Model 6517B then displays the result of the calculation, using scientific notation where necessary. The following display messages indicate which math calculation is being used:

NONE	No calculation selected
POLY	Polynomial
%	Percent calculation selected
%DEV	Percent deviation calculation selected
DEV	Deviation calculation selected
RAT	Ratio calculation selected
LOG	Logarithmic calculation selected

Pressing **MATH** a second time disables the calculation.

Table 9-2
CONFIGURE MATH menu structure

Menu item	Description
None	Select no calculation when MATH key is pressed
Polynomial	Select polynomial calculation and enter constants
Percent	Select percent calculation and enter target (reference) value
%DEV	Select percent deviation calculation and enter reference value
DEVIATION	Select deviation calculation and enter reference value
Ratio	Select ratio calculation and enter reference value
Log10	Select logarithmic base 10 calculation

NONE

With this menu item, no math operation goes into effect when the MATH key is pressed. The MATH annunciator lights, but NONE is displayed on the top line.

POLYNOMIAL

This menu item selects the polynomial calculation and allows you to program the polynomial constants. The “a2” constant is displayed first. You can retain the displayed value or key in a new value. In either case, press **ENTER** to display the “a1” constant. Retain or change this constant and press **ENTER** to display the “a0” constant. If you change the “a0” constant, be sure to press **ENTER** again.

PERCENT

This menu item selects the percent calculation and lets you specify the target value. If you key in a new target value, be sure to press **ENTER**.

%DEV

This menu item selects the percent deviation calculation and lets you specify the reference value. If you key in a new reference, be sure to press **ENTER**.

DEVIATION

This menu item selects the deviation calculation and lets you specify the reference value. If you key in a new reference, be sure to press **ENTER**.

RATIO

This menu item selects the ratio calculation and lets you specify the reference value. If you key in a new reference, be sure to press **ENTER**.

LOG10

This menu item selects the logarithmic base 10 calculation. When MATH is enabled, the absolute value of the input reading will be converted to its log base 10 equivalent and displayed.

Math multiple display

One of the multiple displays lets you view the reading on the bottom line of the display and the result of the calculation on the top line. This display is available by repeatedly pressing either the **NEXT** or **PREV DISPLAY** key to scroll through the multiple displays for the particular function. The following is a typical message for a percentage calculation:

-7.04310e+01 V%

Reading = -0.704310

The display resolution on the bottom line follows that chosen for the top line. The value on the bottom line tracks the units and prefix of the top line (for example, if the top line displays μA , then the units on the bottom line are μA).

Limits, Digital I/O, and Scanning

In this section:

Topic	Page
Introduction	10-2
Limits	10-2
Setting limits	10-2
Strobe control	10-4
Pass pattern	10-4
Limits example	10-4
Digital I/O	10-5
Digital I/O menu	10-5
Digital I/O port	10-6
Scanning	10-9
Internal scanning	10-9
External scanning	10-9

Introduction

This section discusses limits tests, use of the digital I/O port, and internal and external scanning with the Keithley Instruments Model 6517B Electrometer.

Limits

Limit testing is available through the **LIMITS** menu, which is part of the main **MENU** (see *Menu* in [Section 2](#) for more information).

The LIMITS menu is used for the following operations:

- To set and control the limit values that determine the PASS/FAIL and HI/LO status of subsequent measurements
- To set the digital output patterns that signify passing or failing limit checks
- To enable/disable a binning strobe signal on digital output #4 for triggering a user-supplied device handler

Since the logic sense of the digital output lines is programmable (high-true or low-true), this discussion of limits uses the logical terms TRUE/FALSE and ON/OFF, rather than HIGH and LOW.

There are two sets of limits, each with high and low limit values. You can program and enable one or both limit sets. With both sets enabled, the values can overlap of one set can be included in the other. The only restriction is that, within the same set, the high limit must be greater than the low limit for a valid test.

The limit test is performed after MATH operations. Unit prefixes are applied before the limit test, for example:

- Low Limit = -10.0, High limit = 10.0. A 1.5V reading passes (PASS)
- Low Limit = -10.0, High limit = 10.0. A 0.6M Ω reading equals 600,000 (FAIL)

Limit set #1 is available as a multiple display, which shows a bar graph and a pass/fail indication for the measurements. While the limits bar graph is displayed, the programmed values for limit set #1 can be viewed by pressing **INFO**.

The digital output lines can be programmed to reflect the results of limit tests. The first test that fails sets a programmable digital output pattern, where the test execution order is LOW1, HIGH1, LOW2, HIGH2. If all tests pass, another programmable pattern is set.

Setting limits

Limits are controlled with the LIMIT-SET-1 and LIMIT-SET-2 selections. These menu items are similar in that you can enable or disable either or both limit sets, and program the high and low limit values for either or both limit sets.

The options for these menu items are explained as follows:

CONTROL: This enables or disables control of the digital output lines by the results of either or both limit set tests. For example, to let limit set #1 control the digital output lines, highlight the **CONTROL** item in the previous menu and press **ENTER**. Then highlight the **ENABLE** item in the next menu and press **ENTER**. The instrument returns to the LIMIT SET #1 MENU.

LOLIM1, HILIM1, LOLIM2, HILIM2: These items allow you to set values for the low and high limits, and the action performed on the digital output lines for each limit test failure. After selecting a limit, the value for that limit will be displayed. To change the limit, use the cursor keys (**◀** and **▶**) and the **RANGE** keys (**△** and **▽**) to display the desired value. Note that you must enter values in scientific notation.

Press **ENTER** to select your value and display the next menu, which selects the digital output action to be taken if the selected limit is the first limit to be exceeded. The digital outputs can be toggled between **ON** and **OFF** with the **RANGE** keys (Δ and ∇).

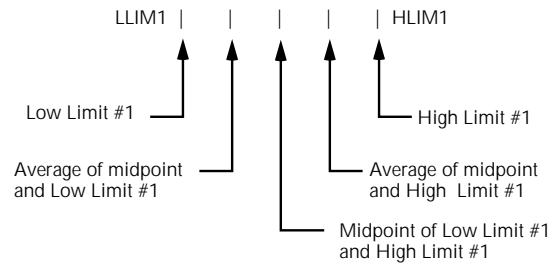
Each measurement function has a multiple display for the limits bar graph. It shows a pass/fail indication and a graphical representation of the reading compared to limit set #1. If Low Limit #1 is less than high limit #1, you will see a display similar to that shown in [Figure 10-1](#).

Note that the Model 6517B does not check the validity of the high and low limit values when you enter them. If Low Limit #1 is greater than or equal to high limit #1, the following message is shown on the bottom line of the limits bar graph next display:

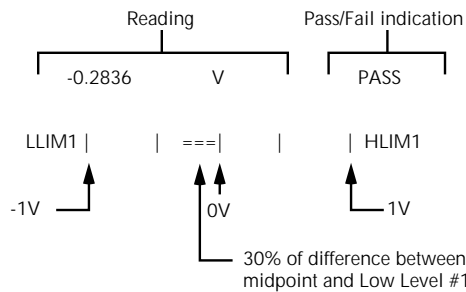
No bar graph: LLIM1 >= HLIM1

The programmed values for limit set #1 are shown by pressing the **INFO** key from the limits bar graph next display.

Figure 10-1
Limits bar graph example



A. Defined points of display



- NOTES :**
1. Press INFO to view the programmed Low Limit #1 and High Limit #1 values.
 2. Multiple display of limit values do not use unit prefixes (i.e., volts not millivolts).

B. Example Display with Limits = ±1V

Strobe control

Strobe control is selected with the **STROBE-CONTROL** menu item, which enables or disables the use of digital output #4 as a binning strobe signal. If enabled, the strobe signal is set TRUE for greater than 10 microseconds after all limit tests have been performed on a new reading. The FALSE to TRUE transition can be used to trigger an external device handler to check digital outputs #1-3 for sorting parts into bins.

When external device handler “binning” is enabled from the front panel or with the bus command :CALCulate3:BSTRobe:STATE ON, the binning strobe signal is set to **FALSE**. When “binning” is disabled, the strobe signal is left unchanged.

DISABLED: Use this selection to disable strobe control.

ENABLED: Use this selection to enable strobe control.

Pass pattern

The **PASS-PATTERN** menu item allows you to program the on/off states of the digital output lines for when all limit tests pass. Note that when the binning strobe is enabled, digital output line #4 cannot be used.

Selecting **PASS-PATTERN** displays the digital output pattern that occurs when all limit tests pass. To change the pattern, use the cursor keys (◀ and ▶) and the **RANGE** keys (△ and ▽). The **RANGE** keys toggle the parameter values between **OFF** and **ON**.

Limits example

This example sorts a quantity of 100kΩ resistors into five “bins,” according to the following tolerances:

- Values less than 90kΩ (outside -10% tolerance)
- Values greater than 110kΩ (outside +10% tolerance)
- Values between 90kΩ and 99kΩ (meets -10% tolerance)
- Values between 101kΩ and 110kΩ (meets +10% tolerance)
- Values between 99kΩ and 101kΩ (meets ±1% tolerance)

The desired test is shown in [Figure 10-2](#). Use the following procedure to program the limits:

1. From the LIMITS menu, set the limit values and actions according to [Table 10-1](#).

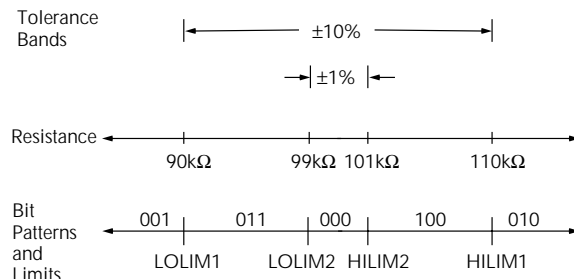
Table 10-1
Limit Values

Limit	Value	Action
LOLIM1	90kΩ	DIGOUT1=ON, others OFF
HILIM1	110kΩ	DIGOUT2=ON, others OFF
LOLIM2	99kΩ	DIGOUT1=ON, DIGOUT2=ON, others OFF
HILIM2	101kΩ	DIGOUT3=ON, others OFF

2. Enable the binning strobe signal from the STROBE-CONTROL item of the LIMITS menu.
3. Set a pass pattern of all lines off from the PASS PATTERN item of the LIMITS menu.
4. Enable the control of the digital output lines by limit set #1 and limit set #2 from the LIMIT SET #1 and LIMIT SET #2 menus. This sets the digital output lines to the “pass pattern” (all OFF in this example). Since binning is enabled, digital output #4 is also OFF.

Note that the actual state (high or low) of the digital output lines depends on the polarity (ACTIVE-HIGH or ACTIVE-LOW). This is programmed from the DIGOUT selection of the GENERAL menu (see *Digital I/O* below).

Figure 10-2
Using limit test to sort 100kΩ resistors



Digital I/O

Digital I/O menu

Access the DIGOUT menu as follows:

1. From the main menu, select **GENERAL** (see *Menu* in [Section 2](#) for more information).
2. Use the cursor keys to highlight **DIGOUT**, and press **ENTER**. The following will be displayed:

```
DIGOUT
STATE LOGIC-SENSE
```

DIGOUT menu items

The DIGOUT menu is used to configure the following operations:

- Check or change the STATE (ON or OFF) of the four digital output lines
- Check or change the LOGIC-SENSE of the digital output lines; the logic sense can be active-high (ON = +5V) or active-low (ON = 0V).

STATE: Use this menu item to check or change the state (ON or OFF) of the four digital output lines. The actual level of an “on” line is determined by the sense, which is controlled by the next menu item (LOGIC-SENSE).

The state (ON or OFF) of a digital output line is changed by placing the cursor on the desired line and pressing the manual **RANGE** (Δ and ∇) keys. These keys simply toggle the state. With the lines configured as desired, press **ENTER**.

LOGIC-SENSE: Use this menu item to check or change the sense of the digital output lines. The sense of each line can be active-high (ON = +5V) or active-low (ON = 0V). When LOGIC-SENSE is selected, you will be prompted to select the desired output line:

- TTL1, TTL2, TTL3, or TTL4: Selects the digital output line and displays the following options:

ACTIVE-HIGH: Use this option to set the sense of the selected output line to active-high.

ACTIVE-LOW: Use this option to set the sense of the selected output line to active-low.

To check or change output sense, place the cursor on the appropriate line and press **ENTER**. Cursor position indicates the present logic sense for the selected line (ACTIVE-HIGH or ACTIVE-LOW). To change the sense, place the cursor on the alternate selection and press **ENTER**.

Digital I/O port

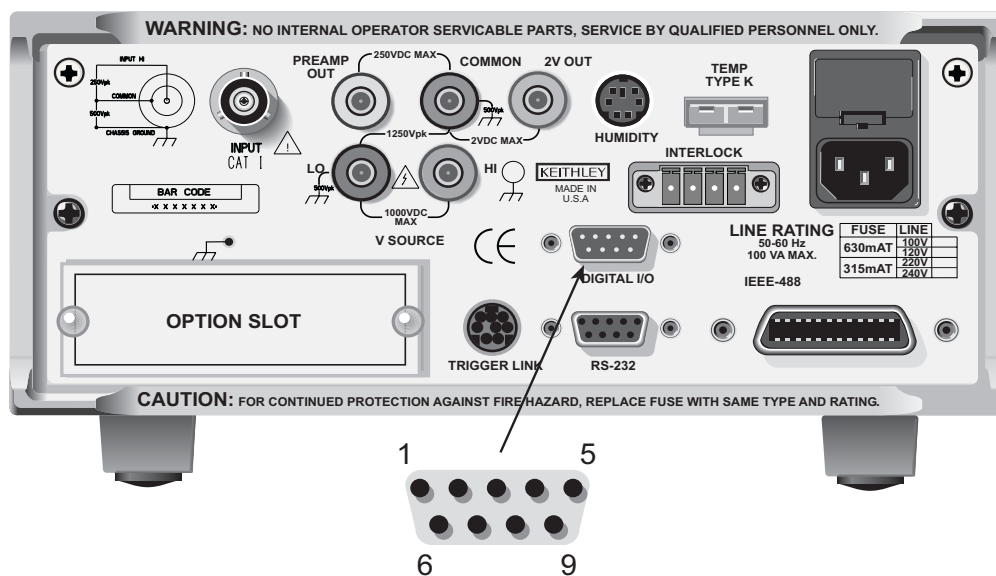
The Digital I/O port is a male DB-9 connector located on the rear panel. The port's location and pin designations are shown in [Figure 10-3](#).

The Digital I/O port can be used to control external circuitry. The port provides four output lines and one input line (input line is for calibration use only). Each open-collector output can be set high (+5V) or low (0V) and will sink up to 100mA. The four output lines can also operate external supplies from +5V to +30V.

Use the DIGITAL I/O Menu to select the following options:

- STATE: ON or OFF selectable for each output line (1 through 4); use to check or change the output state
- LOGIC-SENSE: ACTIVE-HIGH or ACTIVE-LOW selectable for each output line (TTL1 through TTL4); use to check or change the output sense

Figure 10-3
Digital I/O port



- 1 = Digital Output #1
- 2 = Digital Output #2
- 3 = Digital Output #3
- 4 = Digital Output #4
- 5 = Ground
- 6 = Calibration Input
- 7 = +5V
- 8 = Not Used
- 9 = Ground

Controlling digital circuitry

Each of the four digital open-collector outputs includes a built-in pull up resistor to +5V. The output transistor is capable of sinking up to 100mA from voltages up to +30V. The outputs can be controlled independently or tied to one of four limit values (two high, two low).

External voltage supply

Each output can be operated from external voltage supplies (voltage range from +5V to +30V applied through the external device being driven). Refer to [Figure 10-4](#) for a simplified schematic of the digital I/O. The high current sink capacity of the output driver allows direct control of relays, solenoids, and lamps (no additional circuitry needed). Each output channel contains a fly-back diode for protection when switching inductive loads (such as a low power solenoid or relay coils). To use these fly-back diodes, connect the external supply voltage to pin 3 of the digital I/O port. Make sure the external supply voltage is between +5V and +30V and the current required by the device does not exceed 100mA.

CAUTION Do not apply more than 100mA maximum current or exceed +30V maximum voltage on pin 3 of the digital I/O port. Applying current or voltage exceeding these limits may damage the instrument.

An externally powered relay connected to the digital output port is shown in [Figure 10-5](#). Other externally powered devices can be similarly connected by replacing the relay with the device. When using the Model 6517B's collector outputs to activate externally powered devices, set the corresponding digital output line parameters as follows (set through the **GENERAL/DIGITAL I/O** menus):

STATE=ON

LOGIC-SENSE=ACTIVE-LOW

In the low state (0V), the output transistor sinks current through the external device. In the high state, the output transistor is off (transistor switch is open). This interrupts current flow through the external device. Most applications use active-low (ON=0V) LOGIC-SENSE. Use the LOGIC-SENSE menu to check or change the sense of each digital output lines (refer to the LOGIC-SENSE section of this paragraph).

Outputs used as logic inputs

To use the digital outputs as logic inputs to active TTL, Low-power TTL, or CMOS inputs:

1. Connect the Model 6517B digital outputs to the logic inputs.
2. Connect the digital grounds.
3. Using the **STATE** menu, check output state setting of the Model 6517B output lines. The **STATE** value for each output used should be **ON**.
4. Using the **LOGIC-SENSE** menu, check the logic-sense setting of the Model 6517B output lines (TTL1 through TTL4). Make sure the correct LOGIC-SENSE value is selected for each output line. The LOGIC-SENSE value varies according to the type of TTL, Low-power TTL, or CMOS inputs used (ACTIVE-HIGH or ACTIVE-LOW).

When output is low (0V), the output sink can drive at least 10 standard TTL inputs. When output is high (+5V), the 10k Ω pull-up resistor will source >100 μ A while remaining at a >3.75V output (a reliable logic high). If any LIMITS control is enabled (LOLIM1 or 2, HILIM1 or 2, High, Low, or Pass), the **OUTPUT-STATE** menu does not check or change the output status.

Figure 10-4
Digital I/O schematic

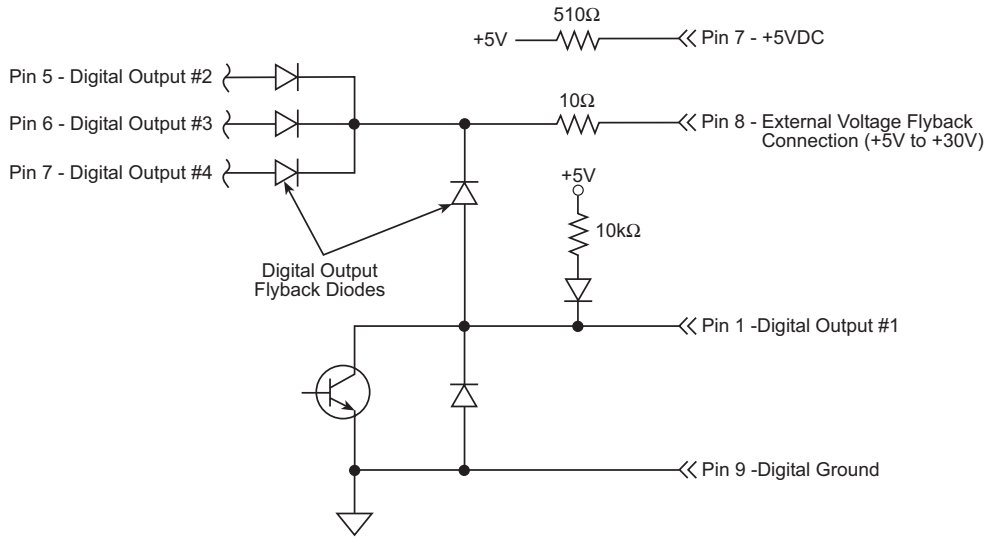
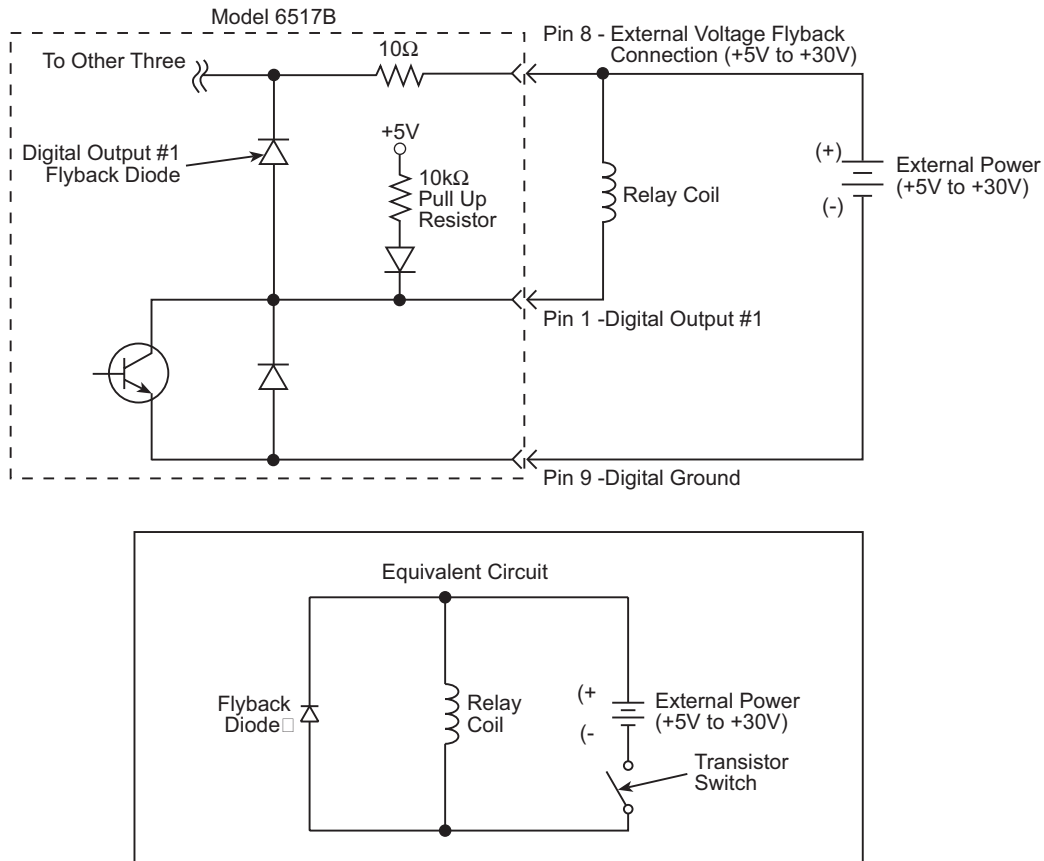


Figure 10-5
Digital I/O external relay control



Scanning

The Model 6517B can be used with an internal scanner card (for example, Keithley Instruments Models 6521 or 6522), or with external scanner cards installed in switching mainframes such as Keithley Instruments Models 7001 and 7002.

A scanner allows you to switch among a number of input signals to the Model 6517B for measurement. The channel control and scanning capabilities depend on whether an internal or external scanner card is being used, as well as on the capabilities of the scanner card in question.

Internal scanning

By installing one of the optional scanner cards in the rear panel option slot, the Model 6517B can close and open individual channels, or scan through the channels.

Detailed operating instructions for internal scanning are provided in the instruction manual for that particular scanner card. To use the Model 6521 scanner card, refer to the Model 6521/6522 Instruction Manual for operating information.

External scanning

When using external scanning, you can configure the Model 6517B to measure up to 400 channels. In order to synchronize Model 6517B measurements with external channel closure, connect the Model 6517B trigger link to the external switching mainframe trigger link (see [Section 7](#)).

Use the following information to configure the Model 6517B for external scanning, and to start the external scan. Refer to the documentation supplied with the switching mainframe and the scanner card for specific configuration and connection information.

The following procedure uses menu structures to configure the instrument for external scanning.

1. Set up the Model 6517B for the desired measurement (for example, set function, range, etc.). If there is no card installed in the option slot of the Model 6517B, external scanning will automatically be selected. If there is a card installed in the option slot, you will have to select external scanning as explained in the following step:
2. Press **CONFIG** and then **CARD**, and perform step a or b.
 - a. Option slot empty: You will be prompted to specify the number of external channels (inputs) to scan. After entering the value, press **ENTER**.
 - b. Card installed in option slot: Select the **EXTERNAL-INPUTS (CHANNELS)** option from the menu and then specify the number of external channels (inputs) to scan. After entering the value, press **ENTER**. Use the **EXIT** key to back out of the menu structure.
3. Press the **CARD** key and perform step a or b.
 - a. Option slot empty: The displayed message will prompt you to reset the external scanner. Press **ENTER** when ready.
 - b. Card installed in option slot: Select the **PERFORM-SCAN** option from the menu and select **EXTERNAL** scanning. The **CHANNEL-CLOSURES** option is used to open/close channels on the scanner card installed in the option slot. For details, see the instruction manual for that card. The displayed message will prompt you to reset the external scanner. Press **ENTER** when ready.
4. The next message will prompt you to set the channel count (CHAN COUNT) of the external scanner to infinite. Press **ENTER** when ready.

5. The next message will prompt you to select the trigger source for the Model 6517B:

```
SELECT TRIG SOURCE
TRIGLINK  EXTERNAL  TIMER  GPIB
MANUAL    IMMEDIATE
```

These trigger sources are explained in [Section 7](#).

6. The next message will prompt you to set the external scanner to the trigger source that you selected in step 5 for the Model 6517B. Press **ENTER** when ready.
7. The next message will prompt you to set the scan list of the external scanner for the appropriate number of channels. This is the same number of external inputs that was specified in step 2. Press **ENTER** when ready.
8. The next message will prompt you to **STEP** the external scanner to the first channel. Press **ENTER** when ready.
9. The next message will prompt you to set the scan count for the Model 6517B. The scan count specifies how many times you wish to repeat the scan. For example, if the scan list has 40 channels, and the scan count is 5, then 40 channels will be scanned five times. Press **ENTER** when ready.
10. The next message will ask if you wish to use the scan timer of the Model 6517B. If you selected **TIMER** as the trigger source in step 5, select **YES**. You will then be prompted to enter the interval between triggers (0.001 second to 999999.999 seconds). Otherwise, select **NO**.
11. The next message will ask if you wish to store the readings in the buffer. If you select **YES**, the number of readings that will be stored in the buffer will be displayed. Note that the buffer size is limited (see [Section 8](#) for details).
12. The last message prompts you to start the external scan by pressing **ENTER**. The selected trigger source will control the scan. Note that the **TRIG** key is always active to allow you to step through the scan.

In this section:

Topic	Page
Introduction	11-2
Standards	11-2
RS-232 serial port	11-2
Connections	11-2
IEEE-488 bus connections	11-2
RS-232 interface connections	11-4
Selecting interface parameters	11-4
Communication menu	11-4
GPIB primary address selection	11-5
General bus commands	11-6
REN (remote enable)	11-6
IFC (interface clear)	11-6
LLO (local lockout)	11-7
GTL (go to local)	11-7
DCL (device clear)	11-7
SDC (selective device clear)	11-7
GET (group execute trigger)	11-7
SPE, SPD (serial polling)	11-7
IEEE-488 front panel operation	11-7
Error and status messages	11-8
IEEE-488 status indicators	11-8
LOCAL key	11-8
Programming syntax	11-8
Command words	11-8
Program messages	11-11
Response messages	11-13
Message exchange protocol	11-13
IEEE-488 trigger model	11-14
Idle and initiate	11-14
Trigger model layers	11-14
RS-232 serial interface	11-17
RS-232 Interface configuration	11-17
RS-232 operating considerations	11-18
Error messages	11-19

Introduction

The IEEE-488 is an instrumentation data bus with hardware and programming standards originally adopted by the Institute of Electrical and Electronic Engineers (IEEE) in 1975 and given the IEEE-488 designation. In 1978 and 1987, the standards were upgraded to IEEE-488-1978 and IEEE-488.1-1987, respectively. The Keithley Instruments Model 6517B Electrometer conforms to these standards.

Standards

The Model 6517B conforms to the IEEE-488.2-1987 standard and the SCPI 1996 (Standard Commands for Programmable Instruments) standard. IEEE-488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, what registers should exist to record the state of the instrument, and a group of common commands. The SCPI standard defines a command language protocol. It goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of an instrument.

RS-232 serial port

The Model 6517B has a serial port that can be used as an alternative to the parallel IEEE-488 bus. All commands, except DDCs, can be used over this serial port. The serial port is based on the electrical and mechanical characteristics of the RS-232-C standard. Typically, the serial port is used with a controller that cannot accommodate an IEEE-488 bus interface, such as a notebook computer.

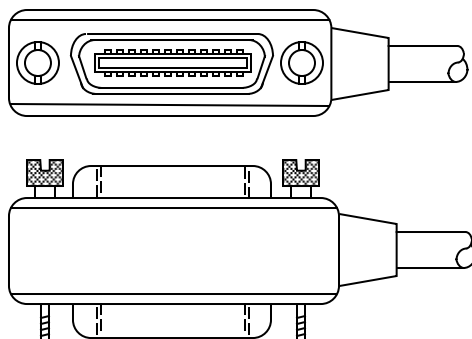
Connections

The following information shows how to make connections using the IEEE-488 bus or the RS-232 serial port.

IEEE-488 bus connections

The Model 6517B can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example is shown in [Figure 11-1](#). The connector can be stacked to allow a number parallel connections to one instrument. Two screws are located on each connector to ensure that connections remain secure.

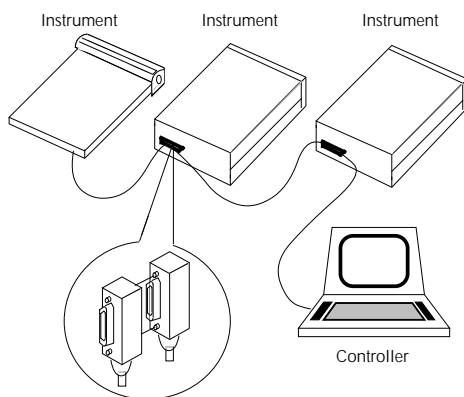
Figure 11-1
IEEE-488 connector



A typical connecting scheme for a multi-unit test system is shown in [Figure 11-2](#). Although any number of connectors could theoretically be stacked on one instrument, it is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage.

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. Keithley Instruments Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley Instruments.

Figure 11-2
IEEE-488 connections

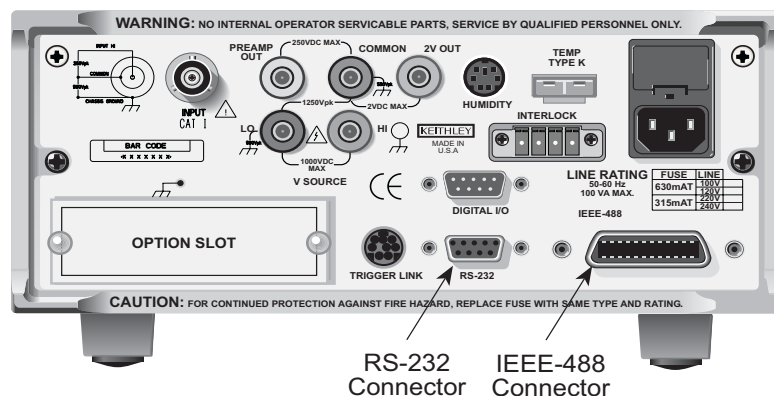


Connect the Model 6517B to the IEEE-488 bus as follows:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so that it will fit only one way. [Figure 11-3](#) shows the location of the IEEE-488 connector on the instrument.
2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments, as required.
4. Make certain that the other end of the cable is properly connected to the controller. Most controllers are equipped with an IEEE-488 style connector, but a few may require a different type of connecting cable. Consult the instruction manual for your controller for the proper connecting method.

Note that the IEEE-488 bus is limited to a maximum of 15 devices, including the controller. The maximum cable length is 20 meters, or two meters times the number of devices, whichever is less. Failure to observe these limits may result in erratic bus operation.

Figure 11-3
IEEE-488 and RS-232 connector locations

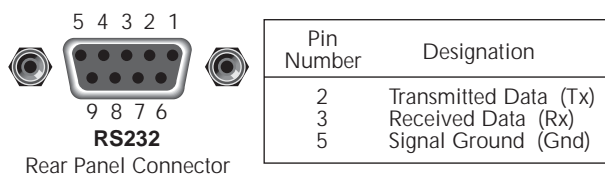


RS-232 interface connections

The serial port of the Model 6517B can be connected to the serial port of a computer or listening device (for example, a serial printer) using an RS-232 cable terminated with DB-9 connectors. The serial port uses the transmit (Tx), receive (Rx), and signal ground (Gnd) lines of the RS-232 standard. Figure 11-4 shows the rear panel connector along with pin numbering and designations.

If your computer uses a DB-25 connector for the RS-232 interface, you will need a cable or an adapter with a DB-25 connector on one end and a DB-9 connector on the other, wired straight-through (not null modem).

Figure 11-4
RS-232 interface connector



Selecting interface parameters

Communication menu

The **COMMUNICATION** menu option allows you to select and configure the GPIB or RS-232 bus. Use the **MENU** key to access this menu option (see *Menu* in Section 2 for more information).

Note that selecting the alternate interface (GPIB or RS-232) resets the instrument to the power-on defaults. This reset action causes the instrument to exit from the **MAIN MENU**.

GPIB

The GPIB menu is used for the following operations:

- To select the IEEE-488 bus (GPIB).
- To view or change the IEEE-488 address.
- To select the data elements to send.

ADDRESSABLE: With the instrument set to **ADDRESSABLE**, it can listen and talk to a bus controller:

- **ADDRESS:** This menu item lets you check and change the IEEE-488 address of the instrument. At the factory the address is set to 27, but it can be changed to any value from 0 to 30. After selecting **ADDRESS**, the present IEEE-488 address will be displayed. If you wish to change the address, use the **RANGE** (Δ and ∇) keys to display the desired number and press **ENTER**.
- **ELEMENTS:** This menu item lets you select the data elements sent. Use one of the **RANGE** keys (Δ and ∇) to toggle between yes (y) and no (n).
 - **RDG:** The numeric value of the reading.
 - **RDG#:** The buffer location of the reading. The reading number can be reset to zero from the **GENERAL MENU**.
 - **UNIT:** The units of the reading.
 - **CH#:** The channel number the reading was taken on.

- **HUM:** Relative humidity reading if the Model 6517-RH is being used. The humidity sensor is enabled from the **A/D CONTROLS** item of the **GENERAL MENU**.
- **ETEMP:** The external temperature reading if the Model 6517-TP is being used. The humidity sensor is enabled from the **A/D CONTROLS** item of the **GENERAL MENU**.
- **TIME:** The real-time or relative time stamp for each reading. Time stamp type is selected from the **TIMESTAMP** item of the **GENERAL MENU**.
- **STATUS:** The reading status information (normal reading, measurement overflow on underflow, relative reading).
- **VSRC:** The actual output level of the V-source.

RS-232

The RS-232 menu is used for the following operations:

- To select the RS-232 Interface.
- To set the parameters for the RS-232 interface (baud rate, terminator, and flow control).
- To select the data elements to send.

BAUD: Use this option to set the baud rate for the RS-232 serial interface. Selections include 115200, 57600, 38400, 19200, 9600, 4800, 2400, 1200, 600, and 300 bits per second.

ELEMENTS: This menu item lets you select the data elements sent. Use one of the **RANGE** keys (Δ and ∇) to toggle between yes (y) and no (n).

- **RDG:** The numeric value of the reading.
- **RDG#:** The buffer location of the reading. The reading number can be reset to zero from the **GENERAL MENU**.
- **UNIT:** The units of the reading.
- **CH#:** The channel number the reading was taken on.
- **HUM:** Relative humidity reading if the Model 6517-RH is being used. The humidity sensor is enabled from the **A/D CONTROLS** item of the **GENERAL MENU**.
- **ETEMP:** The external temperature reading if the Model 6517-TP is being used. The humidity sensor is enabled from the **A/D CONTROLS** item of the **GENERAL MENU**.
- **TIME:** The real-time or relative time stamp for each reading. Time stamp type is selected from the **TIMESTAMP** item of the **GENERAL MENU**.
- **STATUS:** The reading status information (normal reading, measurement overflow or underflow, relative reading).
- **VSRC:** The actual output level of the V-source.

GPIB primary address selection

The Model 6517B is shipped from the factory with a pre-programmed primary address of 27. The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that controllers are also given a primary address, so do not use that address either. Most frequently, controller addresses are 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one, perform the following procedure:

1. Display the **MAIN MENU** by pressing the **MENU** key.

2. Use the cursor keys to place the cursor on **COMMUNICATION** and press **ENTER**. The **COMMUNICATIONS SETUP** menu will be displayed.
3. Place the cursor on **GPIB** and press **ENTER**. If you are switching from the RS-232 interface to the GPIB interface, the instrument will reset to the power-on defaults. In this case, you will have to repeat steps 1, 2 and 3 to display the **GPIB/PRINTER SETUP** menu.
4. Place the cursor on **ADDRESS** and press **ENTER**.
5. The current primary address of the instrument will be displayed. For example, if the instrument is set to primary address 27, the following message will be displayed: ADDRESS = 27 (0-30).
6. To retain the displayed address, press **EXIT** three times to return the instrument to the measurement display state.
7. To change the primary address, use the cursor keys (◀ and ▶) and the **RANGE** keys (△ and ▽) to display the new address value (0 to 30). (Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.) The cursor keys control cursor position and the **RANGE** keys (△ and ▽) increment and decrement the selected digit.
8. With the desired address value displayed, press **ENTER**. The address will be stored in non-volatile memory. That is, it will not be lost when the instrument is turned off.
9. Press **EXIT** two times to return to the measurement display state.

General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. [Table 11-1](#) lists the general bus commands.

Table 11-1
General bus commands

Command	Effect on Model 6517B
REN	Goes into effect when next addressed to listen
IFC	Goes into talker and listener idle states
LLO	LOCAL key locked out
GTL	Cancel remote, restore front panel operation for 6517B
	Cancel remote, restore front panel operation for all devices
DCL	Returns all devices to known conditions
SDC	Returns Model 6517B to known conditions
GET	Initiates a trigger
SPE, SPD	Serial Polls the Model 6517B

REN (remote enable)

The remote enable command is sent to the Model 6517B by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN to true does not actually place the instrument in the remote state. Instead, the instrument must be addressed to listen after setting REN to true before it will go into remote.

Note that the instrument need not be in remote to be a talker.

IFC (interface clear)

The IFC command is sent by the controller to place the Model 6517B in the local, talker, and listener idle states. The unit responds to the IFC command by cancelling front panel **TALK** or **LISTEN** lights, if the instrument was previously placed in one of those states.

Note that this command does not affect the status of the instrument; settings, data, and event registers are not changed.

To send the IFC command, the controller need only set the IFC line true for a minimum of 100 μ seconds

LLO (local lockout)

The LLO command is used to prevent local operation of the instrument. After the unit receives LLO, all its front panel controls except POWER are inoperative. In this state, pressing **LOCAL** will not restore control to the front panel. The GTL command restores control to the front panel.

GTL (go to local)

The GTL command is used to take the instrument out of the remote state. Operation of the front panel keys will also be restored by GTL.

DCL (device clear)

The DCL command may be used to clear the IEEE GPIB interface and return it to a known state. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously.

When the Model 6517B receives a DCL command, it clears the input buffer and output queue, cancels deferred commands, and clears any command that prevents the processing of any other device command. A DCL does not affect instrument settings and stored data.

SDC (selective device clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only selected instruments instead of clearing all instruments simultaneously, as is the case with DCL.

GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan, or measure event to control operation. The Model 6517B will react to this trigger if it is the programmed control source. GET can also be used as the pre-trigger for the reading buffer. The control source is programmed from the SCPI :TRIGger subsystem.

SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 6517B serial poll byte. The serial poll byte contains important information about internal functions. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 6517B.

IEEE-488 front panel operation

The following paragraphs discuss aspects of the front panel that are part of IEEE-488 operation, including messages, status indicators, and the **LOCAL** key.

Error and status messages

[Table 2-4](#) summarizes the error and status messages associated with remote programming using SCPI and Common Commands.

IEEE-488 status indicators

The REM (remote), TALK (talk), LSTN (listen), and SRQ (service request) annunciators show the present IEEE-488 status of the instrument. Each of these indicators is briefly described below.

REM: This indicator shows when the instrument is in the remote state. Note that REM may not always show the state of the REN line, because the instrument must be addressed to listen with REN set to true before the REM indicator turns on. When the instrument is in remote mode, all front panel keys except for the LOCAL key are locked out. When REM is turned off, the instrument is in the local state, and front panel operation is restored.

TALK: This indicator is on when the instrument is in the talker active state. The unit is placed in this state by addressing it to talk with the correct MTA (My Talk Address) command. TALK is off when the unit is in the talker idle state. The instrument is placed in the talker idle state by sending it an UNT (Untalk) command, addressing it to listen, or with the IFC (Interface Clear) command.

LSTN: This indicator is on when the Model 6517B is in the listener active state, which is activated by addressing the instrument to listen with the correct MLA (My Listen Address) command. Listen is off when the unit is in the listener idle state. The unit can be placed in the listener idle state by sending UNL (Unlisten), addressing it to talk, or by sending IFC (Interface Clear) over the bus.

SRQ: The instrument can be programmed to generate a service request (SRQ) when one or more errors or conditions occur. When this indicator is on, a service request has been generated. This indicator will stay on until the serial poll byte is read or all the conditions which caused SRQ have ceased to exist.

LOCAL key

The **LOCAL** key cancels the remote state and restores local operation of the instrument.

Pressing **LOCAL** also turns off the REM indicator and returns the display to normal if a user-defined message was displayed.

Note that the **LOCAL** key is also inoperative if the LLO (Local Lockout) command is in effect.

Programming syntax

The following information covers syntax for both common commands and SCPI commands. For information not covered here, refer to the IEEE-488.2 and SCPI standards. [Section 12](#) of this manual details common commands, and [Section 14](#) provides complete information on SCPI commands.

Command words

Program messages are made up of one or more command words.

Commands and command parameters

Common commands and SCPI commands may or may not use a parameter. Examples:

*SAV <NRf>	Parameter (NRf) required
*RST	No parameter used

```
:INITiate:CONTinuous <b>Parameter (<b>) required
:SYSTem:PRESet          No parameter used
```

NOTE There must be at least one space between the command word and the parameter.

Brackets []: There are command words that are enclosed in brackets ([]). These brackets are used to denote an optional command word that does not need to be included in the program message. For example:

```
:INITiate[:IMMEDIATE]
```

The brackets indicate that `:IMMEDIATE` is implied (optional) and does not have to be used. Thus, the above command can be sent in one of two ways:

```
:INITiate or :INITiate:IMMEDIATE
```

Notice that the optional command is used without the brackets. *Do not include the brackets when using an optional command word.*

Parameter types

Some of the more common parameter types are explained as follows:

**** Boolean: Used to enable or disable an instrument operation. 0 or OFF disables the operation, and 1 or ON enables the operation. Example:

```
:CURRent:DC:RANGe:AUTO ON    Enable auto-ranging
```

<name> Name parameter: Select a parameter name from a listed group. Example:

```
<name>= NEVER
      = NEXT
      = ALWAYS
      = PRETrigger

:TRACe:FEED:CONTrol PRETrigger
```

<NRf> Numeric representation format: This parameter is a number that can be expressed as an integer (for example, 8), a real number (for example, 23.6) or an exponent (for example, 2.3E6). Example:

```
:STATus:MEASurement:ENABleSet Bit B2 of enable register
```

<n> Numeric value: A numeric value parameter can consist of an NRf number or one of the following name parameters; `DEFAULT`, `MINimum`, or `MAXimum`. When the `DEFAULT` parameter is used, the instrument is programmed to the *RST default value. When the `MINimum` parameter is used, the instrument is programmed to the lowest allowable value. When the `MAXimum` parameter is used, the instrument is programmed to the largest allowable value. Examples:

```
:TRIGger:TImEr 0.1    Sets timer to 100msec
:TRIGger:TImEr DEFaultSets timer to 0.1sec
:TRIGger:TImEr MINimumSets timer to 1msec
:TRIGger:TImEr MAXimumSets timer to 999999.999sec
```

<list> List: Specify one or more switching channels. Examples:

```
:ROUTe:SCAN (@1:10)    Specify scan list (1 through 10)
:ROUTe:SCAN (@2,4,6)   Specify scan list (2, 4, and 6)
```

Angle brackets

Angle brackets (<>) are used to denote parameter type. Do not include the brackets in the program message. For example:

```
:SOURce:TTL2 <b>
```

The indicates that a Boolean type parameter is required. Thus, to set digital input line #2 true, you must send the command with the ON or 1 parameter as follows:

```
:SOURce:TTL2 ON or :SOURce:TTL2 1
```

Query commands

This type of command requests (queries) the currently programmed status. It is identified by the question mark (?) at the end of the fundamental form of the command. Most commands have a query form. Example:

```
:TRIGger:TIMer?    Queries the timer interval
```

Most commands that require a numeric parameter (<n>) can also use the DEFault, MINimum, and MAXimum parameters for the query form. These query forms are used to determine the *RST default value, and the upper and lower limits for the fundamental command. Examples:

```
:TRIGger:TIMer? DEFault    Queries the *RST default value
```

```
:TRIGger:TIMer? MINimum    Queries the lowest allowable value
```

```
:TRIGger:TIMer? MAXimum    Queries the largest allowable value
```

Case sensitivity

Common commands and SCPI commands are not case sensitive. You can use upper or lower case, and any case combination. Examples:

```
*RST                =*rst
:SCAN?              =:scan?
:SYSTem:PRESet     =:system:preset
```

Long-form and short-forms

A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in Section 14 provide the commands in the long-form version. However, the short-form version is indicated by upper case characters. Examples:

```
:SYSTem:PRESet     Long-form
:SYST:PRES         Short-form
:SYSTem:PRES       Long and short-form combination
```

Note that each command word must be in long-form or short-form, and not something in between. For example, :SYSTe:PRESe is illegal and will generate an error. The command will not be executed.

Short-form rules

The following rules can be used to determine the short-form version of any SCPI command or parameter:

1. If the length is four letters or less, there is no short-form version. Example:

```
:auto = :auto
```
2. The following rules apply to words that exceed four letters:
 - a. If the fourth letter of the word is a vowel, delete it and all the letters after it. Example:

```
:immediate = :imm
```
 - b. If the fourth letter of the word is a consonant, retain it but drop all the letters after it. Example:

```
:output = :outp
```
3. If there is a question mark (`?`; *query*) or a non-optional number included in the command word, it must be included in the short-form version. Examples:

```
:delay? = :del? :layer2 = :lay2
```
4. As previously explained, command words or characters that are enclosed in brackets (`[]`) are optional and need not be included in the program message.

Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Each common command is simply a three letter acronym preceded by an asterisk (*). SCPI commands are categorized into subsystems and are structured as command paths. The following command paths are contained in the `:STATus` subsystem and are used to help explain how command words are structured to formulate program messages.

<code>:STATus</code>	Path (Root)
<code>:OPERation</code>	Path
<code>:PTRansition <NRf></code>	Command and parameter
<code>:NTRansition <NRf></code>	Command and parameter
<code>:ENABle <NRf></code>	Command and parameter
<code>:PRESet</code>	Command

Single command messages

There are three levels to the above command structure. The first level is made up of the root command (`:STATus`) and serves as a path. The second level is made up of another path (`:OPERation`) and a command (`:PRESet`). The third path is made up of three commands for the `:OPERation` path. The four commands in this structure can be executed by sending four separate program messages as follows:

```
:stat:oper:ptr <NRf>
:stat:oper:ntr <NRf>
:stat:oper:enab <NRf> :stat:pres
```

In each of the above program messages, the path pointer starts at the root command (`:stat`) and moves down the command levels until the command is executed.

Multiple command messages

Multiple commands can be sent in the same program message as long as they are separated by semicolons (;). Example showing two commands in one program message:

```
:stat:pres; :stat:oper:enab <NRf>
```

When the above message is sent, the first command word is recognized as the root command (:stat). When the next colon is detected, the path pointer moves down to the next command level and executes the command. When the path pointer sees the colon after the semicolon (;), it resets back to the root level and starts over.

Commands that are on the same command level can be executed without having to retype the entire command path. Example:

```
:stat:oper:enab <NRf>; ptr <NRf>; ntr <NRf>
```

After the first command (:enab) is executed, the path pointer is at the third command level in the structure. Since :ptr and :ntr are also on the third level, they can be typed in without repeating the entire path name. Notice that the leading colon for :ptr and :ntr are not included in the program message. If a colon were included, the path pointer would reset to the root level and expect a root command; because :ptr and :ntr are not root commands, an error would occur.

Command path rules

1. Each new program message must begin with the root command, unless it is optional (for example, [:SENSE]). If the root is optional, simply treat a command word on the next level as the root.
2. The colon (:) at the beginning of a program message is optional and need not be used.
Example: :stat:pres = stat:pres
3. When the path pointer detects a colon (:) it will move down to the next command level. An exception is when the path pointer detects a semicolon (;), which is used to separate commands within the program message (see next rule).
4. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.
5. The path pointer can only move down. It cannot be moved up a level. Executing a command at a higher level requires that you start over at the root command.

Combining common and SCPI commands

Both common commands and SCPI commands can be used in the same message as long as they are separated by semicolons (;). A common command can be executed at any command level and will not affect the path pointer. Example:

```
:stat:oper:enab <NRf>; ptr <NRf>; *ESE <NRf>; ntr <NRf>
```

Program Message Terminator (PMT)

Each program message must be terminated with an LF (line feed), EOI (end or identify) or an LF + EOI. The bus will hang if your computer does not provide this termination. The following example shows how a multiple command program message must be terminated:

```
:rout:open all; scan (@1:5) <PMT>
```


Command execution rules:

1. Commands are executed in the order that they are presented in the program message.
2. An invalid command will generate an error and, of course, not be executed.
3. Valid commands that precede an invalid command in a multiple command program message will be executed.
4. Valid commands that follow an invalid command in a multiple command program message will be ignored.

Response messages

A response message is the message sent by the instrument to the computer in response to a query command program message.

Sending a response message

After sending a query command, the response message is placed in the output queue. When the Model 6517B is then addressed to talk, the response message is sent from the output queue to the computer.

Multiple response messages

GPIB: If you send more than one query command in the same program message (see *Multiple command messages* above), the multiple response message for all the queries is sent to the computer when the Model 6517B is addressed to talk. The responses are sent in the order that the query commands were sent and are separated by semicolons (;). Items within the same query are separated by commas (,). The following example shows the response message for a program message that contains four single item query commands:

```
0; 1; 1; 0
```

RS-232 Interface: Instead of commas, a <CR>, <LF> will separate each response from multiple queries in the same program message.

Response Message Terminator (RMT)

Each response message is terminated with an LF (line feed) and EOI (end or identify). The following example shows how a multiple response message is terminated:

```
0; 1; 1; 0 <RMT>
```

Message exchange protocol

The message exchange protocol can be summarized by the two following rules:

Rule 1. You must always tell the Model 6517B what to send to the computer.

The following two steps must always be performed, in this order, to send information from the instrument to the computer:

1. Send the appropriate query command(s) in a program message.
2. Address the Model 6517B to talk.

Rule 2. The complete response message must be received by the computer before another program message can be sent to the Model 6517B.

IEEE-488 trigger model

The following information describes the operation process of the Model 6517B over the IEEE-488 bus. The flowchart in [Figure 11-5](#), which summarizes operation over the bus, is called the Trigger model. It is called the trigger model because operation is controlled by SCPI commands from the Trigger subsystem (see [Section 14](#)). Notice that key SCPI commands are included in the trigger model.

See [Section 7](#) for additional trigger information.

Idle and initiate

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the trigger model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any measure or scan functions. Over the bus, there are two SCPI commands that can be used to take the instrument out of the idle state; `:INITiate` or `:INITiate:CONTinuous ON`.

Notice that with continuous initiation enabled (`:INIT:CONT ON`), the instrument will not remain in the idle state after all programmed operations are completed. However, the instrument can be returned to the idle state at any time by sending the `*RST` command, the `*RCL` command, or the `SYST:PRES` command.

Trigger model layers

As can be seen in [Figure 11-5](#), the trigger model uses three layers: Arm Layer1, Arm Layer 2, and the trigger layer. For front panel operation, these layers are known as the arm layer, scan layer, and measure layer.

Once the Model 6517B is taken out of the idle state, operation proceeds through the layers of the trigger model down to the device action where a measurement occurs.

Control sources

In general, each layer contains a control source which holds up operation until the programmed event occurs. The control sources are summarized as follows:

- `IMMEDIATE`: With this control source selected, event detection is immediately satisfied allowing operation to continue.
- `MANUAL`: Event detection is satisfied by pressing the **TRIG** key. Note that the Model 6517B must be taken out of remote before it will respond to the **TRIG** key. Press **LOCAL** or send `LOCAL 27` over the bus to take the instrument out of remote.
- `BUS`: Event detection is satisfied when a bus trigger (`GET` or `*TRG`) is received by the Model 6517B.
- `TIMER`: Event detection is immediately satisfied on the initial pass through the layer. Each subsequent detection is satisfied when the programmed timer interval (1 to 999999.999 seconds) elapses. A timer resets to its initial state when operation loops back to a higher layer (or idle). Note that `TIMER` is not available in Arm Layer 1.
- `EXTERNAL`: Event detection is satisfied when an input trigger through the EXTERNAL TRIGGER connector is received by the Model 6517B.
- `TLINK`: Event detection is satisfied when an input trigger through the trigger link is received by the Model 6517B.
- `RTCLOCK`: Event detection is satisfied when the programmed time and date occurs. Note that the real-time clock is only available as a control source for Arm Layer 1.
- `HOLD`: With this selection, event detection is not satisfied by any of the above control source events and operation is held up.

Control source loops

As can be seen in the flowchart, each layer has three paths that allow operation to loop around the control source. These three paths are described as follows:

- `:DIRection (Source Bypass)`: When a source bypass is enabled (`:DIRection SOURce`) and the `EXTernal` or `TLINK` control source is selected, operation will loop around the control source on the initial pass through the layer. If programmed for another event detection in the layer, the bypass loop will not be in effect even though it is still enabled. The bypass loop resets (be in effect) if operation loops back to a higher layer (or idle).

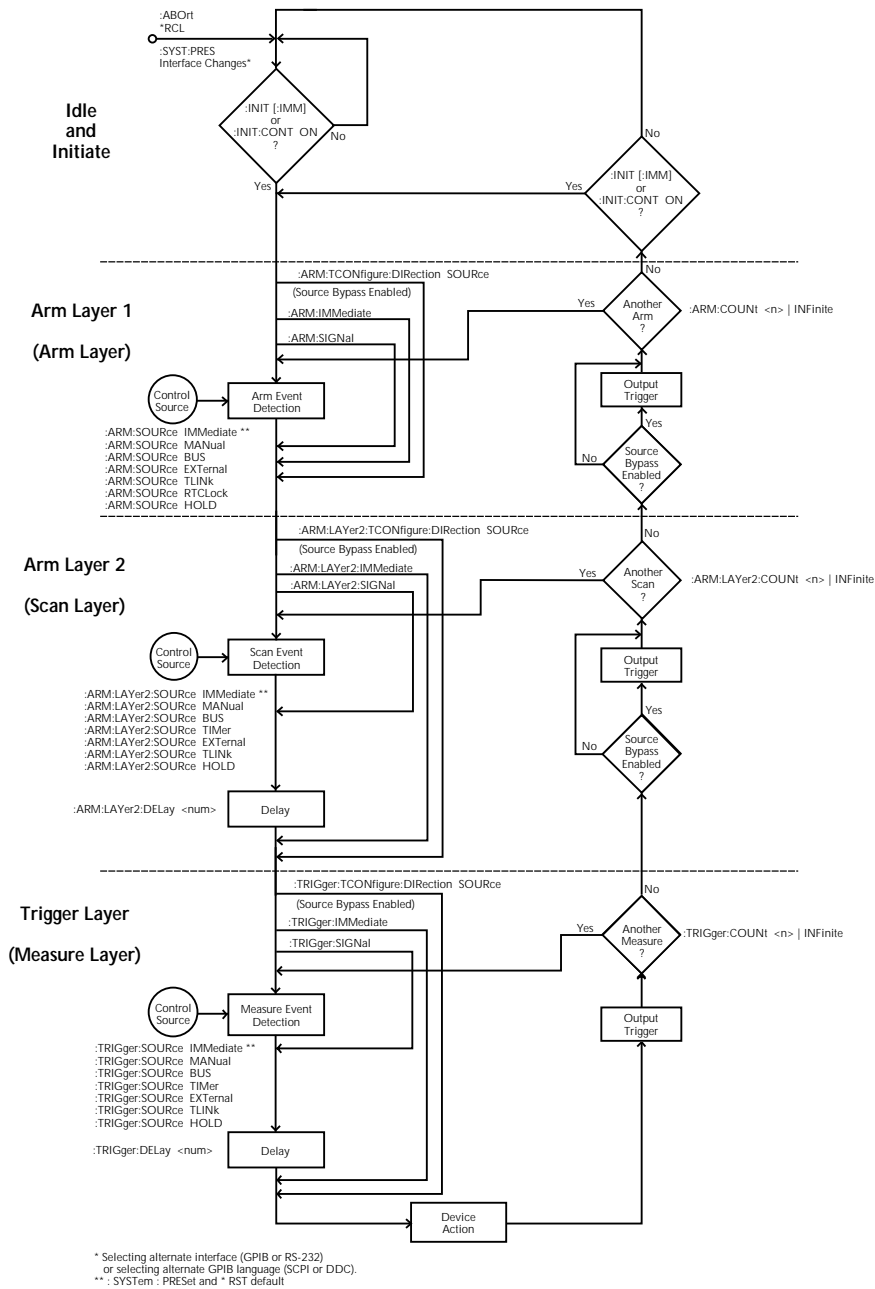
In Arm Layer 1 and Arm Layer 2, enabling a source bypass also enables the respective output trigger. In the trigger layer, its output trigger is always enabled and occurs after every device action. See [“Output triggers”](#) below for more information.

- `:IMMediate`: Each time an `:IMMediate` command is sent, operation loops around the respective control source. It is used when you do not wish to wait for the programmed event to occur (or when the `HOLD` control source is selected). Note that in Arm Layer 1 and the trigger layer, `:IMMediate` also loops operation around the delays.
- `:SIGNal`: Same function as an `:IMMediate` command.

Delays

Arm Layer 2 and the trigger layer have a programmable Delay (0 to 999999.999 seconds) that is asserted after an event detection. Note, however, that a Delay can be bypassed by sending an `:IMMediate` or `:SIGNal` command.

Figure 11-5
IEEE-488 trigger model



Device action

The primary device action is a measurement. However, the device action could include a function change and a channel scan (if scanner is enabled). A channel is scanned (closed) before a measurement is made. When scanning internal channels, the previous channel opens and the next channel closes (break-before-make). Also included in the device action is the internal settling time delay for the relay.

Output triggers

In Arm Layers 1 and 2, the output triggers are enabled only if their respective source bypasses are also enabled. If a `TLINK` control source is selected, the output trigger pulse is available on the selected trigger link output line. For all other control source selections, the trigger pulse is available at trigger link connector.

In the trigger layer, the output trigger is always enabled and occurs after every device action. If the control source is set for `EXTERNAL`, `IMMEDIATE`, `MANUAL`, `BUS` or `TIMER`, the output trigger pulse is available at the trigger link. If the `TLINK` control source is selected, output trigger action occurs on the selected trigger link output line as follows:

- If the asynchronous trigger link mode is selected, the output trigger pulse is available on the programmed output line.
- If the semi-synchronous trigger link mode is selected and the source bypass is disabled (`:trig:tcon:dir acc`), the trigger link line is released (goes high).
- If the semi-synchronous trigger link mode is selected and the source Bypass is enabled (`:trig:tcon:dir sour`), the trigger link line is pulled down low and then released.

Counters

All three layers use programmable counters which allow operation to return to or stay in the respective layer. For example, programming the trigger layer counter for infinity (`:trig:coun inf`) keeps operation in the trigger layer. After each device action and subsequent output trigger, operation loops back to the trigger layer control source. A counter resets when operation loops back to a higher layer (or idle).

RS-232 serial interface

The Model 6517B has a built-in RS-232 serial interface. Over this interface, you can send program messages to the instrument and receive response messages from the instrument. You can also place the instrument in the talk-only mode which allows you to dump readings to an external listening device, such as a serial printer.

The serial port of the Model 6517B can be connected to the serial port of a computer for send/receive operation, or to a listener (such as a serial printer) for talk-only operation (see *RS-232 interface connections* for more information).

The SCPI programming language can be used over the RS-232 Serial Interface to communicate with the Model 6517B. The DDC programming language cannot be used over the RS-232 interface.

RS-232 Interface configuration

Model 6517B:

The RS-232 Serial Interface is selected and configured from the **COMMUNICATION** option of the **MAIN MENU**. The **MAIN MENU** is accessed from the front panel by pressing the **MENU** key. The following information summarizes the steps to select and configure the RS-232 interface.

1. Select the RS-232 interface as follows:
 - Press **MENU**.
 - Select **COMMUNICATIONS**.
 - Select **RS-232**.

Switching from the GPIB interface to the RS-232 interface resets the instrument to the power-on defaults. In this case, you will have to repeat step 1 to display the RS-232 SETUP menu.

2. Set the BAUD rate, terminator, and flow control as follows:
 - Select **BAUD**.
 - Select **115200, 57600, 38400, 19200, 9600, 4800, 2400, 1200, 600** or **300**.
 - Select **terminator**.
 - Select **<CR>, <CR+LF>, <LF>, or <LF+CR>**.
 - Select **FLOW-CTRL, NONE, or XON-XOFF**.
 - Select **STOP**.
 - Select **1** or **2**.
3. Continue on to select the data elements that you want to include for each conversion. Use a manual range key to toggle between yes (y) and no (n):
 - Select **ELEMENTS**.
 - Select **RDG, RDG#, UNIT, CH#, HUM, ETEMP, TIME, or STATUS**.

Data elements can be selected over the RS-232 interface using the `:FORMat:ELEMents` command (see [Section 14](#)). All other RS-232 interface configuration settings have to be changed from the front panel **MAIN MENU**.

Computer:

From your communications software, configure the RS-232 interface for your computer as follows:

- RTS-CTS OFF.
- XON-XON: ON.
- Local echo: ON.
- Make sure the RS-232 parameters (baud rate, terminator, and flow control) of your computer matches the RS-232 parameters of the Model 6517B.

RS-232 operating considerations

Response messages (queries)

After a query command is sent and parsed, the response message will immediately be sent to the computer. Thus, the computer should be ready to receive the response message at that time.

Data format

The RS-232 interface only supports the ASCII data format. Therefore, whenever the RS-232 interface is selected, the data format will default to ASCII. Attempts to change the data format using the `:FORMat:DATA` command will result in an error message and the ASCII data format will be retained.

Flow control

The Model 6517B does not support any form of hardware flow control. Software flow control is in the form of `X_ON` (Control+Q) and `X_OFF` (Control+S) characters. If the input queue of the Model 6517B becomes more than 3/4 full (2048 characters maximum), the instrument issues an `X_OFF` command. The control program should respond to this and stop sending characters until the Model 6517B issues the `X_ON`, which it will do once its input buffer has dropped below half-full. The Model 6517B also recognizes `X_OFF` and `X_ON` sent from the controller. An `X_OFF` will cause

the Model 6517B to stop outputting characters until it sees an `X_ON`. Incoming commands are processed after the `<LF>` character is received.

Device clear action

A Control C (`^C`) sent over the interface interrupts the Model 6517B microprocessor and forces a device-clear action to take place. This clears any pending operation and discards any pending output. Note that `^X` is also recognized as a device-clear character.

Reception of a break condition also causes a device-clear action and displays the appropriate error message.

The Model 6517B signifies the completion of the device-clear by echoing back the "DCL" followed by the carriage return and line feed characters.

Unique SCPI commands

The following SCPI commands are unique to the RS-232 interface and cannot be used over the GPIB interface:

```
:SYSTem:LOCa1      Take the 6517B out of remote
:SYSTem:REMOte     Put the 6517B in remote
:SYSTem:LLOCKout <b> Enable or disable local lockout
```

See [Section 14](#) for more information on using these commands.

Error messages

The following error messages are associated with RS-232 interface operation. These error messages are also listed in [Table 2-4](#). Note that any of the following errors will set Bit B11 of the Operation Condition Register.

Table 11-2
Error messages

Error code	Error message	Description
+800	RS-232 framing error detected	Start or stop bit mismatch between computer and Model 6517B.
+801	RS-232 parity error detected	Parity type mismatch between computer and Model 6517B.
+802	RS-232 overrun detected	Data received before previous data can be read.
+803	RS-232 break detected	A break occurred (device-clear occurs)
+804	RS-232 noise detected	Noisy signal that could corrupt data
+805	Invalid system communication	RS-232 interface selection lost on power-up; instrument defaults to GPIB.
+806	RS-232 settings lost	RS-232 settings lost on power-up; instrument defaults to 9600 baud rate, 8 data bits, no parity (none), and 1 stop bit.
+807	RS-232 OFLO; characters lost	A character was received but discarded due to a lack of input buffer space. Each line-feed character (<code><LF></code>) closes a buffer and opens another. Thus, if too many line-feeds are sent in succession, then all buffers will fill before they have a chance to be read.
+808	ASCII only with RS-232	A data format other than ASCII was selected.

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In this section:

Topic	Page
Introduction	12-2
Common command summary	12-2
Common command descriptions.....	12-2

Introduction

This section provides detailed information on common IEEE-488.2 commands for the Keithley Instruments Model 6517B Electrometer.

Common command summary

Common commands (summarized in [Table 12-1](#)) are device commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Table 12-1
IEEE-488.2 common commands and queries

Mnemonic	Name	Description*
*CLS	Clear status	Clears all event registers, and error queue.
*ESE <NRf>	Event enable command	Program the standard event enable register.
*ESE?	Event enable query	Read the standard event enable register.
*ESR?	Event status register query	Read the standard event status register and clear it.
*IDN?	Identification query	Returns the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the operation complete bit in the standard event status register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII "1" into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Returns an ID code that indicates which memory option is installed and whether or not the optional scanner card is installed.
*RCL <NRf>	Recall command	Returns the Model 6517B to the setup configuration stored in the specified memory location.
*RST	Reset command	Returns the Model 6517B to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup to the specified memory location.
*SRE <NRf>	Service request enable command	Programs the service request enable register.
*SRE?	Service request enable query	Reads the service request enable register.
*STB?	Read status byte query	Reads the status byte register.
*TRG	Trigger command	Sends a bus trigger to the 6517B.
*TST?	Self-test query	Performs a checksum test on ROM and returns the result.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

* See [Section 13](#) for status structure details.

The status structure is covered in [Section 13](#).

Common command descriptions

*CLS (clear status)

Clear status registers and error queue.

Description The *CLS command is used to clear (reset to 0) the bits of the following registers in the Model 6517B:

- Standard event status register
- Operation event register
- Error queue trigger event register
- Sequence event register
- Arm event status register
- Measurement event register
- Questionable event register

This command also forces the instrument into the operation complete command idle state and operation complete query idle state.

***ESE <NRf> (event enable)**

Program the standard event enable register.

***ESE? (event enable query)**

Read the standard event enable register.

Parameters	<NRf> =	0	Clear register
		1	Set OPC (B0)
		4	Set QYE (B2)
		8	Set DDE (B3)
		16	Set EXE (B4)
		32	Set CME (B5)
		64	Set URQ (B6)
		128	Set PON (B7)
		255	Set all bits

Description The *ESE command is used to program the standard event enable register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of the bits in the register. This register is cleared on power up.

This register is used as a mask for the standard event status register. When a standard event is masked, the occurrence of that event will not set the event summary bit (ESB) in the status byte register. Conversely, when a standard event is unmasked (enabled), the occurrence of that event sets the ESB bit. For information on the standard event status register and descriptions of the standard event bits.

A cleared bit (0) in the enable register prevents (masks) the ESB bit in the status byte register from setting when the corresponding standard event occurs. A set bit (1) in the enable register allows (enables) the ESB bit to set when the corresponding standard event occurs.

The standard event enable register is shown in [Figure 12-1](#) and includes the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to be set is the parameter value that is sent with the *ESE command. For example, to set the CME and QYE bits of the standard event enable register, send the following command:

```
*ESE 36
```

```
Where: CME (Bit B5) = 32
       QYE (Bit B2) = 4
       <NRf>         = 36
```

If a command error (CME) occurs, Bit B5 of the standard event status register sets. If a query error (QYE) occurs, Bit B2 of the standard event status register sets. Since both of these events are unmasked (enabled), the occurrence of any one of them causes the ESB bit in the status byte register to set.

The standard event status register can be read by using the *ESE? query command.

Figure 12-1
Standard event enable register

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2 ⁷)	64 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	—	1 (2 ⁰)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Note : Bits B8 through B15 are not shown since they are not used.

Value : 1 = Enable Standard Event
0 = Disable (Mask) Standard Event

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

*ESR? (event status register query)

Read the standard event status register and clear it.

Description This command is used to acquire the value (in decimal) of the standard event status register (see [Figure 12-2](#)). The binary equivalent of the returned decimal value determines which bits in the register are set. This register is cleared on power-up or when *CLS is sent.

A set bit in this register indicates that a particular event has occurred. For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, Bits B4 and B5 of the standard event status register are set. These set bits indicate that a device-dependent error and command error have occurred.

Figure 12-2
Standard event status register

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2 ⁷)	64 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	—	1 (2 ⁰)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Note : Bits B8 through B15 are not shown since they are not used.

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

The bits of the standard event status register are described as follows:

Bit B0, operation complete (OPC): Set bit indicates that all pending selected device operations are completed and the Model 6517B is ready to accept new commands; this bit only sets in response to the `*OPC?` query command.

Bit B1: Not Used

Bit B2, query error (QYE): Set bit indicates that you attempted to read data from an empty output queue.

Bit B3, device-dependent error (DDE): Set bit indicates that an instrument operation did not execute properly due to some internal condition (such as Settings Conflict errors, and buffer sizing and mismatch errors).

Bit B4, execution error (EXE): Set bit indicates that the Model 6517B detected an error while trying to execute a command.

Bit B5, command error (CME): Set bit indicates that a command error has occurred. Command errors include:

- IEEE-488.2 syntax error: Model 6517B received a message that does not follow the defined syntax of the IEEE-488.2 standard.
- Semantic error: Model 6517B received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
- The instrument received a group execute trigger (GET) inside a program message.

Bit B6, user request (URQ): Set bit indicates that the **LOCAL** key on the Model 6517B front panel was pressed.

Bit B7, power on (PON): Set bit indicates that the Model 6517B has been turned off and turned back on since the last time this register has been read.

***IDN? (identification query)**

Read the identification code.

Description The identification code includes the manufacturer, model number, serial number, and firmware revision levels, and is sent in the following format:

```
KEITHLEY INSTRUMENTS INC., MODEL 6517B, xxxxxxxx, yyyyyy/zzzzz
```

Where: xxxxxxxx is the serial number

yyyyyy/zzzzz is the firmware revision levels of the digital board ROM and display board ROM

***OPC (operation complete)**

Set the operation complete bit in the standard event status register after all pending commands are complete.

Description On power-up, or when `*CLS` or `*RST` is executed, the Model 6517B goes into the operation complete command idle state (OCIS). In this state there are no pending overlapped commands. There are three overlapped command used by the Model 6517B:

```
:INITiate:CONTinuous ON :INITiate
*TRG
```

When the `*OPC` command is sent, the Model 6517B exits from OCIS and enters the operation complete command active state (OCAS). In OCAS, the instrument continuously monitors the no-operation-pending flag. After the last pending overlapped command is complete (No-Operation- Pending flag set to true), the

operation complete (OPC) bit in the standard event status register sets, and the instrument goes back into OCIS.

Note that the instrument always goes into OCAS when `*OPC` is executed. If there are no pending command operations (for example, trigger model in idle state), the Model 6517B immediately sets the OPC bit and returns to OCIS.

When used with the `:INITiate` or `:INITiate:CONTinuous ON` command, the OPC bit of the standard event status register will not set until the Model 6517B goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

The `:INITiate:POFLag` command is used to include or exclude the no-operation-pending flag in the internal process of determining whether all pending operations of an initiate command are completed.

When used with the `*TRG` command, the OPC bit will not set until the operations associated with the `*TRG` command (and the initiate command) are finished. The `*TRG` command is considered to be finished when the device action completes or when operation stops at a control source to wait for an event (see [IEEE-488 trigger model](#) in Section 11 for more information).

In order to use `*OPC` exclusively with the `*TRG` command, you will have to first force the completion of the initiate command so that only the `*TRG` command is pending. To do this, send the `:ABORt` command to place the instrument in idle, which (by definition) completes the initiate command. Since continuous initiation is on, operation continues on into the trigger model. After sending the `*TRG` command, the OPC bit sets when the `*TRG` command is finished.

***OPC? (operation complete query)**

Place a 1 in the output queue after all pending operations are completed.

Description On power-up, or when `*CLS` or `*RST` is executed, the Model 6517B goes into the operation complete command query idle state (OQIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 6517B:

```
:INITiate:CONTinuous ON
:INITiate
*TRG
```

When the `*OPC?` command is sent, the Model 6517B exits from OQIS and enters the operation complete command active state (OQAS). In OQAS, the instrument continuously monitors the no-operation-pending flag. After the last pending overlapped command is completed (no-operation-pending flag set to true), an ASCII character 1 is placed into the output queue, the message available (MAV) bit in the status byte sets, and the instrument goes back into OQIS. Addressing the Model 6517B to talk sends the ASCII 1 to the computer.

Note that the instrument always goes into OQAS when `*OPC?` is executed. If there are no pending command operations (for example, trigger model in idle state), the Model 6517B immediately places an ASCII "1" in the output queue, sets the MAV bit and returns to OQIS.

When used with the `:INITiate` or `:INITiate:CONTinuous ON` command, an ASCII "1" will not be sent to the output queue and the MAV bit will not set until the Model 6517B goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

The `:INITiate:POFLaG` command is used to include or exclude the no-operation-pending flag in the internal process of determining whether all pending operations of an initiate command are completed.

When used with the `*TRG` command, an ASCII 1 will not be placed into the output queue and the MAV bit will not set until the operations associated with the `*TRG` command (and the initiate command) are finished. The `*TRG` command is considered to be finished when the device action completes or when operation stops at a control source to wait for an event (see [IEEE-488 trigger model](#) for more information).

In order to use `*OPC?` exclusively with the `*TRG` command you will have to first force the completion of the initiate command so that only the `*TRG` command is pending. To do this, send the `:ABORt` command to place the instrument in idle, which (by definition) completes the initiate command. Since continuous initiation is on, operation continues on into the trigger model. After sending the `*TRG` command, an ASCII 1 is placed in the output queue and the MAV bit sets when the `*TRG` command is finished.

After `*OPC?` is executed, additional commands cannot be sent to the Model 6517B until the pending overlapped commands have finished. For example, `:INITiate:CONTinuous ON` followed by `*OPC?` locks up the instrument and requires a device clear (DCL or SDC) before it will accept any more commands. See `*OPC`, `*TRG`, and `*WAI` for more information.

***OPT? (option identification query)**

Determine which option is installed.

Description The response message provides the model number of the option installed in the option slot of the Model 6517B. If there is no option installed, then a zero (0) will be returned.

***RCL (recall)**

Return to a setup stored in memory.

Parameters `<NRf> = 0 to 9` Specify memory location

Description This command is used to return the Model 6517B to a setup configuration stored at a memory location. The `*SAV` command is used to store a setup configuration at a memory location.

The Model 6517B is shipped from the factory with `:SYSTem:PRESet` defaults loaded into the available setup memories. If a recall error occurs, the setup memories default to the `:SYSTem:PRESet` values.

***RST (reset the Model 6517B)**

Reset the Model 6517B to default conditions.

Description When the `*RST` command is sent, the Model 6517B performs the following operations:

1. Returns the Model 6517B to the `*RST` default conditions (see [Section 14](#) SCPI tables).
2. Cancels all pending commands.
3. Cancels response to any previously received `*OPC` and `*OPC?` commands.

***SAV (save the current setup in memory)**

Save the Model 6517B current setup configuration in memory for later recall.

Parameters <NRf> = 0 to 9 Specify memory location

Description The *SAV command is used to save the current instrument setup configuration in memory for later recall. Any control affected by *RST can be saved by the *SAV command. The *RCL command is used to restore the instrument to a saved setup configuration.

***SRE <NRf> (service request enable)**

Program service request enable register.

***SRE? (service request enable query)**

Read service request enable register.

Parameters	<NRf> =	0	Clears enable register
		1	Set MSB bit (Bit 0)
		4	Set EAV bit (Bit 2)
		8	Set QSB bit (Bit 3)
		16	Set MAV bit (Bit 4)
		32	Set ESB bit (Bit 5)
		128	Set OSB bit (Bit 7)
		255	Sets all bits

Description The *SRE command is used to program the service request enable register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the register. This register is cleared on power-up.

This enable register is used along with the status byte register to generate service requests (SRQ). With a bit in the service request enable register set, an SRQ occurs when the corresponding bit in the status byte register is set by an appropriate event. For details on register structure, refer to [Section 13](#).

The service request enable register is shown in [Figure 12-3](#). Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to set is the value that is sent with the *SRE command. For example, to set the ESB and MAV bits of the service request enable register, send the following command:

```
*SSE 34
```

```
Where: ESB (Bit B5)= 32
       MAV (Bit B4)= 16
       <NRf>      = 48
```

The contents of the service request enable register can be read using the *SRE? query command.

Figure 12-3
Service request enable register

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	—	ESB	MAV	QSB	EAV	—	MSB
Decimal Weighting	128 (2 ⁷)	—	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	—	1 (2 ⁰)
Value	0/1	—	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Enable Service Request Event
 0 = Disable (Mask) Service Request Event

Events : OSB = Operation Summary Bit
 ESB = Event Summary Bit
 MAV = Message Available
 QSB = Questionable Summary Bit
 EAV = Error Available
 MSB = Measurement Summary Bit

***STB? (status byte query)**

Read the status byte register.

Description The *STB? query command is used to acquire the value (in decimal) of the status byte register. The status byte register is shown in Figure 12-4. The binary equivalent of the decimal value determines which bits in the register are set.

All bits, except Bit 6, in this register are set by other event registers and queues. Bit 6 sets when one or more enabled conditions occur.

The *STB? query command does not clear the status byte register. This register can only be cleared by clearing the related registers and queues. Register and queue structure are explained in Section 13.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. This binary value indicates that Bits 4 and 5 of the status byte register are set.

Figure 12-4
Status byte register

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	MSS, RQS	ESB	MAV	QSB	EAV	—	MSB
Decimal Weighting	128 (2 ⁷)	64 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	—	1 (2 ⁰)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
 0 = Event Bit Cleared

Events : OSB = Operation Summary Bit
 MSS = Master Summary Status
 RQS = Request Service
 ESB = Event Summary Bit
 MAV = Message Available
 QSB = Questionable Summary Bit
 EAV = Error Available
 MSB = Measurement Summary Bit

The bits of the status byte register are described as follows:

Bit 0, measurement status (MSB): Set bit indicates that a measurement event has occurred. The event can be identified by reading the measurement event status register using the `:STATus:MEASurement?` command (see [Section 14](#)).

Bit 1: Not used.

Bit 2, error available (EAV): Set bit indicates that an error or status message is present in the error queue. The message can be read using one of the following SCPI commands:

```
:SYSTem:ERRor?
:STATus:QUEue?
```

(See [Section 14](#))

Bit 3, questionable summary bit (QSB): Set bit indicates that a calibration error has occurred.

Bit 4, message available (MAV): Set bit indicates that a message is present in the output queue. The message is sent to the computer when the Model 6517B is addressed to talk.

Bit 5, event summary bit (ESB): Set bit indicates that an enabled standard event has occurred. The event can be identified by reading the standard event status register using the `*ESE?` query command.

Bit 6, master summary status (MSS) / request service (RQS): Set bit indicates that one or more enabled status byte conditions have occurred. The MSS bit can be read using the `STB?` query command, or the occurrence of a service request (RQS bit set) can be detected by performing a Serial Poll.

Bit 7, operation summary bit (OSB): Set bit indicates that an enabled operation event has occurred. The event can be identified by reading the Operation Event Status Register using the `:STATus:OPERation?` query command (see [Section 14](#) for details).

***TRG (trigger)**

Send a GPIB trigger to the Model 6517B.

Description The `*TRG` command is used to issue a GPIB trigger to the Model 6517B. It has the same effect as a group execute trigger (`GET`).

The `*TRG` command is used as an arm, scan, and measure event to control operation. The Model 6517B reacts to this trigger if GPIB is the programmed control source. The control source is programmed from the `:TRIGger subsystem` in [Section 14](#).

`*TRG` can also be used as the pre-trigger for buffer operation.

***TST? (self-test query)**

Run the self-test and acquire the Result.

Description This query command is used to perform a checksum test on ROM and places the coded result (0 or 1) in the output queue. When the Model 6517B is addressed to talk, the coded result is sent from the output queue to the computer.

A returned value of zero (0) indicates that the test passed, and a value of one (1) indicates that the test has failed.

***WAI (wait-to-continue)**

Prevent the execution of commands until all previous commands are completed.

Description There are two types of device commands; Sequential commands and Overlapped commands. A Sequential command is a command whose operations are allowed to finish before the next command is executed. An Overlapped command is a command that allows the execution of subsequent commands while device operations of the Overlapped command are still in progress. The *WAI command is used to hold off the execution of subsequent commands until the device operations of all previous Overlapped commands are finished. The *WAI command is not needed for Sequential commands.

There are three Overlapped commands in the Model 6517B; :INITiate, :INITiate:CONTinuous ON and *TRG. See *OPC, *OPC? and *TRG for more information.

The :INITiate commands take the Model 6517B out of the idle state. The device operations of :INITiate are not considered complete until the Model 6517B goes back into idle mode. By sending the *WAI command after the :INITiate command, all subsequent commands will not execute until the Model 6517B goes back into idle mode.

The *TRG command issues a bus trigger which could be used to provide the arm, scan and measure events for the trigger model. By sending the *WAI command after the *TRG command, subsequent commands will not be executed until the pointer for the trigger model has finished moving in response to *TRG and has settled at its next state.

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In this section:

Topic	Page
Introduction	13-2
Status register sets	13-2
Condition registers	13-9
Transition filters	13-9
Event registers	13-10
Enable registers	13-10
Queues	13-11
Output queue	13-11
Error queue	13-11
Status byte and service request (SRQ)	13-11
Status byte register	13-11
Service request enable register	13-13
Serial poll and SRQ	13-13

Introduction

This section provides detailed information on the Keithley Instruments Model 6517B Electrometer status structure. [Section 12](#) also includes important information on common commands associated with the status structure, and [Section 14](#) details certain Standard Commands for Programmable Instrumentation (SCPI) commands that pertain to the status structure.

Status register sets

The status structure for the Model 6517B is summarized in [Figure 13-1](#). Instrument events, such as errors, are monitored and manipulated by seven status register sets. Notice that these seven status register sets feed directly or indirectly into the status byte register. More detailed illustrations of these register sets are provided by these figures:

- Standard event status registers: [Figure 13-2](#)
- Operation event status registers: [Figure 13-3](#)
- Arm event status registers: [Figure 13-4](#)
- Sequence event status registers: [Figure 13-5](#)
- Trigger event status registers: [Figure 13-6](#)
- Measurement event status registers: [Figure 13-7](#)
- Questionable event status registers: [Figure 13-8](#)

Figure 13-1
Model 6517B status structure

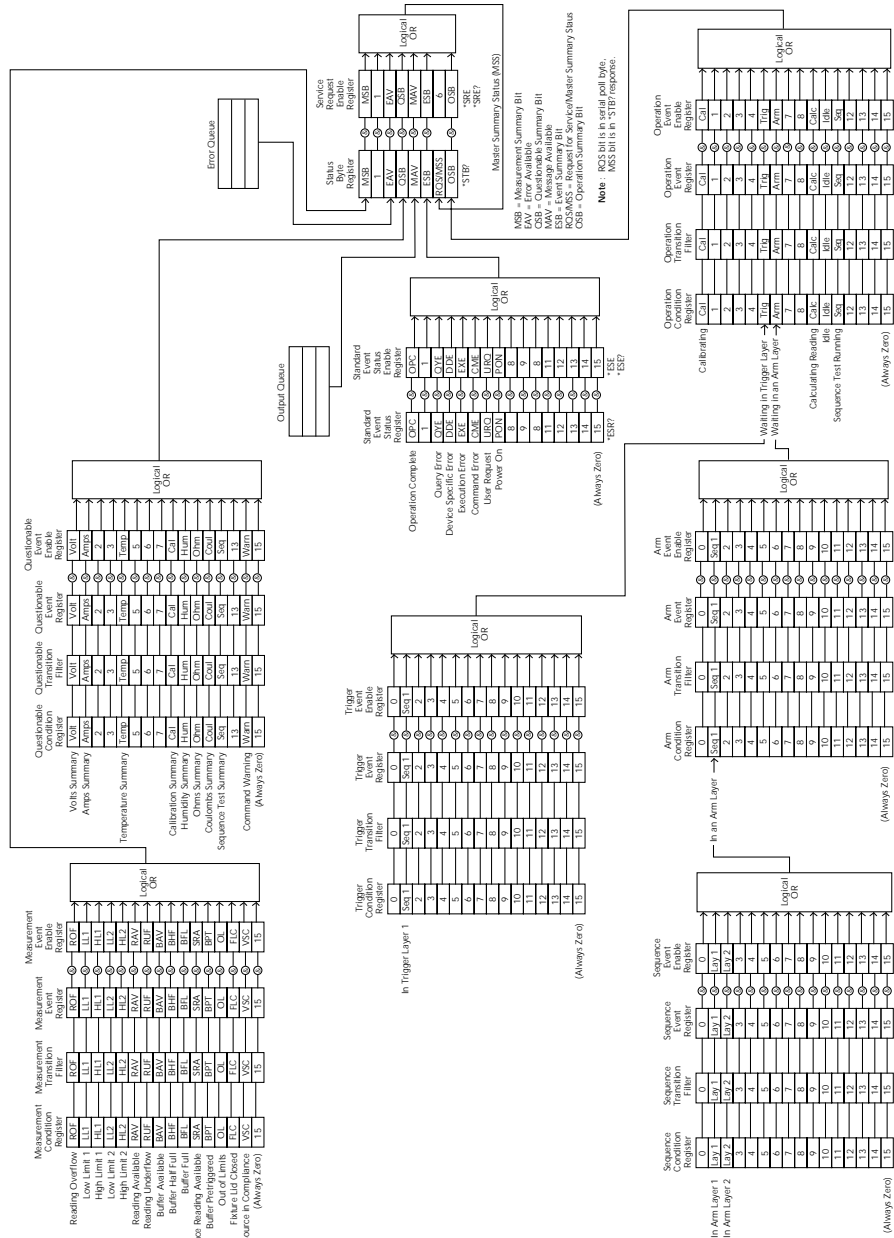


Figure 13-2
Standard event status registers

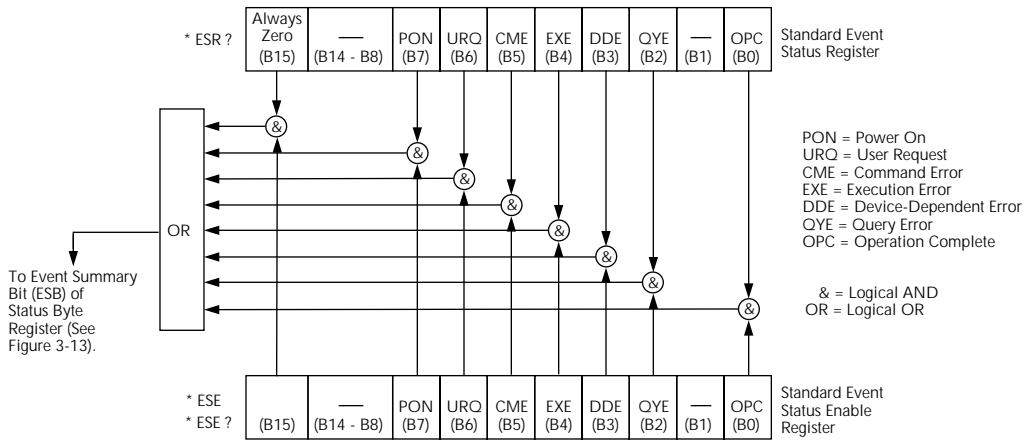


Figure 13-3
Operation event status registers

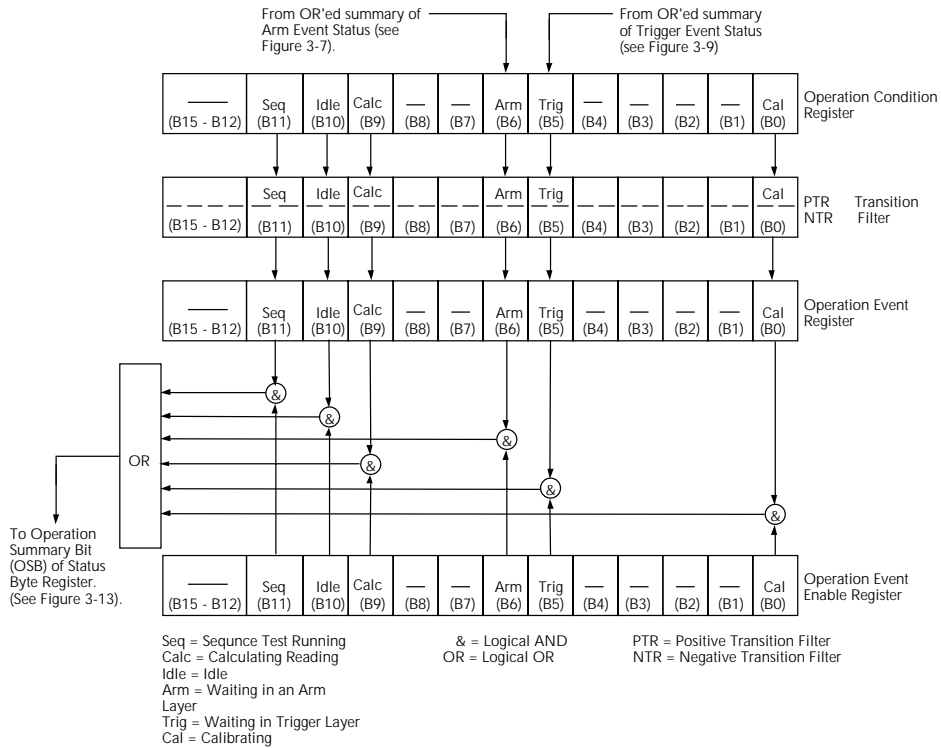
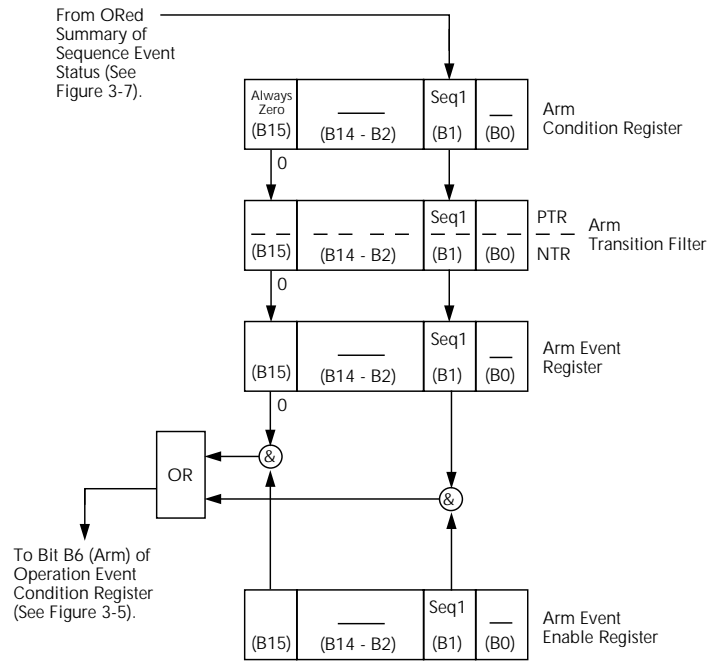


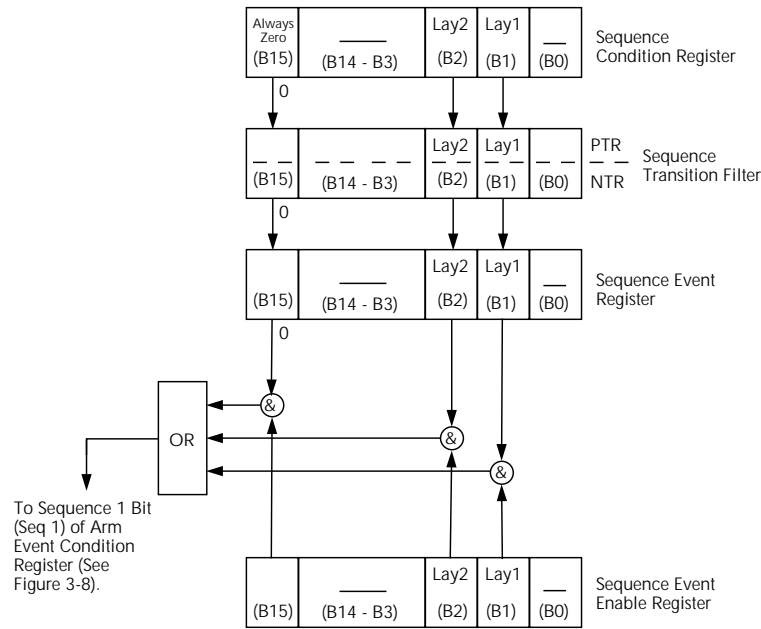
Figure 13-4
Arm event status registers



Seq 1 = Sequence 1 (Set bit indicates that the 6517 is in the arm layer of Sequence 1)

- & = Logical AND
- OR = Logical OR
- PTR = Positive Transition Register
- NTR = Negative Transition Register

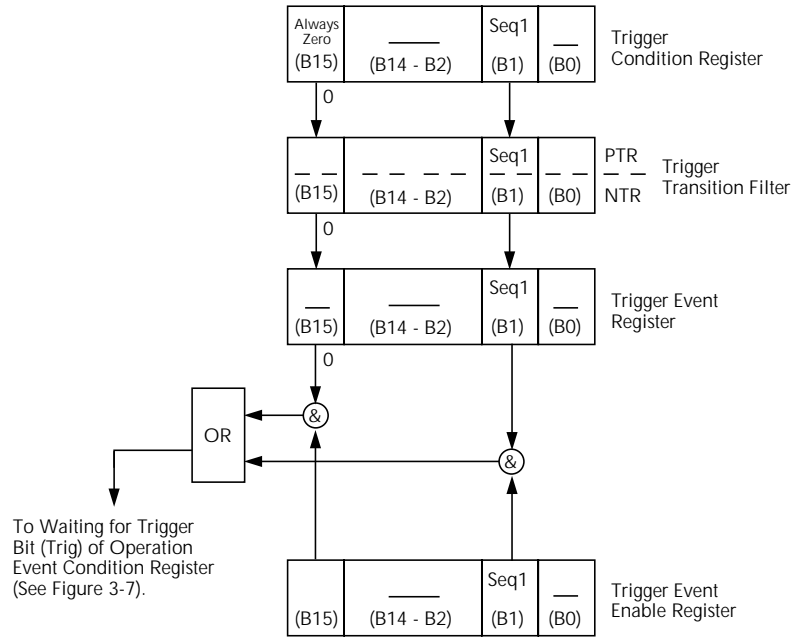
Figure 13-5
Sequence event status registers



Lay1 = Layer 1 (Set bit indicates that 6517 is in arm layer 1).
Lay2 = Layer 2 (Set bit indicates that 6517 is in arm layer 2).

& = Logical AND
OR = Logical OR
PTR = Positive Transition Register
NTR = Negative Transition Register

Figure 13-6
Trigger event status registers



Seq 1 = Sequence 1 (Set bit indicates that the **Model 6517B** is in the trigger layer of Sequence 1)

- & = Logical AND
- OR = Logical OR
- PTR = Positive Transition Register
- NTR = Negative Transition Register

Figure 13-7
Measurement event status registers

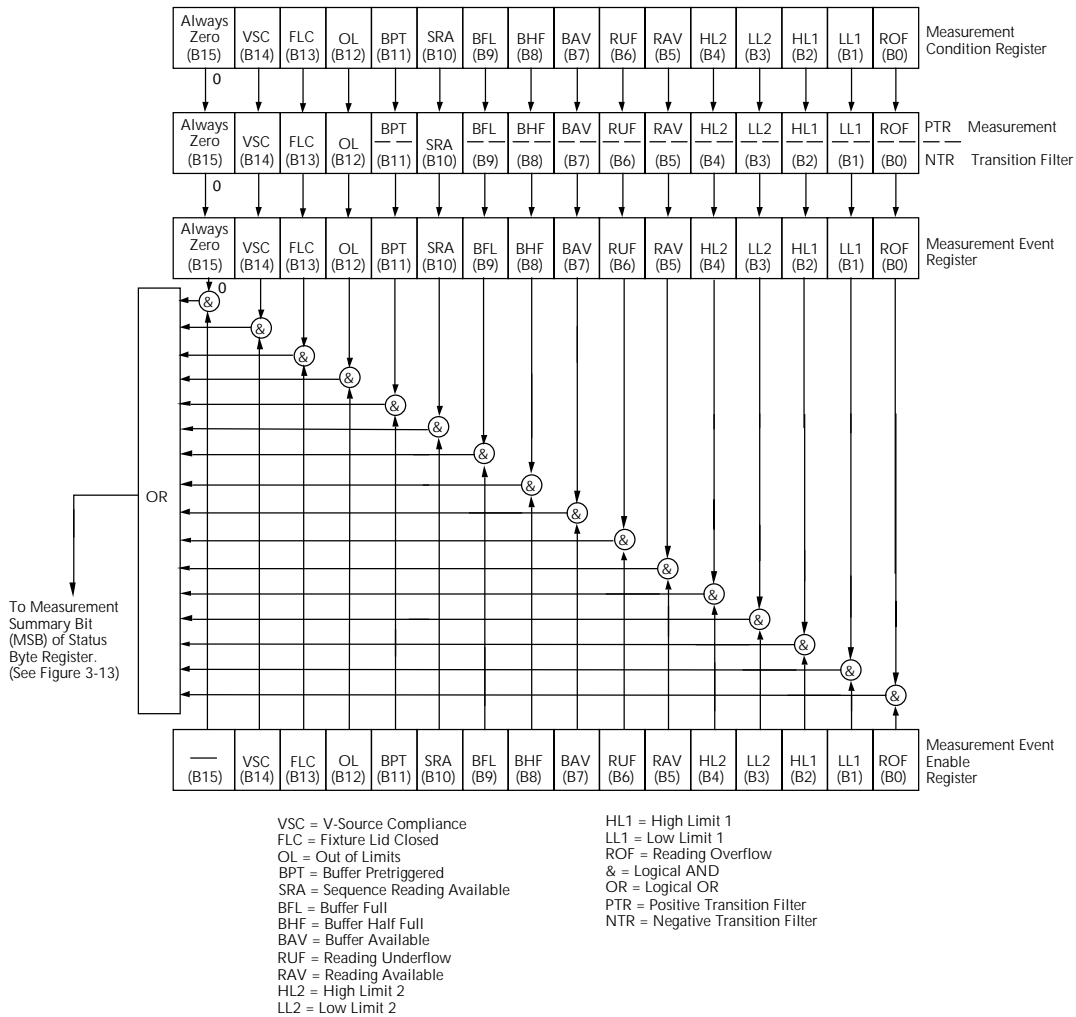
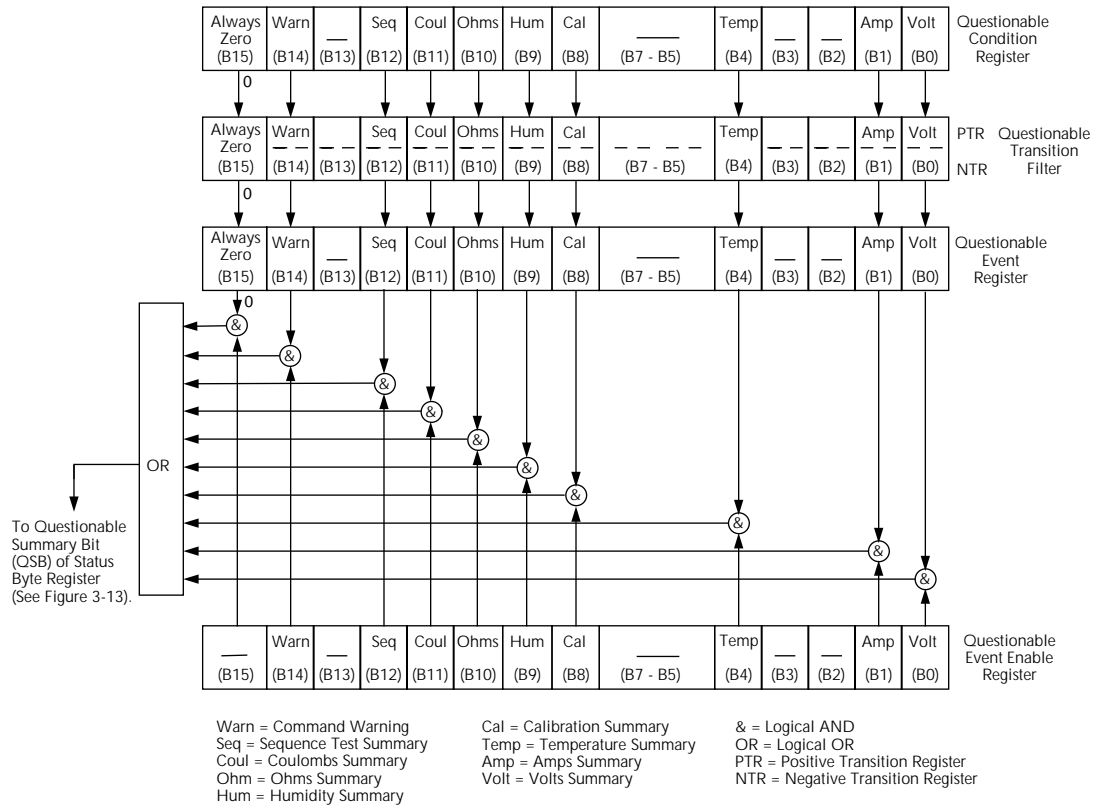


Figure 13-8
Questionable event status registers



Condition registers

As shown in the illustrations, all status register sets, except the standard event status register set, have a condition register. A condition register is a real-time read-only register that constantly updates to reflect the current operating conditions of the instrument. For example, while a calculation is being performed, Bit B9 (Calc) of the Operation Condition Register is set. When the calculation is completed, Bit B9 clears.

The `:CONDition?` query commands in the STATus Subsystem are used to read the condition registers (see [Section 14](#) for details).

Transition filters

As shown in the illustrations, all status register sets, except the standard event status register set, have a transition filter. A transition filter is made up of two registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the condition register will set the corresponding bit in the event register.

A filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event is programmed for a positive transition, the bit in the event register sets when the corresponding bit in the condition register changes for 0 to 1. Conversely, when programmed for a negative transition, the bit in the event register sets when the corresponding bit in the condition register changes from 1 to 0.

The `:PTR` and `:NTR` commands in the Status Subsystem are used to set or clear the individual bits of the transition filter registers, while the `:PTR?` and `:NTR?` query commands are used to read

the registers (see [Section 14](#) for details). Reading a transition filter register does not affect its bit pattern.

The following operations set (1) all bits of all PTR registers and clear (0) all bits of all NTR registers:

- Cycling power
- Sending :STATus:PRESet

Event registers

As shown in the illustrations, each status register set has an event register. An event register is a latched, read-only register whose bits are set by the corresponding condition register and transition filter. Once a bit in an event register is set, it remains set (latched) until the register is cleared by a specific clearing operation. The bits of an event register are logically ANDed with the bits of the corresponding enable register and applied to an OR gate. The output of the OR gate is applied to another register set or to the status byte register.

The *ESR? Common Command is used to read the Standard event register (see [Section 12](#)). All other event registers are read using the [:EVENT]? query commands in the STATus Subsystem (see [Section 14](#)).

An event register is cleared when it is read. The following operations clear all event registers:

- Cycling power
- Sending *CLS

Enable registers

As shown in the illustrations, each status register set has an enable register. An enable register is programmed by the user and serves as a mask for the corresponding event register. An event bit is masked when the corresponding bit in the enable register is cleared (0). When masked, a set bit in an event register cannot set a bit in a following register set or in the status byte register (1 AND 0 = 0).

To use the status byte register to detect events (for example, serial poll), you must unmask the events by setting (1) the appropriate bits of the enable registers.

The standard event status enable register is programmed and queried using the *ESE and *ESE? common commands respectively (see [Section 12](#)). All other enable registers are programmed and queried using the :ENABLe and :ENABLe? commands in the STATus Subsystem (see [Section 14](#)).

An enable register is not cleared when it is read. The enable registers are affected by the following operations:

- Cycling power: Clears all enable registers
- :STATus:PRESet clears the following enable registers:
 - Operation event enable register
 - Questionable event enable register
 - Measurement event enable register
- :STATus:PRESet sets all bits of the following enable registers:
 - Trigger event enable register
 - Arm event enable register
 - Sequence event enable register
- *ESE 0 — Clears the standard event status enable register

Queues

The Model 6517B uses two queues; the output queue and the error queue. The queues are first-in first-out (FIFO) registers. The output queue is used to hold readings and response messages, and the error queue is used to hold error messages and status messages. The Model 6517B status model in [Figure 13-1](#) shows how the two queues are structured with the other registers.

Output queue

The output queue is used to hold data that pertains to the normal operation of the instrument. For example, when a query command is sent, the response message is placed in the output queue.

When data is placed in the output queue, the message available (MAV) bit in the status byte register sets. A data message is cleared from the output queue when it is read. The output queue is considered cleared when it is empty. An empty output queue clears the MAV bit in the status byte register.

A message from the output queue is read by addressing the Model 6517B to talk after the appropriate query is sent.

Error queue

The error queue is used to hold error messages and status messages. When an error or status event occurs, a message that defines the error/status is placed in the error queue. This queue will hold up to 10 messages.

When a message is placed in the error queue, the error available (EAV) bit in the status byte register is set. An error message is cleared from the error/status queue when it is read. The error queue is considered cleared when it is empty. An empty error queue clears the EAV bit in the status byte register. An error message from the error queue is read by sending either of the following SCPI query commands and then addressing the Model 6517B to talk:

```
:SYSTem:ERRor?  
:STATus:QUEue?
```

Refer to [Section 14](#) (:STATus:QUEue? and :SYSTem:ERRor?) for complete information on reading error messages.

Status byte and service request (SRQ)

Service request is controlled by two 8-bit registers; the status byte register and the service request enable register. The structure of these registers is shown in [Figure 13-9](#).

Status byte register

The summary messages from the status registers and queues are used to set or clear the appropriate bits (B0, B2, B3, B4, B5, and B7) of the status byte register. These bits do not latch and their states (0 or 1) are solely dependent on the summary messages (0 or 1). For example, if the standard event status register is read, its register will clear. As a result, its summary message will reset to 0, which in turn will clear the ESB bit in the status byte register.

Bit B6 in the status byte register is either:

- The master summary status (MSS) bit, sent in response to the *STB? command, indicates the status of any set bits with corresponding enable bits set.
- The request for service (RQS) bit, sent in response to a serial poll, indicates which device was requesting service by pulling on the SRQ line.

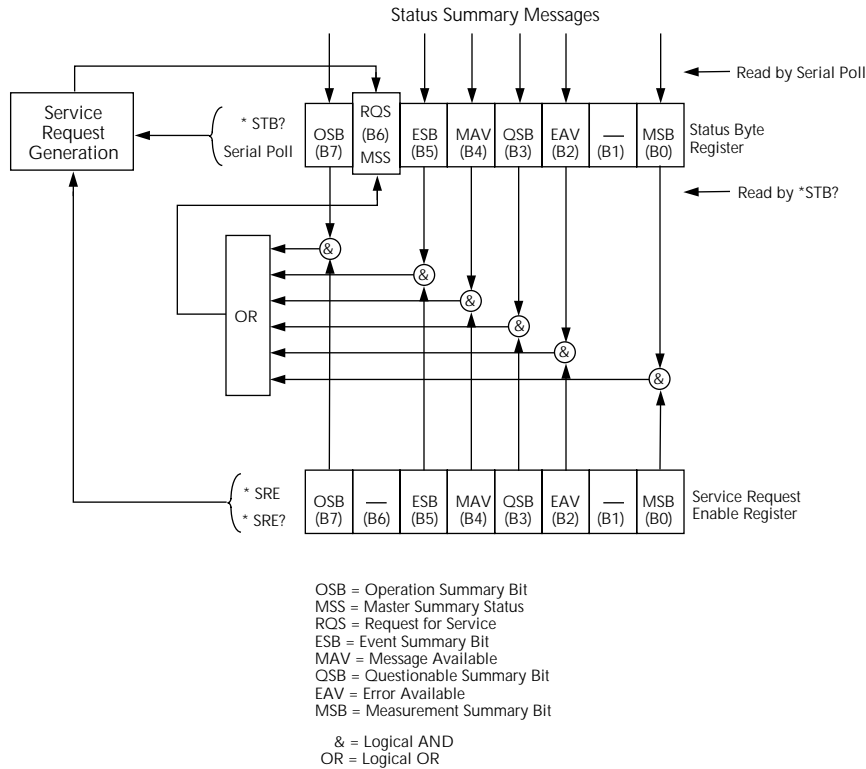
For description of the other bits in the status byte register, refer to [Section 12](#).

The IEEE-488.2 standard uses the following common query command to read the status byte register:

*STB?

When reading the status byte register using the *STB? command, Bit B6 is called the MSS bit. None of the bits in the status byte register are cleared when using the *STB? command to read it.

Figure 13-9
Status byte and service request (SRQ)



The IEEE-488.1 standard has a serial poll sequence that also reads the status byte register and is better suited to detect a service request (SRQ). When using the serial poll, Bit B6 is called the RQS bit. Serial polling causes Bit B6 (RQS) to reset. Serial polling is discussed in more detail later in this section (see Serial Poll and SRQ).

Any of the following operations clear all bits of the status byte register:

- Cycling power
- Sending the *CLS common command

The MAV bit may or may not be cleared.

Service request enable register

This register is programmed by the user and serves as a mask for the status summary message bits (B0, B2, B3, B4, B5 and B7) of the status byte register. When masked, a set summary bit in the status byte register cannot set Bit B6 (MSS/RQS) of the status byte register. Conversely, when unmasked, a set summary bit in the status byte register sets Bit B6.

A status summary message bit in the status byte register is masked when the corresponding bit in the service request enable register is cleared (0). When the masked summary bit in the status byte register sets, it is ANDed with the corresponding cleared bit in the service request enable register. The logic 0 output of the AND gate is applied to the input of the OR gate and thus, will not set the MSS/RQS bit in the status byte register.

A status summary message bit in the status byte register is unmasked when the corresponding bit in the service request enable register is set (1). When the unmasked summary bit in the status byte register sets, it is ANDed with the corresponding set bit in the service request enable register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, sets the MSS/RQS bit in the status byte register.

The individual bits of the service request enable register can be set or cleared by using the following common command (see [Section 12](#) for details):

```
*SRE <NRf>
```

The service request enable register can be read using the following common query command (see [Section 12](#) for details):

```
*SRE?
```

The service request enable register is not cleared when it is read using the `*SRE?` query command. The service request enable register clears when power is cycled or a parameter (n) value of zero is sent with the `*SRE` command (`*SRE 0`).

Serial poll and SRQ

Any enabled event summary bit that goes from 0 to 1 will set RQS and generate a service request (SRQ). The user's test program can periodically read the status byte register to check to see if a service request (SRQ) has occurred and what caused it. In the event of an SRQ, the program can, for example, branch to an appropriate subroutine that will service the request. Typically, service requests (SRQs) are managed by the serial poll sequence of the Model 6517B. If an SRQ does not occur, Bit B6 (RQS) of the status byte register will remain cleared, and the program will simply proceed normally after the serial poll is performed. If an SRQ does occur, Bit B6 of the status byte register will set and the program can branch to a service subroutine when the SRQ is detected by the serial poll.

The serial poll automatically resets RQS of the status byte register. This will allow subsequent serial polls to monitor Bit 6 for an SRQ occurrence generated by other event types. After a serial poll, the same event can cause another SRQ, even if the event register which caused the first SRQ has not been cleared.

A serial poll clears RQS but does not clear MSS. The MSS bit will stay set until all status byte event summary bits are cleared.

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In this section:

Topic	Page
Introduction	14-2
Signal-oriented measurement commands	14-2
SCPI command summary	14-4
SCPI command subsystems	14-25
CALCulate subsystems	14-25
DISPlay subsystem	14-32
FORMat subsystem	14-34
OUTPut subsystems	14-38
:ROUte subsystem	14-39
:SENSe1 subsystem	14-42
:SOURce subsystem	14-61
:STATus subsystem	14-64
:SYSTem subsystem	14-84
:TRACe subsystem	14-92
:TRIGger subsystem	14-96
:TSEQuence subsystem	14-102
:UNIT subsystem	14-109

Introduction

This section provides detailed information on the Keithley Instruments Model 6517B Electrometer Standard Communications for Programmable Instrumentation (SCPI) commands, including signal-oriented commands.

Signal-oriented measurement commands

The signal-oriented command group is used to acquire readings using a set of high-level instructions to control the measurement process, as summarized in [Table 14-1](#).

Table 14-1
Signal-oriented measurement command summary

Command	Description
:FETCh?	Requests the latest reading
:CONFigure:<function>	Places the 6517B in a “one-shot” measurement mode for the specified function
:READ?	Performs an :ABORT, :INITiate, and a :FETCh?
:MEASure[:<function>]?	Performs an :ABORT, :CONFigure:<function>, and a :READ?

:FETCh?

Description This query command is used to request the latest post-processed reading. After sending this command and addressing the Model 6517B to talk, the reading will be sent to the computer. This command does not affect the instrument setup.

This command does not trigger a measurement. It simply requests the last available reading. Note that this command can repeatedly return the same reading. In the absence of a new reading, this command will simply return the old reading. If your application requires “fresh” readings, use the :DATA:FRESH? command. See [:SENSe1 subsystem](#) for more information and refer to the [:FRESH?](#) command for further details.

This command is automatically asserted when the :READ? or :MEASure? command is sent.

:CONFigure:<function>

Where: <function>= VOLTage[:DC] Volts function
 CURRENT[:DC] Amps function
 RESistance Ohms function
 CHARge Coulombs function

Query :CONFigure? Query the selected function

Description This command is used to configure the instrument for subsequent measurements on the specified function. Basically, this command places the instrument in a one-shot measurement mode. The :READ? command can then be used to trigger a measurement and acquire a reading (see [:READ?](#)).

When this command is sent, the Model 6517B will be configured as follows:

- The function specified by this command is selected.
- All controls related to the selected function are defaulted to the *RST values.
- Continuous initiation is disabled (:INITiate:CONTinuous OFF).
- The control sources in all three layers of the trigger model are set to Immediate.
- The count values in all three layers of the trigger model are set to one (1).
- The delay in all three layers of the trigger model are set to zero (0).

- The Model 6517B is placed in the idle state.
- All math calculations are disabled.
- Buffer operation is disabled; a storage operation currently in process will be aborted.
- Autozero controls are set to the *RST default values.
- The acquisition method is set to normal.
- All operations associated with switching cards (scanning) are disabled.

This command is automatically asserted when the :MEASure? command is sent.

:READ?

Description This command is typically used to acquire a post-processed reading after the instrument has been configured by the :CONFigure command. The :CONFigure command places the instrument in a one-shot measurement mode. Every time the :READ? command is then sent, a measurement conversion will occur and the reading will be acquired.

When this command is sent, the following commands will be executed in the order that they are presented:

```
:ABORt
:INITiate
:FETCh?
```

When :ABORt is executed, the instrument will go into the idle state if continuous initiation is disabled. Otherwise, operation will re-start at the beginning of the trigger model.

If the instrument is in the idle state, :INITiate will take the instrument out of the idle state. If continuous initiation is enabled, (:INITiate:CONTinuous ON), then the :INITiate command will generate an error and ignore the command.

Use the :FETCh? for details. Note that an "Init ignored" error will not cancel the execution of the :FETCh? command.

:MEASure[:<function>]?

Where: <function> = VOLTage[:DC]	Volts function
CURRent[:DC]	Amps function
RESistance	Ohms function
CHARge	Coulombs function

Description This command combines all of the other signal oriented measurement commands to perform a "one-shot" measurement and acquire the reading.

SCPI command summary

SCPI commands are summarized by subsystem in the following tables:

Table 14-2

Subsystem	Summary table	Subsystem reference
CALCulate	Table 14-3	Page 14-25
DISPlay	Table 14-4	Page 14-32
FORMat	Table 14-5	Page 14-34
OUTPut	Table 14-6	Page 14-38
ROUte	Table 14-7	Page 14-39
SENSe	Table 14-8	Page 14-42
SOURce	Table 14-9	Page 14-61
STATus	Table 14-10	Page 14-64
SYSTem	Table 14-11	Page 14-84
TRACe	Table 14-12	Page 14-92
Trigger	Table 14-13	Page 14-96
TSEQence	Table 14-14	Page 14-102
UNIT	Table 14-15	Page 14-109

General notes:

- Brackets ([]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets in the program message.
- Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets in the program message.
- The Boolean parameter () is used to enable or disable an instrument operation. 1 or ON enables the operation and 0 or OFF disables the operation.
- Upper case characters indicate the short-form version for each command word.
- Default Parameter: Listed parameters are both the *RST and :SYSTem:PRESet defaults, unless noted otherwise. Parameter notes are located at the end of each table.
- SCPI: A check mark (✓) indicates that the command and its parameters are SCPI-confirmed. An unmarked command indicates that it is non-SCPI. SCPI-confirmed commands that use one or more non-SCPI parameters are explained by notes.

Table 14-3
CALCulate command summary

Command	Description	Default parameter	SCPI
:CALCulate[1]	Subsystem to control CALC1:		√
:FORMat <name>	Select math format (NONE, POLynomial, PERCent, RATio, DEVIation, PDEVIation, LOG10)	Polynomial	√
:FORMat?	Query math format		√
:KMATH	Path to control math calculations:		
:MA0Factor <NRf>	Set "a0" for POLynomial (-9.999999e30 to +9.999999e30)	0	
:MA0Factor?	Query "a0" factor		
:MA1Factor <NRf>	Set "a1" for POLynomial (-9.999999e20 to +9.999999e20)	1	
:MA1Factor?	Query "a1" factor		
:MA2Factor <NRf>	Set "a2" for POLynomial (-9.999999e30 to +9.999999e30)	0	
:MA2Factor?	Query "a2" factor		
:PERCent <NRf>	Specify target value for percent calc (-9.999999e35 to +9.999999e35)	1	
:PERCent?	Query target value		
:REference <NRf>	Set reference value for Ratio, Deviation and % Deviation (-9.999999e35 to +9.999999e35)	1	
:REference?	Query reference value		
:STATe 	Enable or disable calculation	(Note)	√
:STATe?	Query state of math function		√
:DATA	Path to read math result of calculation		√
[:LATEST]?	Return last reading		√
:FRESH?	Return new reading		√
:IMMediate	Recalculate input data		√
:CALCulate2	Subsystem to control CALC 2:		√
:FORMat <name>	Select math format: (MEAN, SDEVIation, MAXimum, MINimum, PKPK, OR NONE)	NONE	√
:FORMat?	Query math format		√
:STATe 	Enable or disable calculation	(Note)	√
:STATe?	Query state of math function		√
:IMMediate	Recalculate raw input data in buffer		√
:DATA?	Read math result of CALC 2		√

Table 14-4
DISPlay command summary

Command	Description	Default parameter	SCPI
:DISPlay	Path to locate message to top display		√
[:WINDow[1]]	Query attributes of display characters; 1=blinking character, 0=other		
:ATTRibutes?			
:TEXT	Path to control user text messages	(Note 1)	√
:DATA <a>	Define ASCII message "a" (up to 20 characters)		√
:DATA?	Query text message		√
:STATe 	Enable or disable message mode	(Note 2)	√
:STATe?	Query text message state		√
:DATA?	Read data on top portion of display		
:WINDow2	Path to locate message to bottom display		√
:ATTRibutes?	Query attributes of display characters; 1=blinking character, 0=other		
:TEXT	Path to control user text messages	(Note 1)	√
:DATA <a>	Define ASCII message "a" (up to 32 characters)		√
:DATA?	Query text message		√
:STATe 	Enable or disable message mode	(Note 2)	√
:STATe?	Query text message state		√
:DATA?	Read data on bottom portion of display		
:CNDisplay	Clear NEXT (or PREV) display messages and cancel associated operations		
:SMESsage 	Enable or disable status message mode	OFF	
:SMESsage?	Query status message state		
:ENABLe 	Enable or disable the front panel display	(Note 3)	√
:ENABLe?	Query state of the display		√

Notes:

1. *RST and :SYSTem:PRESet has no effect on a user-defined message. Cycling power cancels all user-defined messages.
2. *RST and :SYSTem:PRESet has no effect on the state of the message mode. Cycling power disables (OFF) the message mode.
3. *RST and :SYSTem:PRESet has no effect on the display circuitry. Cycling power enables (ON) the display circuitry.

Table 14-5
FORMat command summary

Command	Description	Default parameter	SCPI
:FORMat	Select data format:	ASCII	√
[:DATA]	(ASCii, REAL,32, REAL,64, SREal, or DREal)		√
<type>[, <length>]	Query data format		
[:DATA]?	Specify data elements:	(Note)	
:ELEMEnts <item list>	(READing, CHANnel, RNUMber, UNITS, TSTamp, STATUS, ETEmpErature, HUMidity, and VSourCe)		
:ELEMEnts?	Query data elements		
:BORDER <name>	Select binary byte order: (NORMAL or SWAPped)	SWAPped	√
:BORDER?	Query byte order		√

Note: All elements, except ETEmpErature, HUMidity and VSourCe, are the *RST and :SYSTem:PRESet default.

Table 14-6
OUTPut command summary

Command	Description	Default Parameter	SCPI
:OUTPut1 [:STATe] 	Enable (operate) or disable (standby) V-source output	OFF	√
[:STATe]?	Query state of V-source output		√
:TTL[1] :LSENse <name>	Path to set polarity of digital output line 1: Select polarity; active high (AHIGH) or active low (ALOW)	AHIGH	
:LSENse?	Query polarity of line 1		
:TTL2 :LSENse <name>	Path to set polarity of digital output line 2: Select polarity; active high (AHIGH) or active low (ALOW)	AHIGH	
:LSENse?	Query polarity of line 2		
:TTL3 :LSENse <name>	Path to set polarity of digital output line 3: Select polarity; active high (AHIGH) or active low (ALOW)	AHIGH	
:LSENse?	Query polarity of line 3		
:TTL4 :LSENse <name>	Path to set polarity of digital output line 4: Select polarity; active high (AHIGH) or active low (ALOW)	AHIGH	
:LSENse?	Query polarity of line 4		

Table 14-7
ROUte command summary

Command	Description	Default parameter	SCPI
:ROUte			
:CLOSE <list>	Path and command to close specified channel:		√
:STATe?	Query closed channel		√
:CLOSE? <list>	Query specified channels (1 = closed, 0 = open)		√
:OPEN <list>	Open specified channel or all channels		√
:OPEN:ALL	Open all channels		√
:OPEN? <list>	Query specified channels (1 = open, 0 = closed)		√
:SCAN	Command path to configure and control scan operations:		√
[:INTernal] <list>	Specify internal scan list (2 to 10 channels)	All 10	√
[:INTernal]?	Query the internal scan list		
:EXTernal <n>	Specify external scan list (1 to 400 channels)	10	
:EXTernal?	Query the external scan list		
:LSElect <name>	Select scan operation: (INTernal, EXTernal, or NONE)	NONE	
:LSElect?	Query scan operation		
:STIME <n>	Specify settling time for internal card (0 to 99999.9999 seconds)	0	
:STIME?	Query settling time		
:SMETHod <name>	Select scan method for internal scan (VOLTage or CURRent)	VOLTage	
:SMETHod?	Query scan method		
:VSLimit 	Enable or disable 200V limit for internal card	ON	
:VSLimit?	Query state of 200V limit		

Table 14-8 (continued)
SENSE command summary

Command	Description	Default parameter	SCPI
[:STATE] [:STATE]?	Enable or disable digital filter Query state of digital filter	OFF	
:MEDian [:STATE] [:STATE]?	Path to control the median filter: Enable or disable median filter Query state of median filter	ON	
:RANK <NRF> :RANK?	Specify rank for median filter (1 to 5) Query rank	1	
:GUARd :GUARd?	Enable or disable guard Query state of guard	OFF	
:XFEedback :XFEedback	Enable or disable external feedback Query state of external feedback	OFF	
:CURRent[:DC] :APERture <n>	Path to configure Amps: Set integration rate in seconds (166.67e-6 to 200e-3)	(Note 1)	√
:AUTO :AUTO ONCE :AUTO?	Enable or disable auto aperture Enable and then disable auto aperture Query auto aperture	OFF	√
:APERture? :NPLCycles <n>	Query aperture (integration rate) Set integration rate (line cycles; 0.01 to 10)	1	√
:AUTO :AUTO ONCE :AUTO?	Enable or disable auto NPLC Enable and then disable auto NPLC Query auto line cycle integration	OFF	
:NPLCycles? :RANGe	Query line cycle integration rate Path to configure measurement range:		√
[:UPPer] <n> [:UPPer]?	Select range (0 to 21e-3) Query range	20e-3	√
:AUTO :AUTO ONCE	Enable or disable auto range Set range based on present input signal	(Note 4)	√
:ULIMit <n> :ULIMit?	Set upper limit for auto range (0 to 21e-3) Query upper limit	20e-3	
:LLIMit <n> :LLIMit?	Set lower limit for auto range (0 to 21e-3) Query lower limit	2-e-12	
:AUTO? :REFerence <n>	Query auto range Specify reference (-21e-3 to +21e-3)	0	√
:STATe :STATe?	Enable or disable reference Query state of reference	OFF	√
:ACQuire :REFerence?	Use input signal as reference Query reference value		√
:DIGits <n> :AUTO :AUTO ONCE :AUTO?	Specify measurement resolution (4 to 7) Enable or disable auto resolution Enable and then disable auto resolution Query auto resolution	6	
:DIGits?	Query resolution		

Table 14-8 (continued)
SENSE command summary

Command	Description	Default parameter	SCPI
:AVERage	Path to control the average filter		
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced)	SCALar	
:TYPE?	Query filter type		
:TCONtrol <name>	Select filter type: (MOVing OR REPeat)	(Note 3)	
:TCONtrol?	Query filter type		
:COUNT <n>	Specify filter count (1 to 100)	10	
:COUNT?	Query filter count		
:ADVanced	Path to configure and control advanced filter		
:NTOLerance <n>	Specify noise tolerance level (0 to 100%)	1	
:NTOLerance?	Query noise tolerance level		
[:STATE] 	Enable or disable digital filter	OFF	
[:STATE]?	Query state of digital filter		
:MEDian	Path to control the median filter:		
[:STATE] 	Enable or disable median filter	ON	
[:STATE]?	Query state of median filter		
:RANK <NRf>	Specify rank for median filter	1	
:RANK?	Query rank		
:DAMPing 	Enable or disable damping	OFF	
:DAMPing?	Query state of damping		
:RESistance	Path to configure resistance:		√
:APERTure <n>	Set integration rate in seconds (166.67e-6 to 200e-3)	(Note 1) OFF	√
:AUTO 	Enable or disable auto aperture		
:AUTO ONCE	Enable and then disable auto aperture		
:AUTO?	Query auto aperture		
:APERTure?	Query aperture		√
:NPLCycles <n>	Set integration rate (line cycles; 0.01 to 10)	1	√
:AUTO 	Enable or disable auto NPLC	OFF	
:AUTO ONCE	Enable and then disable auto NPLC		
:AUTO?	Query auto line cycle integration		
:NPLCycles?	Query line cycle integration rate		√
[:AUTO]	Path to configure Auto V-source ohms		
:RANGE	Measurement ranges:		
[:UPPer] <n>	Select range (0 to 100e18)	2e6	
[:UPPer]?	Query range		
:AUTO 	Enable or disable auto range	(Note 4)	
:AUTO ONCE	Set range based on present input signal		
:ULIMit <n>	Set upper limit for auto range (0 to 100e18)	200e12	
:ULIMit?	Query upper limit		
:LLIMit <n>	Set lower limit for auto range (0 to 100e18)	2e6	
:LLIMit?	Query lower limit		
:AUTO?	Query auto range		

Table 14-8 (continued)
SENSe command summary

Command	Description	Default parameter	SCPI
:RESistance			
:MANual	Path to configure Manual V-source ohms:		
:CRANge	Path to configure measurement range:		
[:UPPer] <n>	Select range (0 to 21e-3)	20e-3	
[:UPPer]?	Query range		
:AUTO 	Enable or disable auto range	(Note 4)	
:AUTO ONCE	Set range based on present input signal		
:AUTO?	Query auto range	0	
:VSource	Path to control the V-source:		
[:AMPLitude] <n>	Specify V-source level (0 to 1000V)	100	
[:AMPLitude]?	Query V-source level		
:RANge <n>	Select V-source range; ≤100 selects 100V range, >100 selects 1000V range	0	
:RANge?	Query V-source range		
:OPERate 	Enable (operate) or disable (standby) V-source output	OFF	
:OPERate?	Query state of V-source		
:REFerence <n>	Specify ohms reference (-100e18 to +100e18)	0	√
:STATe 	Enable or disable ohms reference	OFF	√
:STATe?	Query state of ohms reference		√
:ACQuire	Use input signal as ohms reference		
:REFerence?	Query ohms reference value		√
:IREFerence 	Enable or disable amps reference		
:IREFerence?	Query state of amps reference		
:DIGits <n>	Specify measurement resolution (4 to 7)	6	
:AUTO 	Enable or disable auto resolution		
:AUTO ONCE	Enable and then disable auto resolution		
:AUTO?	Query auto resolution		
:DIGits?	Query resolution		
:AVERage	Path to control average filter		
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced)	SCALar	
:TYPE?	Query filter type		
:TCONtrol <name>	Select filter type: (MOVing OR REPeat)	(Note 3)	
:TCONtrol?	Query filter type		
:COUNT <n>	Specify filter count (1 to 100)	10	
:COUNT?	Query filter count		
:ADVanced	Path to configure and control advanced filter		
:NTOLerance <n>	Specify noise tolerance level (0 to 100%)	1	
:NTOLerance?	Query noise tolerance level		
[:STATe] 	Enable or disable digital filter	OFF	
[:STATe]?	Query state of digital filter		

Table 14-8 (continued)
SENSE command summary

Command	Description	Default parameter	SCPI
:RESistance			
:MEDian	Path to control median filter		
[:STATE] 	Enable or disable median filter	ON	
[:STATE]?	Query state of median filter		
:RANK <Nrf>	Specify range (1 to 5)	1	
:RANK?	Query rank		
:DAMPing 	Enable or disable damping	OFF	
:DAMPing?	Query state of damping		
:VSControl <name>	Select ohms V-source mode (MANual or AUTO)	MANual	
:VSControl?	Query ohms V-source mode		
:MSElect <name>	Select ohms measurement type (NORMal or RESistivity)	NORMal	
:MSElect?	Query ohms measurement type		
:RESistivity	Path to configure resistivity:		
:SThickness <Nrf>	Volume; specify sample thickness (0.0001 to 99.9999mm)	1mm	
:SThickness?	Query sample thickness		
:FSElect <name>	Specify test fixture (M8009 or USER)	M8009	
:FSElect?	Query test fixture		
:M8009	Path to query Model 8009 test fixture		
:RSwitch?	Query switch setting (surface or volume)		
:USER	Path to configure user test fixture		
:RSElect <name>	Specify measurement type (SURFace or VOLume)	SURFace	
:RSElect?	Query measurement type		
:KSURface <Nrf>	Surface; specify K_s (0.001 to 999.999)	1.000	
:KSURface?	Query, K_s		
:KVOLume <Nrf>	Volume; specify K_v (0.001 to 999.999)	1.000	
:KVOLume?	Query K_v		
:CHARge	Path to configure Coulombs		√
:APERture <n>	Set integration rate in seconds (166.67e-6 to 200e-3)	(Note 1) OFF	√
:AUTO 	Enable or disable auto aperture		
:AUTO ONCE	Enable and then disable auto aperture		
:AUTO?	Query auto aperture		
:APERture?	Query aperture (integration rate)	1	√
:NPLCycles <n>	Set integration rate (line cycles; 0.01 to 10)	OFF	√
:AUTO 	Enable or disable auto NPLC		
:AUTO ONCE	Enable and then disable auto NPLC		
:AUTO?	Query auto line cycle integration		
:NPLCycles?	Query line cycle integration rate		√

Table 14-8 (continued)
SENSE command summary

Command	Description	Default parameter	SCPI
:CHARge			✓
:RANGe	Path to configure measurement range:		✓
[:UPPer] <n>	Select range (0 to +2.1e-6)	2e-6	✓
[:UPPer]?	Query range		✓
:AUTO 	Enable or disable auto range	ON	✓
:AUTO ONCE	Set range based on present input signal		✓
:LGRoup <name>	Specify HIGH or LOW auto range limit	HIGH	
:LGRoup?	Query auto range limit		
:AUTO?	Query auto range		✓
:REFerence <n>	Specify reference (-2.1e-6 to +2.1e-6)	0	✓
:STATe 	Enable or disable reference	OFF	✓
:STATe?	Query state of reference		✓
:ACQuire	Use input signal as reference		
:REFerence?	Query reference value		✓
:DIGits <n>	Specify measurement resolution (4 to 7)	6	
:AUTO 	Enable or disable auto resolution		
:AUTO ONCE	Enable and then disable auto resolution		
:AUTO?	Query auto resolution		
:DIGits?	Query resolution		
:AVERage	Path to control the average filter		
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced)	NONE	
:TYPE?	Query filter type		
:TCONtrol <name>	Select filter type: (MOVing Or REPeat)	MOVing	
:TCONtrol?	Query filter type		
:COUNT <n>	Specify filter count (1 to 100)	10	
:COUNT?	Query filter count		
:ADVanced	Path to configure and control advanced filter		
:NTOLerance <n>	Specify noise tolerance level (0 to 100%)	1	
:NTOLerance?	Query noise tolerance level		
[:STATe] 	Enable or disable filter	OFF	
[:STATe]?	Query state of digital filter		
:MEDian	Path to control the median filter:		
[:STATe] 	Enable or disable median filter	ON	
[:STATe]?	Query state of median filter		
:RANK <NRf>	Specify rank for median filter	1	
:RANK?	Query rank		
:ADIScharge	Path to control auto discharge:		
[:STATe] 	Enable or disable auto discharge	OFF	
[:STATe]?	Query state of auto discharge		
:LEVel <NRf>	Specify level (-2.2e6 to 2.2e6)	2e-6	
:LEVel?	Query level		

Notes:

- 16.67ms for 60Hz power line frequency and 20ms for 50Hz line frequency.
- *RST — OFF, :SYSTem:PRESet — ON.
- *RST — REPeat, :SYSTem:PRESet — MOVing.
- *RST — ON, :SYSTem:PRESet — OFF.

Table 14-9
SOURce command summary

Command	Description	Default parameter	SCPI
:SOURce		(Note 1)	
:TTL[1]	Path to set digital output line #1:		
[:LEVel] 	Enable or disable line #1		
[:LEVel]?	Query state of line #1		
:TTL2	Path to set digital output line #2:		
[:LEVel] 	Enable or disable line #2		
[:LEVel]?	Query state of line #2		
:TTL3	Path to set digital output line #3:		
[:LEVel] 	Enable or disable line #3		
[:LEVel]?	Query state of line #3		
:TTL4	Path to set digital output line #4:		
[:LEVel] 	Enable or disable line #4		
[:LEVel]?	Query state of line #4		
:VOLTage	Path to set V-source level:		√
[:LEVel]			√
[:IMMediate]			√
[:AMPLitude] <n>	Set V-source level; 0 to ±1000 (volts)	0	√
[:AMPLitude]?	Query V-source level		√
:RANGe <n>	Select V-source range; ≤100 selects 100V range, >100 selects 1000V range	100	√
:RANGe?	Query V-source range		√
:LIMit	Path to control V-source voltage limit:		√
[:AMPLitude] <n>	Set voltage limit; 0 to 1000 (volts)	1000	√
[:AMPLitude]?	Query voltage limit		√
:STATe 	Enable or disable voltage limit	OFF	√
:STATe?	Query state of voltage limit		√
:MCONnect 	Enable or disable V-source LO to ammeter LO connection	OFF	
:MCONnect?	Query Low connection		
:CURRent	Path for current limit:		
:RLIMit	Path to control resistive current limit:		
:STATe 	Enable or disable resistive I-limit	OFF	
:STATe?	Query resistive I-limit		
:LIMit	Path to check current compliance:		
[:STATe]?	Query state of current compliance		

Notes:

- *RST and :SYSTEM:PRESet have no effect on the state of the output lines. However, cycling power sets all output lines false (OFF).

Table 14-10
STATus command summary

Command	Description	Default parameter	SCPI
:STATus			√
:MEASurement	Path to control measurement event registers:		
[:EVENT]?	Read the event register	(Note 2)	
:ENABle <NRf>	Program the enable register	(Note 3)	
:ENABle?	Read the enable register		
:PTRansition <NRf>	Program the positive transition register	(Note 4)	
:PTRansition?	Read the positive transition register		
:NTRansition <NRf>	Program the negative transition register	(Note 5)	
:NTRansition?	Read the negative transition register		
:CONDition?	Read the condition register		
:OPERation	Path to control operation status registers:		√
[:EVENT]?	Read the event register	(Note 2)	√
:ENABle <NRf>	Program the enable register	(Note 3)	√
:ENABle?	Read the enable register		√
:PTRansition <NRf>	Program the positive transition register	(Note 4)	√
:PTRansition?	Read the positive transition register		√
:NTRansition <NRf>	Program the negative transition register	(Note 5)	√
:NTRansition?	Read the negative transition register		√
:CONDition?	Read the condition register		√
:ARM	Path to control arm event registers:		√
[:EVENT]?	Read the event register	(Note 2)	√
:ENABle <NRf>	Program the enable register	(Note 3)	√
:ENABle?	Read the enable register		√
:PTRansition <NRf>	Program the positive transition register	(Note 4)	√
:PTRansition?	Read the positive transition register		√
:NTRansition <NRf>	Program the negative transition register	(Note 5)	√
:NTRansition?	Read the negative transition register		√
:CONDition?	Read the condition register		√
:SEQuence	Path to control sequence status registers:		√
[:EVENT]?	Read the event register	(Note 2)	√
:ENABle <NRf>	Program the enable register	(Note 3)	√
:ENABle?	Read the enable register		√
:PTRansition <NRf>	Program the positive transition register	(Note 4)	√
:PTRansition?	Read the positive transition register		√
:NTRansition <NRf>	Program the negative transition register	(Note 5)	√
:NTRansition?	Read the negative transition register		√
:CONDition?	Read the condition register		√

Table 14-10 (continued)
STATus command summary

Command	Description	Default parameter	SCPI
:STATus			
:OPERation			
:TRIGger	Path to control trigger status registers:		√
[:EVENT]?	Read the event register	(Note 2)	√
:ENABle <NRf>	Program the enable register	(Note 3)	√
:ENABle?	Read the enable register		√
:PTRansition <NRf>	Program the positive transition register	(Note 4)	√
:PTRansition?	Read the positive transition register		√
:NTRansition <NRf>	Program the negative transition register	(Note 5)	√
:NTRansition?	Read the negative transition register		√
:CONDition?	Read the condition register		√
:STATus			
:QUEStionable	Path to control questionable status registers:		√
[:EVENT]?	Read the event register	(Note 2)	√
:ENABle <NRf>	Program the enable register	(Note 3)	√
:ENABle?	Read the enable register		√
:PTRansition <NRf>	Program the positive transition register	(Note 4)	√
:PTRansition?	Read the positive transition register		√
:NTRansition <NRf>	Program the negative transition register	(Note 5)	√
:NTRansition?	Read the negative transition register		√
:CONDition?	Read the condition register		√
:PRESet	Return status registers to default states		√
:QUEue	Path to access error queue:		√
[:NEXT]?	Read the most recent error message	(Note 6)	√
:ENABle <list>	Specify error and status messages for queue	(Note 7)	√
:ENABle?	Read the enabled messages		√
:DISABle <list>	Specify messages not to be placed in queue	(Note 7)	√
:DISABle?	Read the disabled messages		√
:CLEar	Clears all messages from error queue		√

Notes:

Commands in this subsystem are not affected by *RST and :SYSTem:PRESet. The effects of cycling power, *CLS, and :STATus:PRESet are explained by the following notes.

1. Event registers: Power-up and *CLS: Clears all bits of the registers.
 :STATus:PRESet: No effect.
2. Enable registers: Power-up and :STATus:PRESet: Clears all bits of the registers.
 *CLS: No effect.
3. PTR registers: Power-up and :STATus:PRESet Sets all bits of the registers.
 *CLS: No effect.
4. NTR registers: Power-up and :STATus:PRESet Clears all bits of the registers.
 *CLS: No effect.
5. Error aueue: Power-up and *CLS: Clears the error queue.
 :STATus:PRESet: No effect.
6. Enable/disable error queue messages: Power-up: Clears list of messages.
 *CLS and :STATus:PRESet: No effect.

Table 14-12
TRACe command summary

Command	Description	Power-up defaults*	SCPI
:TRACe|:DATA	Use :TRACe or :DATA as root command		
:CLEAr	Clear readings from buffer		
:FREE?	Query bytes available and bytes in use		√
:POINTs <n>	Specify size of buffer		√
:AUTO 	Enable or disable auto buffer sizing.		√
:AUTO?	Query state of auto buffer sizing		√
:ACTual?	Query number of readings stored in the buffer		
:POINTs?	Query buffer size		√
:FEED	Path to control Feed commands		
:PRETrigger	Path to configure pre-trigger storage		
:AMOUNT	Path to specify number of pre-trigger readings		
[:PERCent] <n>	Specify % (0 to 100) of buffer		
[:PERCent]?	Query percentage		
:READings <n>	Specify as a number		
:READings?	Query number of readings		
:SOURce <name>	Select pre-trigger source event (EXTernal, TLINK, BUS, OR MANual)		
:SOURce?	Query pre-trigger source event		
:CONTRol <name>	Select buffer control mode (NEVer, NEXT, ALWays, OR PRETrigger)		√
:CONTRol?	Query buffer control mode		√
:DATA?	Read all readings in the buffer		√
:LAST?	Read last reading stored in buffer by Alternating Polarity test		
:TSTamp	Path to select time stamp format for buffer readings		
:FORMat <name>	Select time stamp format (ABSolute OR DELTa)		
:FORMat?	Query time stamp format		
:ELEMents <name>	Select reading elements (TSTamp, HUMidity, CHANnel, ETEMperature, VSource, NONE)		

*:SYSTEM:PRESet and *RST have no effect on the commands in this subsystem.

Table 14-13
Trigger command summary

Command	Description	Default parameter	SCPI
:INITiate	Subsystem command path:		√
[:IMMediate]	Initiate one trigger cycle		√
:CONTinuous 	Enable or disable continuous initiation	(Note 1)	√
:CONTinuous?	Query continuous initiation		√
:POFLag <name>	INCLude OR EXCLude no pending flag for initiate commands	INCLude	
:POFLag?	Query pending operation flag		
:ABORt	Reset trigger system		√
:ARM[:SEQuence[1]]	Path to configure arm layers:		√
[:LAYer[1]]	Path to program Arm Layer 1:		√
:IMMediate	Loop around control source		√
:COUNT <n>	Specify arm count (1 to 99999, or INF)	1	√
:COUNT?	Query arm count		√
:SOURce <name>	Select control source (HOLD, IMMediate, RTCLock, MANual, BUS, TLINK, or EXTernal)	IMMediate	(Note 2)
:SOURce?	Query control source		√
:SIGNal	Loop around control source		√
:TCONfigure	Path to configure triggers:		
:DIRection <name>	Enable (SOURce) or disable (ACCeptor)	ACCeptor	
:DIRection?	Query direction		
:ASYNchronous	Path to configure asynchronous trigger link:		
:ILINE <Nrf>	Select input line (1 to 6)	2	
:ILINE?	Query input line		
:OLINE <Nrf>	Select output line (1 to 6)	1	
:OLINE?	Query output line		
:RTCLock	Path to configure the RTCLock control source:		
:DATE <yr>, <mo>, <day>	Specify the date for the clock event		
:DATE?	Query the date for the clock event		
:TIME <hr>, <min>, <sec>	Specify the time for the clock event		
:TIME?	Query the time for the clock event		
:LAYer2	Path to program Arm Layer 2:		√
:IMMediate	Loop around control source		√
:COUNT <n>	Specify scan count (1 to 99999 or INF)	(Note 3)	√
:COUNT?	Query scan count		√
:DELay <n>	Program delay (0 to 999999.999 sec)	0	√
:DELay?	Query delay		√
:SOURce <name>	Select control source (HOLD, IMMediate, TIMer, MANual, BUS, TLINK, OR EXTernal)	IMMediate	(Note 2)

Table 14-13 (continued)
Trigger command summary

Command	Description	Default parameter	SCPI
:SOURce? :TIMer <n> :TIMer? :SIGNal :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <Nrf> :ILINe? :OLINe <Nrf> :OLINe?	Query control source Set timer interval (0 to 999999.999 sec) Query timer Loop around control source Path to configure triggers: Enable (SOURce) or disable (ACcEptor) Bypass Query direction Path to configure asynchronous trigger link: Select input line (1 to 6) Query input line Select output line (1 to 6) Query output line	0.1 ACcEptor 2 1	√ √ √ √
:TRIGger[:SEQuence[1]] :IMMediate :COUNT <n> :COUNT? :DELay <n> :DELay? :SOURce <name> :SOURce? :TIMer <n> :TIMer? :SIGNal :TCONfigure :PROTOcol <name> :PROTOcol? :DIRection <name> :DIRection? :ASYNchronous :ILINe <Nrf> :ILINe? :OLINe <Nrf> :OLINe? :SSYNchronous :LINE <Nrf> :LINE?	Path to program trigger layer: Loop around control source Set measure count (1 to 99999, or INF) Query measure count Set delay (0 to 999999.999 sec) Query delay Select control source (HOLD, IMMediate, TIMer, MANUal, BUS, TLINk, OR EXtErnal) Query control source Set timer interval (0 to 999999.999 sec) Request the programmed timer interval Loop around control source Path to configure triggers: Select protocol (ASYNchronous OR SSYNchronous) Query protocol Enable (SOURce) or disable (ACcEptor) Bypass Query direction Path to configure asynchronous trigger link: Select input line (1 to 6) Query input line Select output line (1 to 6) Query output line Path to configure semi-synchronous trigger link: Select trigger line (1 to 6) Query trigger line	(Note 3) 0 IMMediate 0.1 ASYN ACcEptor 2 1 1	√ √ √ √ (Note 2) √ √ √ √

Notes:

- Defaults for continuous initiation:
 :SYSTem:PRESet enables continuous initiation.
 *RST disables continuous initiation.
- TLINK and RTCLock (Arm Layer 1) are non-SCPI parameters for the :SOURce command. The command (:SOURce), and all the other parameters are SCPI confirmed.
- Defaults for count (Arm Layer 2 and trigger layer):
 :SYSTem:PRESet sets the count to INF (infinite).
 *RST sets the count to 1.

Table 14-14
:TSEquence command summary

Command	Description	Default parameter	SCPI
:TSEquence	Path to program test sequences:		
:ARM	Arms selected test sequence		
:ABORT	Stops a test sequence in process		
:TYPE <name>	Specify test; DLEakage, CLEakage, CIResistance, RVCoefficient, SRESistivity, VRESistivity, SIResistivity, SQSweep, STSweep, ALTPolarity	DLEakage	
:TYPE?	Query test type		
:TSource <name>	Specify trigger source; MANual, IMMEDIATE, BUS, TLINK, EXTERNAL, LCLosure	MANual	
:TSource?	Query trigger source		
:TLINe <NRf>	Specify TLINK line; 1 to 6	1	
:TLINe?	Query TLINK line		
DLEakage	Diode leakage test path:		
:START <NRf>	Specify start voltage; -1000 to 1000	+1V	
:START?	Query start voltage		
:STOP <NRf>	Specify stop voltage; -1000 to 1000	+10V	
:STOP?	Query stop voltage		
:STEP <NRf>	Specify step voltage; -1000 to 1000	+1V	
:STEP?	Query step voltage		
:MDElay <NRf>	Specify measure delay; 0 to 10000.0 (sec)	1 sec	
:MDElay?	Query measure delay		
:CLEakage	Capacitor leakage test path:		
:SVOLtage <NRf>	Specify bias voltage (-1000 to 1000)	+1V	
:SVOLtage?	Query bias voltage		
:SPOints <NRf>	Number points (1 to Max Buffer)	10	
:SPOints?	Query number of points		
:SPINterval <NRf>	Interval between points: 0 to 99999.9 (sec)	1 sec	
:SPINterval?	Query interval		
:CIResistance	Cable insulation resistance test path:		
:SVOLtage <NRf>	Specify bias voltage; -1000 to 1000	+1V	
:SVOLtage?	Query bias voltage		
:SPOints <NRf>	Number points (1 to Max Buffer)	5	
:SPOints?	Query number of points		
:SPINterval <NRf>	Interval between points: 0 to 99999.9 (sec)	1 sec	
:SPINterval?	Query interval		

Table 14-14 (continued)
:TSEquence command summary

Command	Description	Default parameter	SCPI
:TSEquence			
:RVCoefficient	Resistor voltage coefficient test path:		
:SVOLtage[1] <NRf>	Specify source voltage 1; -1000 to 1000	+1V	
:SVOLtage[1]?	Query source voltage		
:MDElay[1] <NRf>	Specify measure delay 1; 0 to 99999.9 (sec)	1 sec	
:MDElay[1]?	Query measure delay		
:SVOLtage2 <NRf>	Specify source voltage 2; -1000 to 1000	+2V	
:SVOLtage2?	Query source voltage		
:MDElay2 <NRf>	Specify measure delay 2; 0 to 99999.9 (sec)	1sec	
:MDElay2?	Query measure delay		
:SRESistivity	Surface resistivity test path:		
:PDTime <NRf>	Specify pre-discharge time; 0 to 9999.9 (sec)	0.2 sec	
:PDTime?	Query pre-discharge time		
:SVOLtage <NRf>	Specify bias voltage; -1000 to 1000	+500V	
:SVOLtage?	Query bias voltage		
:STIME <NRf>	Specify bias time; 0 to 99999.9 (sec)	1 sec	
:STIME?	Query bias time		
:MVOLtage <NRf>	Specify measure voltage; -1000 to 1000	+500V	
:MVOLtage?	Query measure voltage		
:MTIME <NRf>	Specify measure time; 0 to 9999.9 (sec)	1 sec	
:MTIME?	Query measure time		
:DTIME <NRf>	Specify discharge time; 0 to 99999.9 (sec)	2 sec	
:DTIME?	Query discharge time		
:VRESistivity	Volume resistivity test path:		
:PDTime <NRf>	Specify pre-discharge time; 0 to 99999.9 (sec)	10 sec	
:PDTime?	Query pre-discharge time		
:SVOLtage <NRf>	Specify bias voltage; -1000 to 1000	+500V	
:SVOLtage?	Query bias voltage		
:STIME <NRf>	Specify bias time; 0 to 99999.9 (sec)	1 sec	
:STIME?	Query bias time		
:MVOLtage <NRf>	Specify measure voltage; -1000 to 1000	+500V	
:MVOLtage?	Query measure voltage		
:MTIME <NRf>	Specify measure time; 0 to 9999.9 (sec)	1 sec	
:MTIME?	Query measure time		
:DTIME <NRf>	Specify discharge time; 0 to 99999.9 (sec)	2 sec	
:DTIME?	Query discharge time		

Table 14-14 (continued)
:TSEquence command summary

Command	Description	Default parameter	SCPI
:TSEquence			
:ALTPolarity	Alternating polarity resistance/resistivity test path:		
:OFSVoltage <NRf>	Specify offset voltage; -1000 to 1000	0V	
:OFSVoltage?	Query offset voltage		
:ALTVoltage <NRf>	Specify alternating voltage; -1000 to 1000	10V	
:ALTVoltage?	Query alternating voltage		
:MTIME <NRf>	Specify measurement time; 0.5 to 9999.9 (sec)	15 sec	
:MTIME?	Query measurement time		
:DISCard <NRf>	Specify number of initial readings to discard; 0 to 9999	3	
:DISCard?	Query number of initial readings to discard		
:READings <NRf>	Specify number of readings to store	1	
:READings?	Query number of readings to store		
:SIResistance	Surface insulation resistance test path:		
:SVOLtage <NRf>	Specify bias voltage; -1000 to 100	+50V	
:SVOLtage?	Query bias voltage		
:STIME <NRf>	Specify bias time; 0 to 99999.9 (sec)	1 sec	
:STIME?	Query bias time		
:MVOLtage <NRf>	Specify measure voltage; -1000 to 1000	+100V	
:MVOLtage?	Query measure voltage		
:MTIME <NRf>	Specify measure time; 0 to 9999.9 (sec)	1 sec	
:MTIME?	Query measure time		
:SQSweep	Square wave sweep test path:		
:HLEVel <NRf>	Specify high-level voltage; -1000 to 1000	+1V	
:HLEVel?	Query high-level voltage		
:HTIME <NRf>	Specify high-level time; 0 to 9999.9 (sec)	1 sec	
:HTIME?	Query high-level time		
:LLEVel <NRf>	Specify low-level voltage; -1000 to 1000	-1V	
:LLEVel?	Query low-level voltage		
:LTIME <NRf>	Specify low-level time; 0 to 9999.9 (sec)	1 sec	
:LTIME?	Query low-level time		
:COUNT <NRf>	Specify number cycles		
:COUNT?	Query cycle count		
:STSweep	Staircase sweep test path:		
:START <NRf>	Specify start voltage; -1000 to 1000	+1V	
:START?	Query start voltage		
:STOP <NRf>	Specify stop voltage; -1000 to 1000	+10V	
:STOP?	Query stop voltage		
:STEP <NRf>	Specify step voltage; -1000 to 1000	+1V	
:STEP?	Query step voltage		
:STIME <NRf>	Specify step time; 0 to 9999.9 (sec)	1 sec	
:STIME?	Query step time		

Table 14-15
:UNIT command summary

Command	Description	Power-up defaults
:UNIT :TEMPerature <name> :TEMPerature?	Select temperature units (C, CEL, F, FAR, K) Query temperature units	C

SCPI command subsystems

CALCulate subsystems

The commands in this subsystem are used to configure and control the three Calculate subsystems and are summarized in [Table 14-3](#).

CALCulate[1]

This subsystem is used to configure and control the polynomial and percent math calculations.

:FORMat <name>

:CALCulate[1]:FORMat <name> Specify CALC 1 format

Parameters <name> = NONE No calculation
 PERCent Percent calculation
 POLynomial Polynomial calculation
 RATio Ratio calculation
 DEVIation Deviation calculation
 PDEVIation Percent deviation calculation
 LOG10 Logarithmic base 10 calculation

Query :FORMat? Query programmed math format

Description This command is used to specify the format for the CALC 1 math calculation. With NONE selected, no CALC 1 calculation is performed. With one of the other formats selected and CALC 1 enabled (see the :STATE command below), the result of the calculation is displayed. The calculated reading is refreshed every time the instrument takes a reading.

KMATH commands

:MA0Factor <NRf>

:CALCulate[1]:KMATH:MA0Factor <NRf> Specify "a0" factor

Parameters <NRf> = -9.999999e30 to +9.999999e30

Query :MA0Factor? Query "a0" factor

Description This command is used to define the "a0" factor for the polynomial calculation.

:MA1Factor <NRf>

:CALCulate[1]:KMATH:MA1Factor <NRf> Specify "a1" factor

Parameters <NRf> = -9.999999e20 to +9.999999e20

Query :MA1Factor? Query "a1" factor

Description This command is used to specify the "a1" factor for the polynomial calculation.

:MA2Factor <NRf>

:CALCulate[1]:KMATH:MA2Factor <NRf> Specify "a2" factor

Parameters <NRf> = -9.999999e20 to +9.999999e20

Query :MA2Factor? Query "a2" factor

Description This command is used to specify the "a2" factor for the polynomial calculation.

:PERCent <NRf>

:CALCulate[1]:KMATH:PERCent <NRf> Specify percent target value

Parameters <NRf> = -9.999999e35 to +9.999999e35 Specify target value for percent calculation

Query :PERCent? Query percent target value

Description This command is used to specify the target value for the percent calculation.

:REFerence <NRf>

:CALCulate[1]:REFerence <NRf> Set reference value for ratio, deviation and percent deviation

Parameters <NRf> = -9.999999e35 to +9.999999e35 Specify reference value

Query :REFerence? Query reference value

Description This command is used to specify the reference value for the ratio, deviation and percent deviation calculation.

**:STATe **

:CALCulate[1]:STATe Control CALC 1

Parameters = 0 or OFF Disable CALC 1 calculation
1 or ON Enable CALC 1 calculation

Query :STATe? Query state (on or off) of CALC 1

Description This command is used to enable or disable the CALC 1 calculation. When enabled, each instrument reading will reflect the selected calculation (see [:FORMat <name>](#)).

DATA commands**[:LATest]?**

:CALCulate[1]:DATA[:LATest]? Read CALC 1 result

Description This query command is used to read the result of the CALC 1 calculation. If CALC 1 is disabled or NONE is selected, the "raw" reading will instead be read.

:FRESH?

:CALCulate[1]:DATA:FRESH? Recalculate CALC 1

Description This query command is used to return a new (fresh) math result of CALC1. This command will not request the same result twice. If a new reading is triggered, this command will wait until the math result is available. When CALC1 is disabled, there is no difference between SENS:DATA:FRES? and CALC:DATA:FRES?.

:IMMEDIATE

:CALCulate[1]:IMMEDIATE Recalculate CALC 1

Query :IMMEDIATE? Perform calculation and read result

Description When you change the math calculation, the next instrument reading reflects the new calculation (assuming CALC 1 math is enabled). If the instrument is not in a continuous measurement mode (for example, waiting for a trigger), the displayed reading will not update to reflect the new calculation until the next reading conversion occurs.

This action command allows you to re-process the current input data to reflect a new calculation. For example, assume the instrument is in a non-continuous measurement mode and requires a manual trigger to cause the next reading conversion. Changing the calculation will not affect the currently displayed reading. However, sending the :IMMEDIATE command re-processes that displayed reading to reflect the new calculation. Note that sending the :IMMEDIATE command does not initiate a reading conversion.

An alternate way to perform the calculation and read the result is by using the query form of the command (:IMMEDIATE?). When this command is sent, the calculation is performed and the result is queried.

CALCulate2

This calculate subsystem is used to configure and control CALC 2 operations on readings stored in the buffer.

:FORMAt <name>

:CALCulate2:FORMAt <name> Specify CALC 2 format

Parameters	<name> = MEAN	Mean value of readings in buffer
	SDEV	Standard deviation of readings in buffer
	MAX	Largest reading in buffer
	MIN	Lowest reading in buffer
	PKPK	Peak-to-peak value of readings in buffer
	NONE	No calculation

Query :FORMAt? Query programmed math format

Description This command is used to specify the format for the CALC 2 math calculation. The calculation operations for CALC 2 use data stored in the buffer.

With NONE selected, no CALC 2 calculation will be performed. With one of the other formats selected and CALC 2 enabled (see :STATE), the calculation is performed every time the :IMMEDIATE or :IMMEDIATE? command is executed.

PKPK = MAX - MIN

Where: MAX is the largest reading in the buffer, and MIN is the lowest reading in the buffer.

:STATe

	:CALCulate2:STATe 	Control CALC 2
Parameters	 = 0 or OFF 1 or ON	Disable CALC 2 calculation Enable CALC 2 calculation
Query	:STATe?	Query state (on or off) of CALC 2
Description	This command is used to enable or disable the CALC 2 calculation. When enabled, the selected CALC 2 format will be calculated when the :IMMediate or :IMMediate? command is executed.	

:IMMediate

	:CALCulate2:IMMediate	Perform CALC 2
Query	:IMMediate?	Perform calculation and read result
Description	The :IMMediate command is used to perform the selected CALC 2 operation on the readings in the buffer (assuming CALC 2 is enabled; see the previous :STATe command). After performing the calculation, the result can be read by using the :CALCulate2:DATA? query command. An alternate way to perform the calculation and read the result is by using the query form of the command (:IMMediate?). When this command is sent, the calculation is performed and the result is queried.	

DATA?

	:CALCulate2:DATA?	Read CALC 2 result
Description	This query command is used to read the result of the CALC 2 operation. If CALC 2 is disabled or NONE is selected, the "raw" reading will instead be read. Note that this command does not initiate a calculation. This command is used to simply read the result of the last calculation.	

CALCulate3

This Calculate subsystem is used to configure and control the limit tests (LIMIT 1 test and LIMIT 2 test).

[:DATA] <n>

	:CALCulate3:LIMit[1]:UPPer[:DATA] <n>	Specify upper LIMIT 1
	:CALCulate3:LIMit[1]:LOWer[:DATA] <n>	Specify lower LIMIT 1
	:CALCulate3:LIMit2:UPPer[:DATA] <n>	Specify upper LIMIT 2
	:CALCulate3:LIMit2:LOWer[:DATA] <n>	Specify lower LIMIT 2
Parameters	<n> = -9.999999e35 to +9.999999e35 DEFault MINimum MAXimum	Specify limit value Set specified upper limit to 1 Set specified lower limit to -1 Set specified limit to -9.999999e35 Set specified limit to +9.999999e35

Query	:UPPer?	Query specified upper limit
	:UPPer? DEFault	Query *RST default upper limit
	:UPPer? MINimum	Query lowest allowable upper limit
	:UPPer? MAXimum	Query largest allowable upper limit
	:LOWer?	Query specified lower limit
	:LOWer? DEFault	Query *RST default lower limit
	:LOWer? MINimum	Query lowest allowable lower limit
	:LOWer? MAXimum	Query largest allowable lower limit

Description These commands are used to set the upper and lower limits for LIMIT 1 and LIMIT 2. The actual limit depends on which measurement function is currently selected. For example, a limit value of 1 μ is 1 μ A for the amps function and 1 μ C for the coulombs function. A limit value is not range sensitive. A limit of 2 for volts is 2V on all measurement ranges.

:SOURce <NRf>

- :CALCulate3:LIMit[1]:UPPer:SOURce <NRf>
Specify pattern; upper LIMIT 1 failure
- :CALCulate3:LIMit[1]:LOWer:SOURce <NRf>
Specify pattern; lower LIMIT 1 failure
- :CALCulate3:LIMit2:UPPer:SOURce <NRf>
Specify pattern; upper LIMIT 2 failure
- :CALCulate3:LIMit2:LOWer:SOURce <NRf>
Specify pattern; lower LIMIT 2 failure

Parameters <NRf> = 0 to 15 Specify digital pattern for output port

Query :SOURce? Query source value for specified limit

Description These commands are used to specify which line(s) of the digital output port will go true when a limit test failure occurs. The first failure in the test sequence determines the digital output pattern. Subsequent failures in the test sequence will not change the digital output pattern on the output port. Each output line is assigned a decimal weight as follows:

<u>Digital Output</u>	<u>Decimal Weight</u>
Line #1	1
Line #2	2
Line #3	4
Line #4	8

The parameter value for the digital pattern is determined by adding the decimal weights of the desired output lines. For example, if you want output lines #2 and #3 to go true when the upper limit of LIMIT 1 is the first failure in the test sequence, use a parameter value of 6 (2+4).

The actual true state (high or low) of each digital output line depends on its programmed polarity. Polarity is programmed from the OUTPut subsystem.

Note that when the binning strobe is enabled (see *:BSTRobe:STATE *), output line #4 is not considered to be part of the digital output pattern. The binning strobe uses line #4. With the binning strobe enabled, parameters 8 through 15 are treated the same as parameters 0 through 7.

**:STATe **

	:CALCulate3:LIMit[1]:STATe 	Control LIMIT 1 test
	:CALCulate3:LIMit2:STATe 	Control LIMIT 2 test
Parameters	 =	1 or ON Enable specified limit test 0 or OFF Disable specified limit test
Query	:STATe?	Query state of specified limit test
Description	<p>These commands are used to enable or disable LIMIT 1 and LIMIT 2 tests. When enabled, the test sequence for limits will be performed every time the instrument performs a measurement. Testing is performed in the following sequence: Low Limit 1, High Limit 1, Low Limit 2 and High Limit 2. Any limit test (LIMIT 1 or LIMIT 2) not enabled is simply not performed.</p> <p>Note that when a limit test (LIMIT 1 or LIMIT 2) is enabled, the digital output port cannot be controlled from the source Subsystem.</p> <p>A fail indication (see :FAIL?) for LIMIT 1 or LIMIT 2 is cleared when the respective limit test is disabled.</p>	

:FAIL?

	:CALCulate3:LIMit[1]:FAIL?	Read LIMIT 1 test results
	:CALCulate3:LIMit2:FAIL?	Read LIMIT 2 test results
Description	<p>These commands are used to read the results of LIMIT 1 and LIMIT 2 tests:</p> <p>0 = Limit test passed 1 = Limit test failed</p> <p>The response message (0 or 1) only tells you if a limit test has passed or failed. It does not tell you which limit (upper or lower) has failed. To determine which limit has failed, you will have to read the transition filter event register.</p> <p>Reading the results of a limit test does not clear the fail indication of the test. A failure can be cleared by using a :CLEAr command, or by disabling the test (:STATe OFF).</p>	

CLEAr**[:IMMediate]**

	:CALCulate3:LIMit[1]:CLEAr[:IMMediate]	Clear LIMIT 1 test failure
	:CALCulate3:LIMit2:CLEAr[:IMMediate]	Clear LIMIT 2 test failure
Description	<p>These action commands are used to clear the fail indication of LIMIT 1 and LIMIT 2 tests. Note that a failure is also cleared when the limit test is disabled (:STATe OFF).</p>	

**:AUTO **

	:CALCulate3:LIMit[1]:CLEAr:AUTO 	Control auto-clear; LIMIT 1
	:CALCulate3:LIMit2:CLEAr:AUTO 	Control auto-clear; LIMIT 2
Parameters	 =	1 or ON Enable auto-clear for limit failure 0 or OFF Disable auto-clear for limit failure
Query	:AUTO?	Query state of auto clear

Description With auto-clear enabled, the fail indication of a limit test clears when instrument operation enters the idle state. With auto-clear disabled, the fail indication will remain until it is cleared by the `:CLear[:IMMEDIATE]` command.

:PASS:SOURce <NRf>

`:CALCulate3:PASS:SOURce <NRf>` Specify "pass" pattern

Parameters `<NRf> = 0 to 15` Specify digital pattern for output port

Query `:SOURce?` Query programmed source value

Description This command is used to specify which line(s) of the Digital Output Port will go true when there are no failures in the limit tests. Each output line is assigned a decimal weight as follows:

<u>Digital Output</u>	<u>Decimal Weight</u>
Line #1	1
Line #2	2
Line #3	4
Line #4	8

The parameter value for the digital pattern is determined by adding the decimal weights of the desired output lines. For example, if you want output lines #2 and #3 to go true when all enabled limit tests pass, use a parameter value of 6 (2+4).

The actual true state (high or low) of each digital output line depends on its programmed polarity. Polarity is programmed from the OUTPut Subsystem (see [OUTPut subsystems](#)).

Note that when the binning strobe is enabled (see `:BSTRobe:STATe `), output line #4 is not considered to be part of the digital output pattern. The binning strobe uses line #4. With the strobe enabled, parameter values 8 through 15 are treated the same as parameters 0 through 7.

:CLIMits:FAIL?

`:CALCulate3:CLIMits:FAIL?` Read composite result of limit tests

Description This query command is used to obtain the composite result of the LIMIT 1 and LIMIT 2 tests. The composite result is the logical OR'ed summary of LIMIT 1 and LIMIT 2:

- 1 = One or both tests have failed
- 0 = Both tests have passed

In the event of a failure (1), you can determine which test(s) has failed by using the fail command of each limit (`:LIMit1:FAIL?` and `:LIMit2:FAIL?`).

This command (like the other fail commands) does not clear the fail indication for LIMIT 1 or LIMIT 2.

**:BSTRobe:STATe **

`:CALCulate3:BSTRobe:STATe ` Control binning strobe

Parameters ` = 1 or ON` Enable binning strobe
`0 or OFF` Disable binning strobe

Query `:STATe?` Query state of binning strobe

Description This command is used to enable or disable the strobe for the binning operation. When enabled, digital output line #4 is used for the binning strobe pulse. After the

appropriate digital pattern is placed on the other three lines of the output port, the >10μsec strobe pulse is asserted on line #4. The strobe is used to "inform" your external binning circuit that the output port (lines 1, 2 and 3) is ready to be read.

:IMMediate

:CALCulate3:IMMediate Perform CALC 3

Description When you change the configuration of the limit test, the next reading is evaluated according to that new test configuration. If the instrument is not in a continuous measurement mode (for example, waiting for a manual trigger), the test will not be performed until the next reading conversion occurs.

This action command allows you to re-process the current input data to test new limits. For example, assume the instrument is in a non-continuous measurement mode and requires a manual trigger to cause the next reading conversion. Changing the test limits will not affect the last test result. However, sending the :IMMediate command re-processes the data and evaluates the reading according to the new test limits. Note that sending the :IMMediate command does not initiate a reading conversion.

DISPlay subsystem

The display subsystem controls the display of the Model 6517B and is summarized in [Table 14-4](#).

TEXT commands

:DATA <a>

:DISPlay[:WINDow[1]]:TEXT:DATA <a> Define message; top display
:DISPlay:WINDow2:TEXT:DATA <a> Define message; bottom display

Parameters

<a> = ASCII characters for message

Types: String 'aa...a' or "aa...a"
Indefinite Block #0aa...a
Definite Block #XYaa...a

Where: Y = number of characters in message:
Up to 20 for top display
Up to 32 for bottom display
X = number of digits that make up Y (1 or 2)

Query

:DATA? Query the defined text message

Description

These commands define text messages for display. A message can be as long as 20 characters for the top display, and up to 32 characters for the bottom display. A space is counted as a character. Excess message characters results in an error.

An indefinite block message must be the only command in the program message or the last command in the program message. If you include a command after an indefinite block message (on the same line), it will be treated as part of the message and is displayed instead of executed.

:STATe

:DISPlay[:WINDow[1]]:TEXT:STATe Control message; top display
:DISPlay:WINDow2:TEXT:STATe Control message; bottom display

Parameters

 = 0 or OFF Disable text message for specified display
1 or ON Enable text message for specified display

Query :STATe? Query state of message mode for specified display

Description These commands enable and disable the text message modes. When enabled, a defined message is displayed. When disabled, the message is removed from the display.

 GPIB operation: A user-defined text message remains displayed only as long as the instrument is in remote. Taking the instrument out of remote (by pressing the **LOCAL** key or sending LOCAL 27), cancels the message and disables the text message mode.

 RS-232 operation: A user-defined text message can only be cancelled by using this command to disable the message or by cycling power.

:ATTRIBUTES?

 :DISPlay[:WINDow[1]]:ATTRIBUTES? Query attributes; primary display

 :DISPlay:WINDow2:ATTRIBUTES? Query attributes; secondary display

Description This query command is used to determine which characters on the display are blinking and which are not. The response message provides that status of each character position for the specified display. The primary display consists of 20 characters and the secondary display consists of 32 characters.

 1 = Character is blinking

 0 = Character is not blinking

For example, assume the following menu is displayed with the SAVESETUP option blinking:

```

MAIN MENU
SAVESETUP COMMUNICATION TEST
    
```

The response message for :disp:attr? (primary display) will result in 20 zeroes:

```
00000000000000000000
```

The response message for :disp:wind2:attr? (secondary display) will display 1s at the character positions for **SAVESETUP**:

```
11111111100000000000000000000000
```

:DATA?

 :DISPlay[:WINDow[1]]:DATA? Read top display

 :DISPlay:WINDow2:DATA? Read bottom display

Description These query commands are used to read what is currently being displayed on the top and bottom displays. After sending one of these commands and addressing the Model 6517B to talk, the displayed data (message or reading) will be sent to the computer.

:CNDisplay

 :DISPlay:CNDisplay Clear (cancel) NEXT display

Description This action command is used to clear the bottom display of NEXT (or PREV) messages and cancel the operations associated with them. This command has no effect on any other message types.

**:SMESsage **

	:DISPlay:SMESsage 	Control status message
Parameters	 = 0 or OFF 1 or ON	Disable status messages Enable status messages
Query	:SMESsage?	Query state of status message mode
Description	This command is used to enable/disable the status message mode. The status message mode is a diagnostic tool that provides real-time messages that relate to the current operating state of the instrument. Table 2-4 lists the status messages.	

**:ENABLE **

	:DISPlay:ENABLE 	Control display circuitry
Parameters	 = 0 or OFF 1 or ON	Disable display circuitry Enable display circuitry
Query	:ENABLE?	Query state of display
Description	This command is used to enable and disable the front panel display circuitry. When disabled, the instrument operates at a higher speed. While disabled, the display is frozen with the following message: FRONT PANEL DISABLED Press LOCAL to resume. As reported by the message, all front panel controls (except LOCAL) are disabled. Normal display operation can be resumed by using the :ENABLE command to enable the display or by putting the Model 6517B into local.	

FORMat subsystem

The commands for this subsystem are used to select the data format for transferring instrument readings over the bus. The BORDer command and DATA command affect readings transferred from the buffer ONLY. (for example, SENSE: DATA? or CALC:DATA? is always be sent in ASCII.) These commands are summarized in [Table 14-5](#).

[:DATA] <type>[,length]

	:FORMat[:DATA] <type>[,<length>]	Specify data format
Parameters	<type>[,<length>] =	ASCII format
	REAL, 32	IEEE754 single precision format
	REAL, 64	IEEE754 double precision format
	SREa1	IEEE754 single precision format
	DREa1	IEEE754 double precision format

NOTE When using the ASCII, SREa1 or DREa1 parameter, a <length> parameter is not required. If you do not use a <length> parameter with the REAL parameter, the <length> defaults to 32 (single precision format).

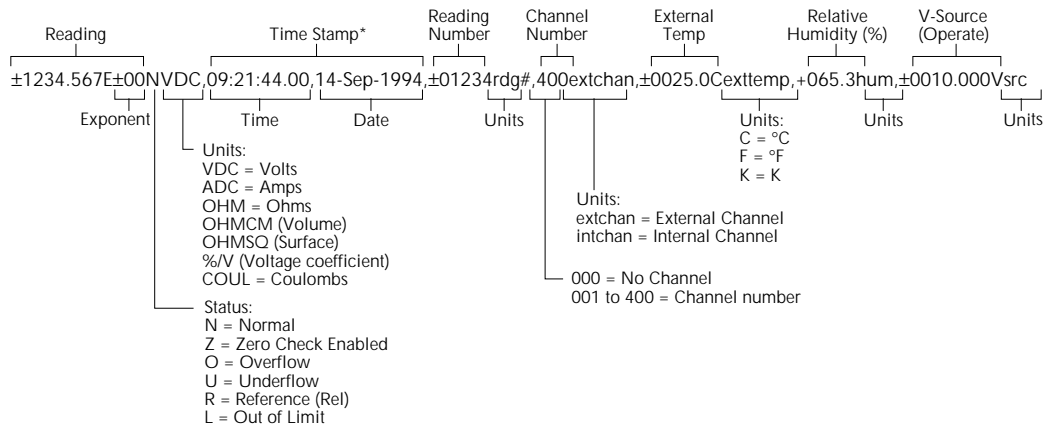
Query	[:DATA]?	Query data format
Description	This command is used to select the data format for transferring readings over the bus. For every reading conversion, the data string sent over the bus contains the elements specified by the :ELEMENTs command. The specified elements are sent in a particular order.	

The ASCII data format is in a direct readable form for the operator. Most BASIC languages easily convert ASCII mantissa and exponent to other formats. However, some speed is compromised to accommodate the conversion. [Figure 14-1](#) shows the ASCII format that includes all the data elements.

REAL, 32 or SREa1 will select the binary IEEE standard 754 single precision data format. [Figure 14-2](#) shows the normal byte order format for each data element. For example, if three valid elements are specified, the data string for each reading conversion is made up of three 32-bit data blocks. Note that the data string for each reading conversion is preceded by a 2-byte header that is the binary equivalent of an ASCII # sign and 0.

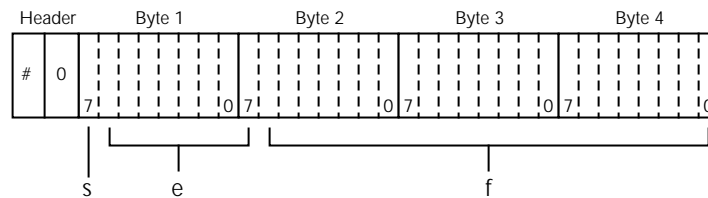
REAL, 64 or DREa1 selects the binary IEEE754 double precision data format and is shown in [Figure 14-3](#) (normal byte order shown). This format is similar to the single precision format except that it is 64 bits long.

Figure 14-1
ASCII data format



* Real time clock timestamp shown

Figure 14-2
IEEE754 single precision data format (32 data bits)

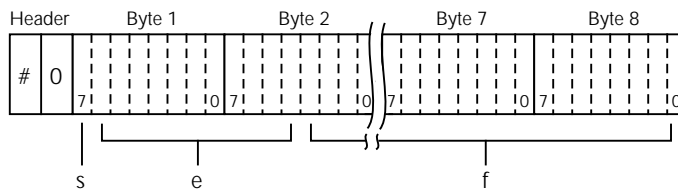


s = sign bit (0 = positive, 1 = negative)
e = exponent bits (8)
f = fraction bits (23)

Normal byte order shown. For swapped byte order, bytes sent in reverse order: Header, Byte 4, Byte 3, Byte 2, Byte 1.

The Header is only sent once for each measurement conversion.

Figure 14-3
IEEE754 double precision data format (64 data bits)



Bytes 3, 4, 5, and 6 not shown.

s = sign bit (0 = positive, 1 = negative)
e = exponent bits (11)
f = fraction bits (52)

Normal byte order shown. For swapped byte order,
bytes sent in reverse order: Header, Byte 8,
Byte 7 ... Byte 1.

The Header is only sent once for each measurement conversion.

:ELEMents <item list>

:FORMat:ELEMents <item list> Specify data elements for data string

Parameters	<item list>:READING	Includes reading in data string
	CHANnel	Includes channel number
	RNUMber	Includes reading number
	UNITs	Includes units
	TSTamp	Includes time stamp
	STATus	Includes status of reading
	HUMidity	Includes humidity reading
	ETEMPeratrue	Includes external temperature reading
	VSource	Includes V-source output

NOTE Each item in the list must be separated by a comma (,).

Query :ELEMents? Query elements in data string

Description This command is used to specify the elements to be included in the data string for each measurement conversion. You can specify from one to all six elements. Each element in the list must be separated by a comma (,). These elements, shown in [Figure 14-1](#), are explained as follows:

READING: Instrument reading. The resolution of this reading tracks the display resolution of the instrument. An overflow and out-of-limit read as +9.9E37; zero-check reads as +9.91E37; underflow reads as 0.00E00.

CHANnel: Corresponds the instrument reading to the channel number of a switching card. If not scanning, the channel number is 000.

RNUMber: The instrument keeps track of the number of readings it has performed. This reading counter starts at zero when the instrument is turned on or when :SYSTEM:RNUMber:RESet is sent over the bus. When a reading is sent over the bus (for example, :FETCh?), the RNUMber element indicates the reading number. The instrument also keeps track of the number of readings it has stored in the buffer. When buffer readings are sent over the bus (:TRACe:DATA?), each reading number is referenced to the first reading, which is #0, stored in the buffer.

If using the pre-trigger to store readings, the pre-trigger readings are assigned negative numbers.

UNITs: This element attaches the function unit to the reading, the time unit (sec) to the time stamp, and the channel unit (internal or external) to the channel number. An internal channel refers to an internally installed switching card channel, while an external channel refers to the channel for an external switch system. This element is not available for the binary formats.

TIMEstamp: A time stamp is available to reference each reading to a point in time. There are two basic types of time stamps: real-time time stamp and relative time time stamp. The real-time time stamp provides the time (24-hour clock format) and date for each reading sent over the bus. The relative time stamp operates as a timer that starts at zero seconds when the instrument is turned on or when the relative time stamp is reset (`:SYSTem:TSTamp:RELative:RESet`). See the `:SYSTem:TSTamp:RELative:RESet` definition for the `:RELative:RESet` command for more information. The time stamp for each reading sent over the bus is referenced, in seconds, to the start time. After 99,999.999999 seconds, the timer resets back to zero and starts over.

TIMEstamp is also available for buffer readings. **TIMEstamp** can be referenced to the first reading stored in the buffer (absolute format) which is time stamped at 0 seconds, or can provide the time between each reading (delta format). The `:TRACe:TSTamp:FORMat` command is used to select the absolute or delta format. For the delta format, real-time time stamp is expressed as the days, hours, minutes and seconds between each reading, while the relative time stamp is expressed as seconds between each reading. When using the absolute format for the relative time stamp, any pre-trigger readings will have a negative time stamp.

STATus: This element indicates if the reading is normal (N), overflowed (O) or referenced (R) to another value, zero (Z), underflow (U), out-of-limits (L). This element is not available for the binary formats.

HUMidity: Relative humidity can be read by connecting (and enabling) the Model 6517-RH humidity probe to the instrument. The humidity probe is enabled or disabled from the `:SYSTem` Subsystem. A reading of 999.99 means humidity is disabled. This data element includes the humidity reading (in %) in the data string.

ETEMperature: External temperature can be measured by connecting (and enabling) the Model 6517-TP temperature sensor to the instrument. The temperature sensor is enabled or disabled from the `:SYSTem` Subsystem. A reading of 9999.99 means temperature is disabled. This data element includes the temperature reading (in °C, °F or K) in the data string. Temperature units are selected from the `:UNIT` subsystem.

VSource: This element indicates the voltage that is being sourced by the V-source. In standby, 0V is sourced.

The ASCII format shown in [Figure 14-1](#) shows the byte order of the data string. Keep in mind that the byte order can only be reversed for the binary formats.

When using this command to add an element, you must include all elements that you want in the format. For example, if the reading is already specified and you want to add the time-stamp, you must include the `READing` parameter.

```
:form:elem time, read.
```

Data elements for the item list can be listed in any order, but are always sent in the order shown in [Figure 14-1](#).

:BORDER <name>

	<code>:FORMat:BORDER <name></code>	Specify binary byte order
Parameters	<code><name> = NORMal</code> <code> SWAPped</code>	Normal byte order for binary formats Reverse byte order for binary formats
Query	<code>:BORDER?</code>	Query byte order
Description	This command is used to control the byte order for the IEEE754 binary formats. For normal byte order, the data format for each element is sent as follows: Byte 1 Byte 2 Byte 3 Byte 4 (Single precision) Byte 1 Byte 2 ... Byte 8 (Double precision) For reverse byte order, the data format for each element is sent as follows: Byte 4 Byte 3 Byte 2 Byte 1 (Single precision) Byte 8 Byte 7 ... Byte 1 (Double precision) The “#,0” Header is not affected by this command. The Header is always sent at the beginning of the data string for each measurement conversion. The ASCII data format can only be sent in the normal byte order. The <code>SWAPped</code> selection is simply ignored when the ASCII format is selected.	

OUTPut subsystems

The Output subsystems are used to control the V-source (standby or operate), and set polarities for the digital output port. Commands for these subsystems are summarized in [Table 14-6](#).

:OUTPut1 subsystem**[:STATe] **

	<code>:OUTPut1[:STATe] </code>	Control V-source
Parameters	<code> = ON or 1</code> <code> OFF or 0</code>	Enable V-source (operate) Disable V-source (standby)
Query	<code>[:STATe]?</code>	Query state of V-source
Description	This command is used to enable or disable the V-source. When enabled, the V-source is placed in operate. When disabled, the V-source is placed in standby. The V-source is configured from the <code>:SOURCE</code> subsystem. Note that the V-source for Auto-V-source Ohms is controlled from the <code>:SENSe</code> Subsystem.	

:OUTPut2 subsystem**:LSENse <name>**

	<code>:OUTPut2:TTL[1]:LSENse <name></code>	Set polarity of line #1
	<code>:OUTPut2:TTL2:LSENse <name></code>	Set polarity of line #2
	<code>:OUTPut2:TTL3:LSENse <name></code>	Set polarity of line #3
	<code>:OUTPut2:TTL4:LSENse <name></code>	Set polarity of line #4
Parameters	<code><name> = AHIGH</code> <code> ALOW</code>	Set polarity of specified line to active high Set polarity of specified line to active low
Query	<code>:LSENse?</code>	Query polarity of specified line

Description These commands are used to set the polarity of the digital output lines. When set for active high (AHIGH) polarity, the specified output line is true (ON) when the output level is high. The output line is false (OFF) when the output level is low. When set for active low (ALOW) polarity, the output line is true (ON) when the output level is low. The output line is false (OFF) when the output level is high.

The logic levels (true or false) of the digital output lines are set from the SOURCE Subsystem.

:ROUTe subsystem

The commands in this subsystem are used to configure and control switching and are summarized in [Table 14-7](#).

:CLOSe <list>

	:ROUTe:CLOSe <list>	Close specified channel
Parameters	<list> = (@ chanlist)	Specify channel to be closed where: chanlist is the channel (1 to 10) to be closed
Query	CLOSe? <list>	Query specified channel
Description	<p>The :CLOSe <list> command is used to close a channel on an optional scanner card installed in the Model 6517B. Only one channel can be closed at a time. Thus, for this command, the chanlist must consist of only one channel. When this command is sent, any other closed channel will first open and then the specified channel will close.</p> <p>The :CLOSe? <list> query command is used to determine the state (closed or not closed) of each channel specified by the list parameter. For this command, the chanlist can consist of multiple channels. The following examples demonstrate the various forms for expressing the channel list.</p> <p>List = (@ 2) Single channel (@ 2,4,6) Multiple channels separated by commas (,) (@ 1:10) Range of channels (1 through 10); range limits separated by a colon (:) (@ 1:5,7) Range entry and single entry separated by a comma</p> <p>After sending this query command and addressing the Model 6517B to talk, the values for the specified channels are sent to the computer. A value of "1" indicates that the channel is closed, and a "0" indicates that the channel is not closed.</p>	

STATe?

	:ROUTe:CLOSe:STATe?	Query closed channel
Description	<p>This query command is used to determine which (if any) channel on the internal scanner card is closed. After sending this command and addressing the Model 6517B to talk, the channel list is sent to the computer.</p>	

:OPEN <list>

	:ROUTe:OPEN <list>	Open closed channel
Parameters	<list> = (@ chanlist)	Specify channel to open
	ALL	Open all channels
	Where: colonist = 1 to 10	
Query	:OPEN? <list>	Query specified channel

Description The `:OPEN <list>` command is used to open a channel on the internal scanner card. Since only one channel can be closed, the chanlist for this command can only consist of one channel. An alternate way to open a closed channel is to simply use the `ALL` parameter. It opens whichever channel is closed.

The `:OPEN? <list>` query command is used to determine the state (opened or not opened) of each channel specified by the list parameter. For this command, the chanlist can consist of multiple channels. See `:CLOSE <list>` for examples to express a chanlist.

After sending this query command and addressing the Model 6517B to talk, the values for the specified channels are sent to the computer. A value of "1" indicates that the channel is open, and a "0" indicates that the channel is not open.

:OPEN:ALL

`:ROUTE:OPEN:ALL` Open closed channel

Description This action command is used to open a closed channel on the internal scanner card. Note that this command performs the same function as the `:ROUTE:OPEN ALL` command that was previously discussed.

:SCAN commands

[:INTernal] <list>

`:ROUTE:SCAN[:INTernal] <list>` Define internal scan list and enable scan

Parameters `<list> = (@ scanlist)`
where; scanlist is the specified list of channels (1 to 10) to be scanned

Query `[:INTernal]?` Query programmed scan list

Description This command is used to define the scan list for the internal scanner card. The scan list can contain 2 to 10 channels. The following examples demonstrate the various forms for expressing a scan list:

`list = (@ 2,4,6)` Channels separated by commas (,)
`(@ 1:8)` Range of channels (1 through 8);
range limits separated by a colon (:)
`(@ 1:5,7)` Range entry and single entry separated by a comma

Refer to the instruction manual for the scanner card for details on scanning (see [Scanning](#) in Section 10 for more information).

:EXTERNAL <n>

`:ROUTE:SCAN:EXTERNAL <n>` Specify number of external channels

Parameters `<n> =`

1 to 400	Specify number of external channels
DEFault	10 external channels
MINimum	1 external channel
MAXimum	400 external channels

Query

<code>:EXTERNAL?</code>	Query programmed number of external channels
<code>:EXTERNAL? DEFault</code>	Query *RST default channel number value
<code>:EXTERNAL? MINimum</code>	Query minimum channel number value
<code>:EXTERNAL? MAXimum</code>	Query maximum channel number value

Description The Model 6517B can operate with an external switch system, such as the Keithley Instruments Model 7001 or 7002. The Model 6517B can measure up to

400 channels that are switched by the external switching system. This command is used to specify the number of external channels to scan.

The external scan by the Model 6517B is enabled by the `ROUTE:SCAN:LSElect EXTERNAL` command.

:LSElect <name>

`:ROUTE:SCAN:LSElect <name>` Perform specified scan operation

Parameters <name> = INTERNAL Enable scan for internal scanner card
 EXTERNAL Enable scan for external scanner card
 NONE Disable all scan operations

Query :LSElect? Query scan operation

Description This command is used to select and perform the desired scan operation. When INTERNAL is selected, the Model 6517B scans the channels of the internal switching card according to how the scan is configured. See [:INTERNAL <list>] for more information on :ROUTE:SCAN[:INTERNAL] <list>. EXTERNAL is used to measure channels that are controlled by an external switch system. When EXTERNAL is selected, the Model 6517B scans the channels of the external scanner card. The :ROUTE:SCAN:EXTERNAL command is used to specify the number of external channels to scan. See :EXTERNAL <n> for more information on :ROUTE:SCAN:EXTERNAL] <n>.

The NONE selection disables all operations associated with a scan.

:STIME <n>

`:ROUTE:SCAN:STIME <n>` Specify settling time

Parameters <n> = 0.003 to 99999.999 Specify settling time in seconds
 DEFAULT 0 seconds
 MINIMUM 0 seconds
 MAXIMUM 99999.999 seconds

Query :EXTERNAL? Query programmed settling time
 :EXTERNAL? DEFAULT Query *RST default settling time
 :EXTERNAL? MINIMUM Query minimum settling time
 :EXTERNAL? MAXIMUM Query maximum settling time

Description This command is used to specify the settling time for the relay switches on the internal scanner card. After each switch closes, a measurement will not occur until after the specified settling time expires.

:SMETHOD <name>

`:ROUTE:SCAN:SMETHOD <name>` Select switching method

Parameters <name> = VOLTAGE Break-before-make switching method
 CURRENT Normal switching method

Query :SMETHOD? Query switching method

Description This command is used to select the switching method during an internal scan. The VOLTAGE method ensures that each switch will open (break) before the next switch in the scan closes (make). This method ensures that two or more channels cannot be closed at the same time.

Use the CURRENT switching method for optimum speed in applications where "break-before-make" is not necessary.

**:VSLimit **

	<code>:ROUTe:SCAN:VSLimit </code>	Control 200V V-source Limit
Parameters	<code> = 0 or OFF</code> <code>1 or ON</code>	Disable 200V V-source Limit Enable 200V V-source Limit
Query	<code>:VSLimit?</code>	Query state of 200V V-source limit
Description	This 200V V-source limit is used to help protect internal scanner cards from high voltage that could damage them. With the 200V limit enabled, the V-source can never source more than +/-200V.	
	Note that the <code>:SOURce:VOLTage:LIMit</code> command is also used to set the voltage limit of the V-source. Of the two voltage limit methods, the one that is set to the lower limit value (absolute) is the one that will be in effect.	

:SENSe1 subsystem

The `:SENSe1` subsystem is used to configure and control the measurement functions of the Model 6517B. The commands for this subsystem are summarized in [Table 14-8](#).

Function command

The function command selects volts, amps, ohms and coulombs. Note that a function does not have to be selected in order to program its various configurations. When the function is later selected, it assumes the programmed states.

:FUNCTION <name>

	<code>[:SENSe[1]]:FUNCTION <name></code>	Select measurement function
Parameters	<code><name> = 'VOLTage[:DC]'</code> <code>'CURRent[:DC]'</code> <code>'RESistance'</code> <code>'CHARge'</code>	Select Volts Select Amps Select Ohms Select Coulombs
Query	<code>:FUNCTION?</code>	Query currently programmed function
Description	The <code>:FUNCTION</code> command is used to select the measurement function of the instrument. Note that parameter names are enclosed in single quotes ('). However, double quotes (") can instead be used. For example: <code>:func 'volt' = :func "volt"</code>	
	Each measurement function remembers its own unique setup configuration, such as range, speed, resolution, filter and rel. This eliminates the need to re-program setup conditions every time you switch from one function to another.	

:DATA commands

The data commands are primarily used to return a reading to the computer. Humidity, external temperature, and change from calibration temperature readings can also be included in the data string if they are included as data elements. See [FORMat subsystem](#) to select data elements.

[:LATest]?

	<code>[:SENSe[1]]:DATA[:LATest]?</code>	Return latest reading
Description	This query command is used to read the latest instrument reading. This command returns the raw reading or a reading that is the result of the reference (REL from the front panel) operation. For example, if a reference value of 1.0 is established,	

the reading returned by this command is the raw reading minus 1.0. Calculated (MATH) readings cannot be read with this command (*CALCulate subsystems* to read math calculations).

The reading is returned in exponent form. For example, a 10V DC reading will be displayed on the CRT as follows:

+1.000000E+01

Notice that the measurement function is not included in the response message. Thus, you may want to perform a function query (*:FUNction <name>*) after a reading query.

:FRESH?

[:SENSe[1]] :DATA:FRESH? Return new reading

Description This query command is used to return a new (fresh) reading. This reading will not request the same reading twice. If a new reading is triggered, this command will wait until the reading is available, rather than request the old reading.

Sending this query command before the instrument is finished processing previous commands will cause the Model 6517B to lock up. One way to prevent this is to insert an appropriate delay in the program. The required delay can be up to six seconds. Program Fragment 1 shows how to use a specific delay with the :FRESH? command.

The *OPC? command can also be used to incorporate the necessary delay. When *OPC? is used properly, all previous commands will be allowed to finish before :FRESH? is executed.

:APERTure <n>

[:SENSe[1]] :VOLTage[:DC] :APERTure <n> Set aperture for Volts
 [:SENSe[1]] :CURRent[:DC] :APERTure <n> Set aperture for Amps
 [:SENSe[1]] :RESistance :APERTure <n> Set aperture for Ohms
 [:SENSe[1]] :CHARge :APERTure <n> Set aperture for Coulombs

Parameters <n> = 166.666666667e-6 to 200e-3 Integration period in seconds
 DEFault Power line cycle integration:
 16.67msec for 60Hz power line
 20msec for 50Hz and 400Hz power line
 MINimum 166.666666667e-6sec
 MAXimum 200msec

Query :APERTure? Query programmed aperture value
 :APERTure? DEFault Query *RST default aperture value
 :APERTure? MINimum Query minimum aperture value
 :APERTure? MAXimum Query maximum aperture value

Description The integration period (measurement speed) for the Model 6517B can be set using either of two commands: NPLCycle or :APERTure. The NPLC method specifies the integration period as the number of power line cycles per integration, while aperture specifies the time (in seconds) per integration. The relationship between NPLC and aperture is expressed as follows:

$$Aperture = \frac{NPLC}{f}$$

Where:

Aperture is the integration rate in seconds per integration.

NPLC is the number of power line cycles per integration.

f is the power line frequency.

For 400Hz line power, use 50Hz to calculate aperture.

When the integration period is set using the `:APERTure` command, the value for the `:NPLCycle` command changes accordingly to reflect the new integration period. Conversely, if the integration period is set using the `:NPLCycle` command, the value for the `:APERTure` command changes accordingly.

On power-up, the instrument uses the NPLC value to determine the integration period. Thus, if using a different power line frequency, NPLC will remain the same, but aperture may change.

NOTE If line synchronization is enabled (`:LSYNc:STATe `), the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero volts.

:AUTO |ONCE

```
[ :SENSe[1] ]:VOLTage[:DC]:APERTure:AUTO <b>|ONCE
```

Control auto aperture; Volts

```
[ :SENSe[1] ]:CURRent[:DC]:APERTure:AUTO <b>|ONCE
```

Control auto aperture; Amps

```
[ :SENSe[1] ]:RESistance:APERTure:AUTO <b>|ONCE
```

Control auto aperture; Ohms

```
[ :SENSe[1] ]:CHARge:APERTure:AUTO <b>|ONCE
```

Control auto aperture; Coulombs

Parameters	<code> =</code>	1 or ON	Enable auto aperture
		0 or OFF	Disable auto aperture
		ONCE	Enable and then disable auto aperture

Query	<code>:AUTO?</code>	Query state of auto aperture
--------------	---------------------	------------------------------

Description These commands are used to enable or disable auto aperture for the specified measurement function. With auto aperture enabled, the instrument automatically optimizes the aperture value for the present resolution setting. This is the same as selecting SET-BY-RSLN from the front panel.

[Table 5-5](#) provides the integration times for SET-BY-RSLN (AUTO). Note that the times are provided as NPLC values. To convert to aperture times, use the formula on the previous page.

The ONCE parameter is analogous to a momentary toggle switch. When `:AUTO ONCE` is sent, auto aperture turns on momentarily and then disables. While enabled, it automatically selects the appropriate value as summarized in the tables. When auto aperture disables, the aperture remains at the selected value.

`:APERTure:AUTO` is coupled to the command that manually sets the aperture value (`:APERTure <n>`). When auto aperture is enabled, the parameter value for

:APERTure <n> changes to the automatically selected aperture value. Thus, when auto aperture is disabled, the aperture remains at the automatically selected value. Also, a valid aperture value sent using the :APERTure <n> command disables auto aperture.

Auto aperture is also coupled to auto NPLC. Enabling or disabling auto aperture also enables or disables auto NPLC. Also, a valid NPLC value sent using the :NPLC command disables auto aperture.

:NPLCycles <n>

```
[ :SENSE[1] ]:VOLTage[:DC]:NPLCycles <n> Set NPLC for Volts
[ :SENSE[1] ]:CURRent[:DC]:NPLCycles <n> Set NPLC for Amps
[ :SENSE[1] ]:RESistance:NPLCycles <n> Set NPLC for Ohms
[ :SENSE[1] ]:CHARge:NPLCycles <n> Set NPLC for Coulombs
```

Parameters <n> = 0.01 to 10 Power line cycles per integration
 DEFault 1
 MINimum 0.01
 MAXimum 10

Query :NPLCycles? Query programmed NPLC value
 :NPLCycles? DEFault Query *RST default value
 :NPLCycles? MINimum Query minimum NPLC value
 :NPLCycles? MAXimum Query maximum NPLC value

Description The integration period (measurement speed) for the Model 6517B can be set using either of two commands; :APERTure or :NPLCycles. Aperture specifies time (in seconds) per integration, while NPLC expresses the integration period by basing it on the power line frequency.

When the integration period is set using the :NPLCycles command, the time value for the :APERTure command changes accordingly to reflect the new integration rate. Conversely, if the integration period is set using the :APERTure command, the value for the :NPLCycles command changes accordingly.

On power-up, the instrument uses the NPLC value to determine the integration period.

NOTE If line synchronization is enabled (see :LSYNc:STATE in "SYSTEM subsystem"), the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero volts.

:AUTO |ONCE

```
[ :SENSE[1] ]:VOLTage[:DC]:NPLCycles:AUTO <b>|ONCE Control auto NPLC for Volts
[ :SENSE[1] ]:CURRent[:DC]:NPLCycles:AUTO <b>|ONCE Control auto NPLC for Amps
[ :SENSE[1] ]:RESistance:NPLCycles:AUTO <b>|ONCE Control auto NPLC for Ohms
[ :SENSE[1] ]:CHARge:NPLCycles:AUTO <b>|ONCE Control auto NPLC for Coulombs
```

Parameters = 1 or ON Enable auto NPLC
 0 or OFF Disable auto NPLC
 ONCE Enable and then disable auto NPLC

Query	<code>:AUTO?</code>	Query state of auto NPLC
Description	<p>These commands are used to enable or disable auto NPLC for the specified measurement function. With auto NPLC enabled, the instrument automatically optimizes the NPLC value for the present resolution setting. Table 5-5 provides the integration times for SET-BY-RSLN (AUTO).</p> <p>The ONCE parameter is analogous to a momentary toggle switch. When <code>:AUTO ONCE</code> is sent, auto NPLC turns on momentarily and then disables. While enabled, it automatically selects the appropriate value as summarized in the tables. When auto NPLC disables, NPLC remains at the selected value.</p> <p><code>:NPLC:AUTO</code> is coupled to the command that manually sets the NPLC value (<code>:NPLC <n></code>). When auto NPLC is enabled, the parameter value for <code>:NPLC <n></code> changes to the automatically selected NPLC value. Thus, when auto NPLC is disabled, NPLC remains at the automatically selected value. Also, a valid NPLC value sent using the <code>:NPLC <n></code> command disables auto NPLC.</p> <p>Auto NPLC is also coupled to auto aperture. Enabling or disabling auto NPLC also enables or disables auto Aperture. Also, a valid aperture value sent using the <code>:APERTure</code> command disables auto NPLC.</p>	

:RANGE commands

Volts, Amps and Coulombs ranges:

[[:UPPer] <n>

```
[:SENSE[1]]:VOLTage[:DC]:RANGE[:UPPer] <n>
                                     Set measurement range for Volts
[:SENSE[1]]:CURRent[:DC]:RANGE[:UPPer] <n>
                                     Set measurement range for Amps
[:SENSE[1]]:CHARge:RANGE[:UPPer] <n>
                                     Set measurement range for Coulombs
```

Parameters	<code><n> =</code>	0 to 210	Expected reading in volts
		0 to 21e-3	Expected reading in amps
		0 to 2.1e-6	Expected reading in coulombs
	<code>DEFault</code>	210 (volts)	
		21e-3 (amps)	
		2.1e-6 (coulombs)	
	<code>MINimum</code>	0 (all functions)	
	<code>MAXimum</code>	Same as <code>DEFault</code>	
Query	<code>:RANGE[:UPPer]?</code>		Query programmed measurement range
	<code>:RANGE[:UPPer]? DEFault</code>		Query *RST default range
	<code>:RANGE[:UPPer]? MINimum</code>		Query lowest measurement range
	<code>:RANGE[:UPPer]? MAXimum</code>		Query highest measurement range

Description	<p>This command is used to manually select the measurement range for the specified measurement function. The range is selected by specifying the expected reading as an absolute value. The Model 6517B will then go to the most sensitive range that will accommodate that expected reading. For example, if you expect a reading of approximately 10mA, simply let the parameter (<code><n></code>) = 0.01 (or 10e-3) in order to select the 20mA range.</p>		
--------------------	--	--	--

:AUTO |ONCE

```
[ :SENSe[1] ] :VOLTagE[ :DC ] :RANGe :AUTO <b> | ONCE
Control auto range for Volts
[ :SENSe[1] ] :CURRent[ :DC ] :RANGe :AUTO <b> | ONCE
Control auto range for Amps
[ :SENSe[1] ] :CHARGe :RANGe :AUTO <b> | ONCE
Control auto range for Coulombs
```

Parameters

 =	1 or ON	Enable auto range
	0 or OFF	Disable auto range
	ONCE	Enable and then disable auto range

Query :AUTO? Query autorange (on or off)

Description These commands are used to control autoranging. With autoranging enabled, the instrument automatically goes to the most sensitive range to perform the measurement (*Measurement range*).

The ONCE parameter is analogous to a momentary toggle switch. When :RANGe:AUTO ONCE is sent, auto range enables and the most sensitive range is selected for the input signal. Auto range will then disable, but the selected measurement range is retained. Note that the instrument must currently be on the specified function in order for ONCE to be effective. Using ONCE while on any other function results in an error.

The autorange command (:RANGe:AUTO) is coupled to the command that manually selects the measurement range (:RANGe <n>). When autorange is enabled, the parameter value for :RANGe <n> changes to the automatically selected range value. Thus, when autorange is disabled, the instrument remains at the automatically selected range. When a valid :RANGe <n> command is sent, autoranging disables.

When using auto range, upper and lower range limits can be established to keep the instrument from autoranging to ranges that are not going to be used. (See :ULIMit <n> and :LLIMit <n>).

NOTE Allow sufficient time for settling when autoranging over multiple ranges or down to the lower current ranges, or erroneous readings may occur.

:ULIMit <n>

```
[ :SENSe[1] ] :VOLTagE[ :DC ] :RANGe :AUTO :ULIMit <n>
Set upper limit for Volts
[ :SENSe[1] ] :CURRent[ :DC ] :RANGe :AUTO :ULIMit <n>
Set upper limit for Amps
```

:LLIMit <n>

```
[ :SENSe[1] ] :VOLTagE[ :DC ] :RANGe :AUTO :LLIMit <n>
Set lower limit for Volts
[ :SENSe[1] ] :CURRent[ :DC ] :RANGe :AUTO :LLIMit <n>
Set lower limit for Amps
```

Parameters

<n> =	0 to 210	Range limit for volts
	0 to 21e-3	Range limit for amps
	DEFault	210 (volts)
		21e-3 (amps)
	MINimum	0 (volts and amps)
	MAXimum	Same as DEFault

Query	<pre> :ULIMit? DEFault MINimum MAXimum :LLIMit? DEFault MINimum MAXimum </pre>	<pre> Query upper range limit :ULIMit? Query *RST default upper limit :ULIMit? Query lowest allowable upper limit :ULIMit? Query largest allowable upper limit Query lower range limit :LLIMit? Query *RST default lower limit :LLIMit? Query lowest allowable lower limit :LLIMit? Query largest allowable lower limit </pre>
Description	<p>Automatic range changes slow down the reading rate. By setting upper and lower measurement range limits, you can prevent inadvertent range changes to ranges that you are not going to use.</p> <p>The upper range limit is selected by specifying the maximum expected reading that you expect to measure. For example, if the maximum expected reading is approximately 1mA, let the parameter (<n>) = 0.001 (or 1e-3). The lowest (most sensitive) range that can measure 1mA is the 2mA range. Thus, the 2mA range is selected as the upper range limit. With this upper limit, the instrument cannot uprange to the 20mA measurement range.</p> <p>The lower range limit is selected by specifying the lowest expected reading that you expect to measure.</p>	

NOTE See [:LGRoup <name>](#) to set the autorange limit for coulombs.

:LGRoup <name>

	<pre> [:SENSe[1]]:CHARge:RANGe:AUTO:LGRoup <name> </pre> <p style="text-align: right;">Select Coulombs autorange limit</p>	
Parameters	<pre> <name> = HIGH LOW </pre>	<pre> 200nC to 2µC autorange limit 2nC to 20nC autorange limit </pre>
Query	<pre> :LGRoup? </pre>	<pre> Query coulombs autorange limit </pre>
Description	<p>This command is used to set the autorange limit for the coulombs function. With HIGH selected, the instrument will only autorange between the two high coulombs ranges (200nC and 2µC). With LOW selected, the instrument will only autorange between the two low coulomb ranges (2nC and 20nC).</p>	

Ohms ranges:

[:UPPer] <n>

	<pre> [:SENSe[1]:RESistance[:AUTO]:RANGe[:UPPer] <n> </pre> <p style="text-align: right;">Set measurement range for Auto V-source Ohms</p>	
	<pre> [:SENSe[1]:RESistance:MANual:CRANGe[:UPPer] <n> </pre> <p style="text-align: right;">Set measurement range for Manual V-source Ohms</p>	
Parameters	<pre> <n> = 0 to 100e18 0 to 21e3 DEFault MINimum MAXimum </pre>	<pre> Expected reading in ohms (Auto V-source ohms) Expected reading in ohms (Manual V-source ohms) 100e18 (Auto V-source ohms) 21e3 (Manual V-source ohms) 0 Same as DEFault </pre>
Query	<pre> [:UPPer]? [:UPPer]? DEFault [:UPPer]? MINimum [:UPPer]? MAXimum </pre> <p>Query programmed measurement range Query *RST default range Query lowest measurement range Query highest measurement range</p>	

Description These commands are used to manually select the measurement range for the ohms function. The range is selected by specifying the expected reading as an absolute value. The Model 6517B will then go to the most sensitive range that will accommodate that expected reading. For example, if you expect a reading of approximately 100MΩ, simply let the parameter (<n>) = 100e6 in order to select the 200MΩ range.

:AUTO |ONCE

```
[ :SENSe[1]:RESistance[:AUTO]:RANGe:AUTO <b>|ONCE
                                Control auto range for Auto V-source Ohms
[:SENSe[1]:RESistance:MANual:CRANGe:AUTO <b>|ONCE
                                Control auto range for Manual V-source Ohms
```

Parameters

 =	1 or ON	Enable auto range
	0 or OFF	Disable auto range
	ONCE	Enable and then disable auto range

Query :AUTO? Query autorange (on or off)

Description These commands are used to control autoranging. With autoranging enabled, the instrument automatically goes to the most sensitive range to perform the measurement.

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE is sent, auto range enables and the most sensitive range is selected for the input signal. Auto range will then disable, but the selected measurement range is retained. Note that the instrument must be on the ohms function in order for ONCE to be effective. Using ONCE while on any other function results in an error.

The autorange commands (:RANGe:AUTO and :CRANGe:AUTO) are coupled to the commands that manually select the measurement range (:RANGe <n> and :CRANGe <n>). When autorange is enabled, the parameter value for the manual range command changes to the automatically selected range value. Thus, when autorange is disabled, the instrument remains at the automatically selected range. When a valid manual range command is sent, autoranging disables.

When using auto range, upper and lower range limits can be established for Auto V-source Ohms to keep the instrument from autoranging to ranges that are not going to be used (see :ULIMit <n> and :LLIMit <n>).

:ULIMit <n>

```
[ :SENSe[1]:RESistance[:AUTO]:RANGe:AUTO:ULIMit <n>
                                Set upper limit for Auto V-source Ohms
```

:LLIMit <n>

```
[ :SENSe[1]:RESistance[:AUTO]:RANGe:AUTO:LLIMit <n>
                                Set lower limit for Auto V-source Ohms
```

Parameters

<n> =	0 to 100e18	Range limit for Auto V-source Ohms
	DEFault	100e18
	MINimum	0
	MAXimum	Same as DEFault

Query	<code>:ULIMit?</code>		Query upper range limit
	<code>:ULIMit? DEFault</code>		Query *RST default upper limit
	<code>:ULIMit? MINimum</code>		Query lowest allowable upper limit
	<code>:ULIMit? MAXimum</code>		Query largest allowable upper limit
	<code>:LLIMit?</code>		Query lower range limit
	<code>:LLIMit? DEFault</code>		Query *RST default lower limit
	<code>:LLIMit? MINimum</code>		Query lowest allowable lower limit
	<code>:LLIMit? MAXimum</code>		Query largest allowable lower limit
Description	Automatic range changes slow down the reading rate. By setting upper and lower measurement range limits, you can prevent inadvertent range changes to ranges that you are not going to use. Note that these limits can only be set for Auto V-source Ohms. They are not available for Manual V-source Ohms.		
	The upper range limit is selected by specifying the maximum expected reading that you expect to measure. For example, if the maximum expected reading is approximately $1\text{G}\Omega$, let the parameter ($\langle n \rangle$) = $1\text{e}9$. The lowest (most sensitive) range that can measure $1\text{G}\Omega$ is the $2\text{G}\Omega$ range. Thus, the $2\text{G}\Omega$ range is selected as the upper range limit. With this upper limit, the instrument cannot uprange to the $20\text{G}\Omega$ (or higher) measurement range.		
	The lower range limit is selected by specifying the lowest expected reading that you expect to measure.		

:VSource:RANGE $\langle n \rangle$

`[:SENSe[1]:RESistance:MANual:VSource:RANGE $\langle n \rangle$`
Set V-source range for Manual V-source Ohms

Parameters	$\langle n \rangle$ =	0 to 1000	Specify output in volts
		DEFault	100V range
		MINimum	100V range
		MAXimum	1000V range
Query	<code>:RANGE?</code>		Query V-source range
	<code>:RANGE? DEFault</code>		Query *RST default V-source range
	<code>:RANGE? MINimum</code>		Query lowest allowable range
	<code>:RANGE? MAXimum</code>		Query largest allowable range
Description	This command is used to select the optimum V-source range for Auto V-source Ohms. Specifying the output voltage value automatically selects the most sensitive range. For example, specifying a value less than or equal to 100 selects the 100V range. Specifying a value greater than 100 selects the 1000V range.		
	You cannot select the 100V range if the programmed amplitude is greater than 100V; a Settings Conflict error will result (see <code>:VSource[:AMPLitude] $\langle n \rangle$</code>).		

:VSource[:AMPLitude] $\langle n \rangle$

`[:SENSe[1]:RESistance:MANual:VSource[:AMPLitude] $\langle n \rangle$`
Set V-source level for Manual V-source Ohms

Parameters	$\langle n \rangle$ =	-100 to 100	Set voltage for 100V range
		-1000 to 10000	Set voltage for 1000V range
		DEFault	0V
		MINimum	Greatest allowable negative value
		MAXimum	Greatest allowable positive value

Query

<code>[:AMPLitude]?</code>		Query programmed V-source level
<code>[:AMPLitude]? DEFault</code>		Query *RST default V-source level
<code>[:AMPLitude]? MINimum</code>		Query lowest allowable level
<code>[:AMPLitude]? MAXimum</code>		Query largest allowable level

Description This command is used to set the V-source level for Manual V-source Ohms. With Auto V-source Ohms selected, you will not be able to adjust the V-source level.

The amplitude level is limited by the selected V-source range (see [:VSource:RANGe <n>](#)). When on the 100V range, attempts to set the amplitude to a value that exceeds 100V will result in a Settings Conflict error. The amplitude may also be limited by the `:SOURCE:VOLTage:LIMit[:AMPLitude]` command. Attempts to set an amplitude that exceeds this programmed limit will set the amplitude to that limit.

The `MINimum` and `MAXimum` parameters are also affected by range and voltage limit. Setting the V-source to the `MINimum` (or `MAXimum`) amplitude selects the greatest negative (or positive) value allowed by the programmed limit or range. The V-source output (operate or standby) is controlled from the `:OPERate` command (see [:VSource:OPERate](#)).

**:VSource:OPERate **

`[:SENSe[1]:RESistance:MANual:VSource:OPERate <n>`
 Enable/disable V-source

Parameters `` = `ON` or `1` Enable V-source (operate)
 `OFF` or `0` Disable V-source (standby)

Query `:OPERate?` Query state of V-source

Description This command is used to enable or disable the V-source for Manual V-source Ohms. When enabled, the V-source is placed in operate. When disabled, the V-source is placed in standby.

:REFerence <n>

`[:SENSe[1]]:VOLTage[:DC]:REFerence <n>` Specify reference; Volts
`[:SENSe[1]]:CURRent[:DC]:REFerence <n>` Specify reference; Amps
`[:SENSe[1]:RESistance:REFerence <n>` Specify reference; Ohms
`[:SENSe[1]]:CHARge:REFerence <n>` Specify reference; Coulombs

Parameters `<n>` = `-210` to `210` Reference for volts
 `-21e-3` to `21e-3` Reference for amps
 `0` to `100e18` Reference for ohms
 `-2.1e-6` to `2.1e-6` Reference for coulombs
 `DEFault` 0 (All functions)
 `MINimum` Minimum value for specified function
 `MAXimum` Maximum value for specified function

Query

<code>:REFerence?</code>		Query programmed reference value
<code>:REFerence? DEFault</code>		Query *RST default reference value
<code>:REFerence? MINimum</code>		Query lowest allowable reference value
<code>:REFerence? MAXimum</code>		Query largest allowable reference value

Description These commands are used to establish a reference value for the specified function. When Reference is enabled (see [:STATE](#) for `:REFerence:STATE`), the result will be the algebraic difference between the input signal and the reference value:

Reading = Input signal - Reference

On the ohms function, the input signal is considered to be the computed resistance value seen at the input. Thus, the final result is the algebraic difference between the input resistance and the reference. Note that a reference for the current component of a resistance measurement can be established.

From the front panel, reference is called relative (REL) (see [Relative \(REL\)](#)).

The `:REFERENCE <n>` command is coupled to the `:ACQUIRE` command. The last command sent (`:REFERENCE <n>` or `:ACQUIRE`) establishes the reference. When a reference is set using the `:REFERENCE <n>` command, the `:REFERENCE?` query command returns the programmed value. Conversely, when a reference is set using the `:ACQUIRE` command, the `:REFERENCE?` query command returns the acquired reference value.

**:STATE **

```
[ :SENSE[1] ]:VOLTage[:DC]:REFERENCE:STATE <b>
                               Control reference for Volts
[ :SENSE[1] ]:CURRent[:DC]:REFERENCE:STATE <b>
                               Control reference for Amps
[ :SENSE[1] ]:RESistance:REFERENCE:STATE <b>
                               Control reference for Ohms
[ :SENSE[1] ]:CHARGE:REFERENCE:STATE <b>
                               Control reference for Coulombs
```

Parameters = 1 or ON Enable reference
0 or OFF Disable reference

Query :STATE? Query state of reference

Description These commands are used to enable or disable Reference for the specified function. When enabled, the displayed reading will include the programmed reference value (see [:REFERENCE <n>](#) and [:ACQUIRE](#)). When disabled, the displayed reading will not include the reference value.

:ACQUIRE

```
[ :SENSE[1] ]:VOLTage[:DC]:REFERENCE:ACQUIRE
                               Acquire Reference; Volts
[ :SENSE[1] ]:CURRent[:DC]:REFERENCE:ACQUIRE
                               Acquire Reference; Amps
[ :SENSE[1] ]:RESistance:REFERENCE:ACQUIRE
                               Acquire Reference; Ohms
[ :SENSE[1] ]:CHARGE:REFERENCE:ACQUIRE
                               Acquire Reference; Coulombs
```

Description When one of these commands is sent, the measured input signal is acquired and established as the reference value. This command is typically used to zero the display. For example, if the instrument is displaying a 1nA offset, sending this command and enabling Reference (see [:STATE](#)) zeroes the display.

This command is functional only if the instrument is on the specified measurement function. Sending this command while in any other function causes an error. Also, if the latest reading is overflowed ("OFLO") or a reading has not been triggered ("----"), an error occurs when this command is sent.

The `:ACQUIRE` command is coupled to the `:REFERENCE <n>` command. See the description for the [:REFERENCE <n>](#) command (above) for details.

**:IREFERENCE **

[:SENSE[1]] :RESistance :IREFERENCE Control amps reference

Parameters = ON or 1 Enable amps reference for ohms
OFF or 0 Disable amps reference for ohms

Query :IREFERENCE? Query state of amps reference for ohms

Description This command allows you to use an established amps reference for the resistance measurement. When an amps reference is established, and this command is used to enable the amps reference for ohms, the current value used to compute resistance (I_{ohm}) is the algebraic difference between the input current and the reference:

$$I_{ohm} = I_{input} - I_{reference}$$

Resistance (R) is then computed using I_{ohm} and the V-source output (V).

$$R = V / I_{ohm}$$

Typically, amps reference represents the leakage current in a test fixture. Thus, this command allows you to eliminate this leakage current for the resistance calculation.

:DIGITS <n>

[:SENSE[1]] :VOLTage [:DC] :DIGITS <n> Specify resolution; Volts
[:SENSE[1]] :CURRent [:DC] :DIGITS <n> Specify resolution; Amps
[:SENSE[1]] :RESistance :DIGITS <n> Specify resolution; Ohms
[:SENSE[1]] :CHARGE :DIGITS <n> Specify resolution; Coulombs

Parameters <n> = 4 3.5 digits
5 4.5 digits
6 5.5 digits
7 6.5 digits
DEFault 6 (5.5 digits)
MINimum 4 (3.5 digits)
MAXimum 7 (6.5 digits}

Query :DIGITS? Query selected resolution
:DIGITS? DEFault Query *RST default resolution
:DIGITS? MINimum Query minimum allowable resolution
:DIGITS? MAXimum Query maximum allowable resolution

Description These commands are used to select display resolution for the specified measurement function.

Even though the parameters for this command are expressed as integers (4 to 7), you can specify resolution using real numbers. For example, to select 3.5 digit resolution let <n> = 3.5, for 4.5-digit resolution let <n> = 4.5, and so on. Internally, the instrument rounds the entered parameter value to the nearest integer.

:AUTO |ONCE

```
[ :SENSe[1]]:VOLTage[:DC]:DIGits:AUTO <b>|ONCE
                                     Control auto resolution; Volts
[:SENSe[1]]:CURRent[:DC]:DIGits:AUTO <b>|ONCE
                                     Control auto resolution; Amps
[:SENSe[1]:RESistance:DIGits:AUTO <b>|ONCE
                                     Control auto resolution; Ohms
[:SENSe[1]]:CHARge:DIGits:AUTO <b>|ONCE
                                     Control auto resolution; Coulombs
```

Parameters

 =	1 or ON	Enable auto resolution
	0 or OFF	Disable auto resolution
	ONCE	Enable and then disable auto resolution

Query :AUTO? Query state of auto resolution

Description These commands are used to enable or disable auto resolution for the specified function. With auto resolution selected, the instrument automatically selects the optimum resolution for the present integration time setting.

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE is sent, auto resolution turns on momentarily and then disables. While enabled, resolution is selected automatically. Auto resolution then disables but the selected value is retained.

The auto resolution command (:DIGits:AUTO) is coupled to the command that manually selects resolution (:DIGits <n>). When auto resolution is enabled, the parameter value for :DIGits <n> changes to the automatically selected resolution value. Thus, when auto resolution is disabled, the instrument remains at the automatically selected resolution.

:AVERage commands

The :AVERage commands are used to configure and control the digital filter ([Filters](#) for more information).

:TYPE <name>

```
[ :SENSe[1]]:VOLTage[:DC]:AVERage:TYPE <name>
                                     Select filter type; Volts
[:SENSe[1]]:CURRent[:DC]:AVERage:TYPE <name>
                                     Select filter type; Amps
[:SENSe[1]:RESistance:AVERage:TYPE <name>
                                     Select filter type; Ohms
[:SENSe[1]]:CHARge:AVERage:TYPE <name>
                                     Select filter type; Volts
```

Parameters

<name> =	NONE	No digital filter selected
	SCALar	Select scalar filter
	ADVanced	Select advanced filter

Query :TYPE? Query the digital filter type

Description This command is used to select the digital filter type. The SCALar filter is a simple averaging type filter. The ADVanced filter is similar except that it incorporates a noise window to allow faster response time to large signal step changes. The :NTOLerance command is used to set the window for the ADVanced filter.

The number of readings that are averaged by the filter is set with the :COUNT command, and the :TCONtrol command is used to select the filter mode (moving or repeating). The [:STATE] command is used to enable or disable the filter.

Setting TYPE to NONE with MEDian:STATe set to OFF will set AVER:STATe to OFF.

:TCONtrol <name>

- [:SENSe[1]] :VOLTagE[:DC] :AVERAge :TCONtrol <name>
Select filter mode; Volts
- [:SENSe[1]] :CURRent[:DC] :AVERAge :TCONtrol <name>
Select filter mode; Amps
- [:SENSe[1]] :RESistance :AVERAge :TCONtrol <name>
Select filter mode; Ohms
- [:SENSe[1]] :CHARge :AVERAge :TCONtrol <name>
Select filter mode; Coulombs

Parameters <name> =REPeat Select repeating filter mode
MOVing Select moving filter mode

Query :TCONtrol? Query filter mode

Description These commands are used to select the filter mode (REPeat or MOVing) for the specified function (see *Digital filters* for more information).

MOV during scan or test sequence will generate a “Settings Conflict Error.” TCON will be set to REPeat during a scan or test sequence if filter is ON and the appropriate function is encountered.

:COUNT <n>

- [:SENSe[1]] :VOLTagE[:DC] :AVERAge :COUNT <n>
Specify filter count for Volts
- [:SENSe[1]] :CURRent[:DC] :AVERAge :COUNT <n>
Specify filter count for Amps
- [:SENSe[1]] :RESistance :AVERAge :COUNT <n>
Specify filter count for Ohms
- [:SENSe[1]] :CHARge :AVERAge :COUNT <n>
Specify filter count for Coulombs

Parameters <n> = 1 to 100 Specify filter count
DEFault 10
MINimum 1
MAXimum 100

Query :COUNT? Query filter count
:COUNT? DEFault Query the *RST default filter count
:COUNT? MINimum Query the lowest allowable filter count
:COUNT? MAXimum Query the largest allowable filter count

Description These commands are used to specify the filter count. In general, the filter count is the number of readings that are acquired and stored in the filter buffer for the averaging calculation. The larger the filter count, the more filtering that is performed.

**[:STATe] **

[:SENSe[1]] :VOLTage[:DC] :AVERAge[:STATe] Control filter; Volts
 [:SENSe[1]] :CURRent[:DC] :AVERAge[:STATe] Control filter; Amps
 [:SENSe[1]] :RESistance :AVERAge[:STATe] Control filter; Ohms
 [:SENSe[1]] :CHARge :AVERAge[:STATe] Control filter;
 Coulombs

Parameters = 0 or OFF Disable the digital filter
 1 or ON Enable the digital filter

Query [:STATe] ? Query state of digital filter

Description These commands are used to enable or disable the digital averaging filter for the specified function. When enabled, readings will be filtered according to how the filter is configured.

Attempting to set `STATe` to ON with `TYPE` at NONE and `MED:STAT` at OFF will generate a "Settings Conflict Error." Setting `STATe` to ON during a scan or test sequence will change `TCON` to `REPeat`.

:NTOLerance <n>

[:SENSe[1]] :VOLTage[:DC] :AVERAge :ADVanced :NTOLerance <n>
 Specify noise tolerance for Volts
 [:SENSe[1]] :CURRent[:DC] :AVERAge :ADVanced :NTOLerance <n>
 Specify noise tolerance for Amps
 [:SENSe[1]] :RESistance :AVERAge :ADVanced :NTOLerance <n>
 Specify noise tolerance for Ohms
 [:SENSe[1]] :CHARge :AVERAge :ADVanced :NTOLerance <n>
 Specify noise tolerance for Coulombs

Parameters <n> = 1 to 100 Specify noise tolerance in percent (+/-)
 DEFault +/-1%
 MINimum 0%
 MAXimum +/-100%

Query :NTOLerance? Query noise tolerance
 :NTOLerance? DEFaultQuery *RST default noise tolerance
 :NTOLerance? MINimumQuery lowest allowable noise tolerance
 :NTOLerance? MAXimumQuery largest allowable noise tolerance

Description Each measurement function can utilize the advanced filter which adds a noise tolerance window to the averaging algorithm. These commands are used to set the noise tolerance level of the advanced filter for the specified function. The `:ADVanced[:STATe]` commands are used to enable or disable the advanced filter.

The noise tolerance level is expressed as a percent of the last averaged reading. In general, if the noise is within this window, the reading is simply based on the normal averaging algorithm. If a reading is outside this window, then the advanced averaging algorithm is used.

:MEDian commands

See also [Median filter](#) for more information.

**[:STATe] **

[:SENSe[1]] :VOLTage[:DC] :MEDian[:STATe] Control median; Volts
 [:SENSe[1]] :CURRent[:DC] :MEDian[:STATe] Control median; Amps
 [:SENSe[1]] :RESistance :MEDian[:STATe] Control median; Ohms
 [:SENSe[1]] :CHARge :MEDian[:STATe] Control median;
 Coulombs

Parameters = 1 or ON Enable median filter
 0 or OFF Disable median filter

Query [:STATe] ? Query state of median filter

Description This command is used to control (on or off) the median filter. When enabled, the instrument will determine and display the median reading for the specified number of readings. The :RANK command is used to specify the number of readings used to determine the median.

Note that the median filter can be used with the average filter. When both of these filters are enabled, each displayed reading will reflect the median for the average readings.

Setting STATE to OFF with AVER :TYPE set to NONE will set AVER :STAT to OFF.

:RANK <NRf>

[:SENSe[1]] :VOLTage[:DC] :MEDian :RANK <NRf> Specify median rank for Volts
 [:SENSe[1]] :CURRent[:DC] :MEDian :RANK <NRf> Specify median rank for Amps
 [:SENSe[1]] :RESistance :MEDian :RANK <NRf> Specify median rank for Ohms
 [:SENSe[1]] :CHARge :MEDian :RANK <NRf> Specify median rank for Coulombs

Parameters <NRf> = 1 to 5 Specify rank

Query :RANK ? Query rank

Description The number of sample readings used for the median calculation is determined by the selected range (1 to 5) as follows:

$$\text{Sample readings} = (2 \times R) + 1$$

Where: R is the selected range (1 to 5)

For example, a rank of 5 will use the last 11 readings to determine the median; $(2 \times 5) + 1 = 11$.

Each new reading replaces the oldest reading, and the median is then determined from the updated sample of readings.

**:DAMPing **

[:SENSe[1]] :CURRent :DC :DAMPing Control damping for Amps
 [:SENSe[1]] :RESistance :DAMPing Control damping for Ohms

Parameters = 0 or OFF Disable damping
 1 or ON Enable damping

Query :DAMPing ? Query state of damping

Description This command is used to control damping for the Amps and Ohms function. Damping is used to decrease noise caused by high input capacitance. However, damping will also slow down the response of the measurement.

Note that damping is only valid for the lowest two current ranges (20pA and 200pA ranges).

:GUARd

[:SENSE[1]]:VOLTage:DC:GUARd Control guard for Volts

Parameters = 0 or OFF Disable guard
1 or ON Enable guard

Query :GUARd? Query state of guard

Description This command is used to control guard for the Volts function. When enabled, preamp output high (which is used as guard) is placed on the inner shell of the triax input connector. When disabled, input LO is placed on the inner shell of the triax connector (see [Shielding and guarding](#) for more information).

:ADIScharge commands

Auto discharge is used to reset the charge reading to zero.

[:STATe]

[:SENSE[1]]:CHARGE:ADIScharge[:STATe] Control auto discharge

Parameters = 1 or ON Enable auto discharge
0 or OFF Disable auto discharge

Query [:STATe]? Query state of auto discharge

Description This command is used to enable or disable the auto discharge feature for the Coulombs function. When enabled, the charge measurement will reset to zero when the specified level is reached (see [:LEVEl <NRf>](#)).

:LEVEl <NRf>

[:SENSE[1]]:CHARGE:ADIScharge:LEVEl <NRf>Specify level

Parameters <NRf> = -2.2e6 to 2.2e6 Specify discharge level

Query :LEVEl? Query level for auto discharge

Description This command is used to specify the coulombs level for auto discharge. Charge will reset when the charge reading reaches the specified level.

:XFEedback

[:SENSE[1]]:VOLTage[:DC]:XFEedback Control external feedback

Parameters = ON or 1 Enable external feedback
OFF or 0 Disable external feedback

Query :XFEedback? Query state of external feedback

Description This command is used to enable or disable external feedback (see [Using external feedback](#) for more information).

:VSControl <name>

[:SENSe[1]] :RESistance :VSControl <name> Select ohms V-source mode

Parameters <name> = MANual Manual V-source Ohms
 AUTO V-source Ohms

Query :VSControl? Query ohms V-source mode

Description This command is used to select Manual V-source ohms or Auto V-source ohms. With MANual selected, you can set the V-source level for ohms measurements. With AUTO selected, the V-source level is automatically set for the ohms measurement (40V or 400V).

:MSElect <name>

[:SENSe[1]] :RESistance :MSElect <name>
 Select ohms measurement type

Parameters <name> = NORMal Normal resistance measurements
 RESistivity Resistivity measurements

Query :MSElect? Query ohms measurement type

Description This command is used to select the ohms measurement type. NORMal is used to make normal resistance measurements, and RESistivity is used for resistivity (surface and volume) measurements (see [Resistivity measurements](#) for more information).

:RESistivity commands

The following commands are used for resistivity measurements. If using the Model 8009 Resistivity Test Fixture, the measurement type (surface or volume) is automatically sensed by the Model 6517B through the safety interlock cable. Also, when using the Model 8009, you do not need to use the :USER commands (:RSElect, :KSURface and :KVOLume).

See also [Resistivity measurements](#) for more information.

:FSElect <name>

[:SENSe[1]] :RESistance :RESistivity :FSElect <name>
 Specify test fixture

Parameters <name> = M8009 Model 8009 Resistivity Test Fixture
 USER User-supplied test fixture

Query :FSElect? Query selected test fixture

Description This command is used to specify which test fixture is being used for resistivity measurements. M8009 specifies the Model 8009 test fixture. When using the Model 8009, the only parameter that needs to be entered is the sample thickness for volume resistivity (see [:STHickness <NRf>](#)).

Specify USER when using any other resistivity test fixture. When using this type of test fixture, you will have to enter the other parameters for resistivity measurements (see [:USER commands](#)).

:STHickness <NRf>

`[:SENSe[1]] :RESistance:RESistivity:STHickness <NRf>`
 Volume resistivity; specify sample thickness

Parameters <NRf> = 0.0001 to 99.9999 Sample thickness in millimeters

Query :STHickness? Query programmed sample thickness

Description This command is used to specify the thickness (in millimeters) of the sample for volume resistivity measurements. Sample thickness is not required for surface resistivity.

M8009:RSWitch?

`[:SENSe[1]] :RESistance:RESistivity:M8009:RSWitch?`
 Query switch setting on Model 8009

Description When using the Model 8009 Resistivity Test Fixture, the Model 6517B senses the switch setting (Surface or Volume) of the test fixture through the safety interlock cable and automatically configures the instrument for that resistivity measurement type.

This query command is used to read the switch setting (Surface or Volume) of the Model 8009 Resistivity Test Fixture.

:USER commands

The following commands are used to configure the instrument for resistivity measurements when using a user-supplied test fixture. These command are not needed if using the Model 8009 Resistivity Test Fixture.

:RSElect <name>

`[:SENSe[1]] :RESistance:RESistivity:USER:RSElect <name>`
 Specify measurement type for user test fixture

Parameters <name> =SURFace Surface resistivity
 VOLume Volume resistivity

Query :RSElect? Query programmed resistivity measurement type

Description This command is used to specify the resistivity type (SURFace or VOLume) for the user-supplied test fixture. This command is not needed when using the Model 8009 test fixture.

:KSURface <NRf>

`[:SENSe[1]] :RESistance:RESistivity:USER:KSURface <NRf>`
 Specify Ks parameter for surface resistivity

Parameters <NRf> = 0.001 to 999.999 Ks parameter

Query :KSURface? Query programmed Ks parameter

Description This command is used to specify the Ks parameter for surface resistivity measurements when using a user-supplied test fixture. This command is not needed when using the Model 8009 test fixture.

The Ks parameter is calculated as follows:

$$Ks = P/g$$

Where: P = Effective perimeter (in mm) of the guarded electrode

g = Distance (mm) between the guarded electrode and the ring electrode

:KVOLume <NRf>

[[:SENSe[1]]:RESistance:RESistivity:USER:KVOLume <NRf>
Specify Kv parameter for volume resistivity

Parameters <NRf> = 0.001 to 999.999Kv parameter

Query :KVOLume? Query programmed Kv parameter

Description This command is used to specify the Kv parameter for volume resistivity measurements when using a user-supplied test fixture. This command is not needed when using the Model 8009 test fixture.

:SOURce subsystem

This subsystem is used to set the logic level (true or false) of each digital output line, and is used to configure the V-source. Note that the V-source is controlled (standby/operate) from the :OUTput1 subsystem.

The commands for this subsystem are summarized in [Table 14-9](#).

Digital output commands

**[[:LEVel] **

:SOURce:TTL[1]:[LEVel] Control digital output line #1
:SOURce:TTL2:[LEVel] Control digital output line #2
:SOURce:TTL3:[LEVel] Control digital output line #3
:SOURce:TTL4:[LEVel] Control digital output line #4

Parameters = 1 or ON Set output line true
0 or OFF Set output line false

Query [[:LEVel]? Query logic level of specified line

Description These commands are used to set the logic levels for the digital output port. The actual level (high or low) of a digital output line depends on its programmed polarity (see [OUTPut subsystems](#) for more information). If the polarity of a line is active-high, then that line is high when it is set to be true (1 or ON), and low when it is set to be false (0 or OFF). Conversely, if polarity is active-low, the line is low when it is set to be true, and high when it is set to be false.

If a LIMITS control is enabled (LOLIM1 or 2, HILIM1 or 2—High, Low, or Pass), this command does not check or change the output status.

V-source configuration commands:

:VOLTage commands

[[:LEVel]][:IMMediate]][:AMPLitude] <n>

:SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude] <n>
Set V-source amplitude

Parameters <n> = -100 to +100 Set voltage for 100V range
 -1000 to +1000 Set voltage for 1000V range
 DEFault 0V
 MINimum Greatest allowable negative value
 MAXimum Greatest allowable positive value

Query :VOLTage? Query programmed amplitude
 :VOLTage? DEFault Query *RST default value
 :VOLTage? MINimum Query minimum amplitude
 :VOLTage? MAXimum Query maximum amplitude

Description This command is used to set the amplitude for the V-source. Notice that three commands in the path are enclosed by brackets ([]) to indicate that they are optional. Thus, this command can be sent in the following form:

:SOURce:VOLTage <n>

Note that the amplitude level is limited by the selected range and programmed voltage limit (see [:RANGe <n>](#) and [:LIMit\[:AMPLitude\] <n>](#)). When on the 100V range, attempts to set the amplitude to a level that exceeds the 100V range will result in a Settings Conflict error. Attempts to set an amplitude that exceeds a programmed voltage limit will set the amplitude to that limit.

The MINimum and MAXimum parameters are also affected by range and voltage limit. Setting the V-source to the MINimum (or MAXimum) amplitude selects the greatest negative (or positive) value allowed by the programmed limit or range.

The V-source output (operate and standby) is controlled from the [:OUTPut1 subsystem](#) (see [:OUTPut1 subsystem](#) for more information).

:RANGe <n>

:SOURce:VOLTage:RANGe <n> Select V-source range

Parameters <n> = 0 to 1000 Specify output in volts
 DEFault 100V range
 MINimum 100V range
 MAXimum 1000V range

Query :RANGe? Query voltage range
 :RANGe? DEFault Query *RST default range
 :RANGe? MINimum Query minimum range
 :RANGe? MAXimum Query maximum range

Description This command is used to select the optimum range for the V-source. Specifying the output voltage value automatically selects the most sensitive range. For example, specifying a value ≤ 100 selects the 100V range. Specifying a value > 100 selects the 1000V range.

You cannot select the 100V range if the programmed amplitude value is greater than 100. A Settings Conflict error will result.

:LIMit[:AMPLitude] <n>

:SOURce:VOLTage:LIMit[:AMPLitude] <n> Set voltage limit

Parameters <n> = 0 to 1000 Set voltage limit
 DEFault 1000V
 MINimum 0V
 MAXimum 1000V

Query :LIMit? Query voltage limit
 :LIMit? DEFault Query *RST default limit
 :LIMit? MINimum Query minimum limit
 :LIMit? MAXimum Query maximum limit

Description This command is used to set an absolute value limit for the V-source. For example, setting a limit of 75V limits the V-source output to $\pm 75V$.

The specified voltage limit is only in effect if the limit is enabled (see [:LIMit:STATe](#)). If disabled, the limit is simply dictated by the selected range.

**:LIMit:STATe **

:SOURce:VOLTage:LIMit:STATe Control voltage limit

Parameters = 0 or OFF Disable voltage limit
 1 or ON Enable voltage limit

Query :STATe? Query state of voltage limit

Description This command is used to enable or disable voltage limit. When enabled, the programmed voltage limit is in effect. When disabled, voltage limit is determined by the selected range.

Attempts to enable voltage limit when the present V-source level (amplitude) exceeds the limit value will generate a Settings Conflict error.

**:MCONnect **

:SOURce:VOLTage:MCONnect Control LO connection

Parameters = ON or 1 Enable LO connection
 OFF or 0 Disable LO connection

Query :MCONnect? Query LO connection

Description This command is used to control the internal V-source LO to Ammeter LO connection. When enabled, V-source LO is connected to Ammeter LO. This connection simplifies the connection requirements for ohms measurements and source voltage measure current measurements. When disabled, this connection is broken.

:CURRent commands**:RLIMit:STATe **

:SOURce:CURRent:RLIMit:STATe Control resistance current limit

Parameters = 0 or OFF Disable resistance current limit
 1 or ON Enable resistance current limit

Query :STATe? Query state of resistance current limit

Description This command is used to enable or disable resistance current limit for the V-source. When enabled, a 1M Ω resistor is placed in series with the HI V-SOURCE OUT lead to extend the current limit capabilities of the V-source. When disabled, normal current limit occurs at 1mA.

:LIMit[:STATe]?

:SOURce:CURRent:LIMit[:STATe]? Query current compliance

Description This command is used to determine if the V-source has reached its current compliance limit of 1mA. The response message is explained as follows:

0 = Current compliance not reached

1 = Current compliance reached

:STATus subsystem

The **STATus** subsystem is used to control the status registers of the Model 6517B. These registers and the overall status structure is explained in [Section 13](#). The commands in this subsystem are summarized in [Table 14-10](#).

[:EVENT]?

:STATus:MEASurement[:EVENT]? Read transition filter event register

:STATus:QUEStionable[:EVENT]? Read questionable event register

:STATus:OPERation[:EVENT]? Read operation event register

:STATus:OPERation:TRIGger[:EVENT]? Read trigger event register

:STATus:OPERation:ARM[:EVENT]? Read arm event register

:STATus:OPERation:ARM:SEQuence[:EVENT]? Read sequence event register

Description These query commands are used to read the event registers. After sending one of these commands and addressing the Model 6517B to talk, a decimal value is sent to the computer. The binary equivalent of this value determines which bits in the appropriate register are set. The event registers are shown in [Figure 14-4](#) through [Figure 14-9](#). Note that reading an event register clears the bits in that register.

For example, assume that reading the transition filter event register results in an acquired decimal value of 544. The binary equivalent is 0000001000100000. For this binary value, Bits B5 and B9 of the transition filter event register are set.

The significance of a set bit in these registers depends on how the transition filter is programmed. See [:PTRansition <NRF>](#) and [:NTRansition <NRF>](#) for more information. If an event is programmed for a positive transition (PTR), the corresponding bit in this register sets when the event occurs. If the event is instead programmed for a negative transition (NTR), the bit sets when the event becomes not true.

Measurement event register ([Figure 14-4](#)):

Bit B0, reading overflow (ROF): Set bit indicates that the reading exceeds the measurement range of the instrument (PTR), or the instrument has gone from an overflow condition to a normal reading condition (NTR).

Bit B1, low limit 1 (LL1): Set bit indicates that the reading is less than the low limit 1 setting (PTR), or that a subsequent reading is no longer less than the low limit 1 setting (NTR).

Bit B2, high limit 1 (HL1): Set bit indicates that the reading is greater than the High Limit 1 setting (PTR), or that a subsequent reading is no longer greater than the High Limit 1 setting (NTR).

Bit B3, low limit 2 (LL2): Set bit indicates that the reading is less than the low limit 2 setting (PTR), or that a subsequent reading is no longer less than the low limit 2 setting (NTR).

Bit B4, high limit 2 (HL2): Set bit indicates that the reading is greater than the High Limit 2 setting (PTR), or that a subsequent reading is no longer greater than the High Limit 2 setting (NTR).

Bit B5, reading available (RAV): Set bit indicates that a reading was taken and processed (PTR), or that a subsequent reading is in process (NTR).

Bit B6, reading underflow (RUF): Set bit indicates that the ohms reading is less than the lower range limit (PTR) or the instrument has gone from an underflow condition to a normal reading condition (NTR).

Bit B7, buffer available (BAV): Set bit indicates that there are at least two readings in the trace buffer (PTR), or the buffer has become empty (NTR).

Bit B8, buffer half-full (BHF): Set bit indicates that the trace buffer is half-full (PTR), or that the buffer is no longer half-full (NTR).

Bit B9, buffer full (BFL): Set bit indicates that the trace buffer is full (PTR), or that the buffer is no longer full (NTR).

Bit B10, sequence reading available (SRA): Set bit indicates that a fresh reading from the alternating polarity test sequence is available and has been placed in the buffer (PTR).

Bit B11, buffer pretriggered (BPT): Set bit indicates that the trace buffer pretrigger event has occurred (PTR), or the operations associated with the pretrigger have been completed (NTR).

Bit B12, out of limits (OL): Set bit indicates that signal transients (for example, noise spikes) exceed the range limit (PTR) (see [Range messages](#) for more information).

Bit B13, fixture lid closed: Set bit indicates that a fixture using the interlock cable is closed. If no interlock cable is connected to the 6517B, bit is also set. If the interlock cable is connected to the 6517B but not to the fixture, bit is not set (PTR).

Bit B14 (VSC): Set bit indicates that the V-source is in compliance (PTR).

Bit B15: Always zero.

Figure 14-4
Measurement event register

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	FLC	OL	BPT	SRA	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2 ¹⁴)	8192 (2 ¹³)	4096 (2 ¹²)	2048 (2 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	2 (2 ¹)	1 (2 ⁰)
Value	0	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Measurement Event Set
0 = Measurement Event Cleared

Events : VSC = V-Source Compliance
FLC = Fixture Lid Closed
OL = Out of Limits
BPT = Buffer Pretriggered
SRA = Sequence Reading Available
BFL = Buffer Full
BHF = Buffer Half Full
BAV = Buffer Available
RUF = Reading Underflow
RAV = Reading Available
HL2 = High Limit 2
LL2 = Low Limit 2
HL1 = High Limit 1
LL1 = Low Limit 1
ROF = Reading Overflow

Questionable event register (Figure 14-5):

Bit B0, volts summary (Volt): Set bit indicates that an invalid volts measurement has occurred (PTR), or a subsequent valid volts measurement has occurred (NTR).

Bit B1, amps summary (Amp): Set bit indicates that an invalid amps measurement has occurred, or a subsequent valid amps measurement has occurred (NTR).

Bits B2 and B3: Not used.

Bit B4, temperature summary (Temp): Set bit indicates that an invalid external temperature measurement has occurred (PTR), or a subsequent valid temperature measurement has occurred (NTR).

Bit B5, B6, and B7: Not used.

Bit B8, calibration summary (Cal): Set bit indicates that an invalid calibration constant was detected during the power-up sequence (PTR). The instrument will instead use a default calibration constant. This error will clear after successful calibration of the instrument.

Bit B9, humidity summary (Hum): Set bit indicates that an invalid relative humidity measurement has occurred (PTR), or a subsequent valid temperature measurement has occurred (NTR).

Bit B10, ohms summary (Ohm): Set bit indicates that an invalid ohms measurement has occurred (PTR), or a subsequent valid ohms measurement has occurred (NTR).

Bit B11, coulombs summary (Coul): Set bit indicates that an invalid Coulombs measurement has occurred, or a subsequent valid coulombs measurement has occurred (NTR).

Bit B12, sequence test summary (Seq): Set bit indicates that a sequence test has been aborted (PTR).

Bit B13: Not used.

Bit B14, command warning (Warn): Set bit indicates that a Signal Oriented transition filter Command parameter has been ignored (PTR), or a subsequent Signal Oriented transition filter Command has executed successfully (NTR).

Bit B15: Always zero.

NOTE Whenever a questionable event occurs, the ERR annunciator will turn on. The annunciator will turn off when the questionable event clears.

Figure 14-5
Questionable event register

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Warn	—	Seq	Coul	—	Hum	Cal	BAV	RUF	RAV	Temp	—	—	Amp	Volt
Decimal Weighting	—	16384 (2 ¹⁴)	—	4096 (2 ¹²)	2048 (2 ¹¹)	—	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁸)	32 (2 ⁵)	16 (2 ⁴)	—	—	2 (2 ¹)	1 (2 ⁰)
Value	0	0/1	—	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1	—	—	0/1	0/1

Value : 1 = Questionable Event Bit Set
0 = Questionable Event Bit Cleared

Events : Warn = Command Warning
Seq = Sequence Test Summary
Coul = Coulombs Summary
Hum = Humidity Summary
Cal = Calibration Summary
Temp = Temperature Summary
Amp = Amps Summary
Volt = Volts Summary

Operation event register (Figure 14-6):

Bit B0, calibrating (Cal): Set bit indicates that the instrument is calibrating (PTR), or calibration is complete (NTR).

Bits B1, B2, B3, and B4: Not used.

Bit B5, waiting for trigger (Trig): Set bit indicates that the instrument is waiting in the trigger layer (PTR) of the trigger model, or that it has left the trigger layer (NTR).

Bit B6, waiting for arm (Arm): Set bit indicates that the instrument is waiting in an arm layer of the trigger model (PTR), or operation has proceeded from the arm layers into the trigger layer (NTR).

Bits B7 and B8: Not used.

Bit B9, calculating (Calc): Set bit indicates that the instrument is calculating a reading (PTR), or that the calculation is completed (NTR).

Bit B10, idle: Set bit indicates that the instrument is in the idle state (PTR), or has left the idle state to perform an operation (NTR).

Bit B11, sequence test running (Seq): Set bit indicates that a sequence test is running (PTR), or that the test has finished (NTR).

Bits B12, B13, and B14: Not used.

Bit B15: Always zero.

Figure 14-6
Operation event register

Bit Position	B15	B14 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	—	Seq	Idle	Calc	—	—	Arm	Trig	—	—	—	—	Cal
Decimal Weighting	—	—	2048 (10 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	—	—	64 (2 ⁶)	32 (2 ⁵)	—	—	—	—	1 (2 ⁰)
Value	0	—	0/1	0/1	0/1	—	—	0/1	0/1	—	—	—	—	0/1

Value : 1 = Operation Event Set
0 = Operation Event Cleared

Events : Seq = Sequence Test Running
Idle = Idle state of the 6517A
Calc = Calculating Reading
Arm = Waiting for Arm
Trig = Waiting for Trigger
Meas = Measuring
Cal = Calibrating

Trigger event register (Figure 14-7):

Bit B0: Not used.

Bit B1, sequence 1 (Seq1): Set bit indicates that the instrument is in the trigger layer (PTR), or that the instrument has exited from the trigger layer (NTR).

Bits B2 through B14: Not used.

Bit B15: Always zero.

Figure 14-7
Trigger event register

Bit Position	B15	B14 - B2	B1	B0
Event	—	—	Seq1	—
Decimal Weighting	—	—	2 (2 ¹)	—
Value	0	—	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Seq1 = Sequence 1

Arm event register (Figure 14-8):

Bit B0: Not used.

Bit B1, sequence 1 (Seq1): Set bit indicates that the instrument is in an arm layer (PTR), or that the instrument has exited from the arm layers (NTR).

Bits B2 through B14: Not used.

Bit B15: Always zero.

Figure 14-8
Arm event register

Bit Position	B15	B14 - B2	B1	B0
Event	—	—	Seq1	—
Decimal Weighting	—	—	2 (2 ¹)	—
Value	0	—	0/1	—

Value : 1 = Event Bit Set Event : Seq1 = Sequence 1
 0 = Event Bit Cleared

Sequence event register (Figure 14-9):

Bit B0: Not used.

Bit B1, layer 1 (Lay1): Set bit indicates that instrument operation is in arm layer 1 (PTR), or that operation has exited from arm layer 1 NTR).

Bit B2, layer 2 (Lay2): Set bit indicates that instrument operation is in arm layer 2 (PTR), or that operation has exited from arm layer 2 NTR).

Bits B3 through B14: Not used.

Bit B15: Always zero.

Figure 14-9
Sequence event register

Bit Position	B15	B14 - B3	B2	B1	B0
Event	—	—	Lay2	Lay1	—
Decimal Weighting	—	—	4 (2 ²)	2 (2 ¹)	—
Value	0	—	0/1	0/1	—

Value : 1 = Event Bit Set Event : Lay1 = Layer 1
 0 = Event Bit Cleared Lay2 = Layer 2

:ENABLE <NRf>

- :STATus:MEASurement:ENABle <NRf>
 Program transition filter event enable register
- :STATus:QUESTionable:ENABle <NRf>
 Program questionable event enable register
- :STATus:OPERation:ENABle <NRf>
 Program operation event enable register
- :STATus:OPERation:TRIGger:ENABle <NRf>
 Program trigger event enable register
- :STATus:OPERation:ARM:ENABle <NRf>
 Program arm event enable register
- :STATus:OPERation:ARM:SEQuence:ENABle <NRf>
 Program sequence event enable register

Parameters	<NRf> = 0	Clear register
	1	Set Bit B0
	2	Set Bit B1
	4	Set Bit B2
	8	Set Bit B3
	16	Set Bit B4
	32	Set Bit B5
	64	Set Bit B6
	128	Set Bit B7
	256	Set Bit B8
	512	Set Bit B9
	1024	Set Bit B10
	2048	Set Bit B11
	4096	Set Bit B12
	8192	Set Bit B13
	16384	Set Bit B14
32768	Set Bit B15	
65535	Set all bits	
Query	:ENABle?	Query enable register
Description	<p>These commands are used to set the contents of the event enable registers (see Figure 14-10 through Figure 14-15). An :ENABle command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the appropriate register.</p> <p>Each event enable register is used as a mask for events. See [:EVENT]? for descriptions of events. When a bit in an event enable register is cleared (0), the corresponding bit in the event register is masked and thus, cannot set the corresponding summary bit of the next register set in the status structure. Conversely, when a bit in an event enable register is set (1), the corresponding bit in the event register is unmasked. When the unmasked bit in the event register sets, the summary bit of the next register set in the status structure will set.</p> <p>The decimal weighting of the bits for each event enable register are included in Figure 14-10 through Figure 14-15. The sum of the decimal weights of the bits that you wish to set is sent as the parameter (<NRf>) for the appropriate :ENABle command. For example, to set the BFL and RAV bits of the transition filter event enable register, send the following command:</p> <pre>:stat:meas:enab 544</pre> <p>Where: BFL (Bit B9) = Decimal 512 RAV (Bit B5) = Decimal 32 <NRf> = 544</p>	

Figure 14-10
Measurement event enable register

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	FLC	OL	BPT	SRA	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2 ¹⁴)	8192 (2 ¹³)	4096 (2 ¹²)	2048 (2 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Measurement Event
0 = Disable (Mask) Measurement Event

Events : VSC = V-Source Compliance
FLC = Fixture Lid Closed
OL = Out of Limits
BPT = Buffer Pretriggered
SRA = Sequence Reading Available
BFL = Buffer Full
BHF = Buffer Half Full
BAV = Buffer Available
RUF = Reading Underflow
RAV = Reading Available
HL2 = High Limit 2
LL2 = Low Limit 2
HL1 = High Limit 1
LL1 = Low Limit 1
ROF = Reading Overflow

Figure 14-11
Questionable event enable register

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Warn	—	Seq	Coul	—	Hum	Cal	BAV	RUF	RAV	Temp	—	—	Amp	Volt
Decimal Weighting	—	16384 (2 ¹⁴)	—	4096 (2 ¹²)	2048 (2 ¹¹)	—	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁶)	32 (2 ⁵)	16 (2 ⁴)	—	—	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	—	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1	—	—	0/1	0/1

Value : 1 = Enable Questionable Event
0 = Disable (Mask) Questionable Event

Events : Warn = Command Warning
Seq = Sequence Test Summary
Coul = Coulombs Summary
Hum = Humidity Summary
Cal = Calibration Summary
Temp = Temperature Summary
Amp = Amps Summary
Volt = Volts Summary

Figure 14-12
Operation event enable register

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Seq	Idle	Calc	—	—	Arm	Trig	—	—	—	—	Cal
Decimal Weighting	—	2048 (10 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	—	—	64 (2 ⁶)	32 (2 ⁵)	—	—	—	—	1 (2 ⁰)
Value	—	0/1	0/1	0/1	—	—	0/1	0/1	—	—	—	—	0/1

Value : 1 = Enable Operation Event
0 = Disable (Mask) Operation Event

Events : RS-232 = RS-232 Interface Error
Idle = Idle state of the 6517A
Arm = Waiting for Arm
Trig = Waiting for Trigger
Meas = Measuring
Cal = Calibrating

Figure 14-13
Trigger event enable register

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Trigger Event Event : Seq1 = Sequence 1
 0 = Disable (Mask) Trigger Event

Figure 14-14
Arm event enable register

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Arm Event Event : Seq1 = Sequence 1
 0 = Disable (Mask) Arm Event

Figure 14-15
Sequence event enable register

Bit Position	B15 - B3	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2 ²)	2 (2 ¹)	—
Value	—	0/1	0/1	—

Value : 1 = Enable Sequence Event Events : Lay1 = Layer 1
 0 = Disable (Mask) Sequence Event Lay2 = Layer 2

:PTRansition <NRf>

- :STATus:MEASurement:PTRansition <NRf>
Program transition filter transition filter (PTR)
- :STATus:QUEStionable:PTRansition <NRf>
Program questionable transition filter (PTR)
- :STATus:OPERation:PTRansition <NRf>
Program operation transition filter (PTR)
- :STATus:OPERation:TRIGger:PTRansition <NRf>
Program trigger transition filter (PTR)
- :STATus:OPERation:ARM:PTRansition <NRf>
Program arm transition filter (PTR)
- :STATus:OPERation:ARM:SEQuence:PTRansition <NRf>
Program sequence transition filter (PTR)

Parameters	<NRf> =	1	Set Bit B0
		2	Set Bit B1
		4	Set Bit B2
		8	Set Bit B3
		16	Set Bit B4
		32	Set Bit B5
		64	Set Bit B6
		128	Set Bit B7
		256	Set Bit B8
		512	Set Bit B9
		1024	Set Bit B10
		2048	Set Bit B11
		4096	Set Bit B12
		8192	Set Bit B13
		16384	Set Bit B14
		32768	Set Bit B15
	65536	Set all bits	

Query :PTRansition? Query PTR register

Description These commands are used to program the positive transition (PTR) registers. A positive transition is defined as a 0 to 1 state change in the condition register. Thus, when an event is programmed for a positive transition, the appropriate bit in the corresponding event register sets when the corresponding bit in the condition register changes from 0 to 1. For example, if Bit B9 of the positive transition register of the transition filter transition filter is set, then the buffer full event is programmed for a positive transition. The BFL bit (B9) in the transition filter event register sets when the trace buffer becomes full. For details on register structure, see [Section 13](#).

The PTR registers are shown in [Figure 14-16](#) through [Figure 14-21](#). Included is the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program RAV (B5) and BFL (B9) measurement events for positive transitions, send the following command:

```
:stat:meas:ptr 544
```

Where: BFL (Bit B9) = Decimal 512
 RAV (Bit B5) = Decimal 32
 <NRf> = 544

Table 14-16
Positive transition effect on transition filter event register

Measurement event	Positive transition effect on transition filter event register
Reading overflow	Sets B0 when reading exceeds range limits
Low limit 1	Sets B1 when reading is less than the low limit 1 setting
High limit 1	Sets B2 when reading is greater than the low limit 1 setting
Low limit 2	Sets B3 when reading is less than the low limit 2 setting
High limit 2	Sets B4 when reading is greater than the high limit 2 setting
Reading available	Sets B5 after a reading is taken and processed
Reading underflow	Sets B6 when an ohms reading is below the lower range limit
Buffer available	Sets B7 when the trace buffer has at least two readings
Buffer half-ful	Sets B8 when the trace buffer becomes half-ful
Buffer full	Sets B9 when the trace buffer becomes full
Sequence reading available	Sets B10 when an alternating polarity test sequence is being read
Buffer pretriggered	Sets B11 when the trace buffer pretrigger event occurs
Out of Limits	Sets B12 when a noise spike occurs
Fixture lid closed	Sets B13 when fixture lid is closed
V-source compliance	Sets B14 when V-source goes in compliance

Figure 14-16
transition filter transition filter

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	FLC	OL	BPT	SRA	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2 ¹⁴)	8192 (2 ¹³)	4096 (2 ¹²)	2048 (2 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁸)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Positive Transition
 0 = Disable Positive Transition

Events : VSC = V-Source Compliance
 FLC = Fixture Lid Closed
 OL = Out of Limits
 BPT = Buffer Pretriggered
 SRA = Sequence Reading Available
 BFL = Buffer Full
 BHF = Buffer Half Full
 BAV = Buffer Available
 RUF = Reading Underflow
 RAV = Reading Available
 HL2 = High Limit 2
 LL2 = Low Limit 2
 HL1 = High Limit 1
 LL1 = Low Limit 1
 ROF = Reading Overflow

A) Positive Transition (PTR) Register

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	FLC	OL	BPT	SRA	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2 ¹⁴)	8192 (2 ¹³)	4096 (2 ¹²)	2048 (2 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁸)	32 (2 ⁵)	16 (2 ⁴)	8 (2 ³)	4 (2 ²)	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Negative Transition
 0 = Disable Negative Transition

Events : VSC = V-Source Compliance
 FLC = Fixture Lid Closed
 OL = Out of Limits
 BPT = Buffer Pretriggered
 SRA = Sequence Reading Available
 BFL = Buffer Full
 BHF = Buffer Half Full
 BAV = Buffer Available
 RUF = Reading Underflow
 RAV = Reading Available
 HL2 = High Limit 2
 LL2 = Low Limit 2
 HL1 = High Limit 1
 LL1 = Low Limit 1
 ROF = Reading Overflow

A) Negative Transition (NTR) Register

Table 14-17
Positive transition effect on questionable event register

Questionable event	Positive transition effect on questionable event register
Volts summary	Sets B0 when an invalid volts measurement occurs
Amps summary	Sets B1 when an invalid amps measurement occurs
Temperature summary	Sets B4 when an invalid external temperature reading occurs
Humidity summary	Sets B9 when an invalid relative humidity reading occurs
Ohms summary	Sets B10 when an invalid ohms measurement occurs
Coulombs summary	Sets B11 when an invalid coulombs measurement occurs
Sequence test summary	Sets B12 when a sequence test is aborted

Figure 14-17
Questionable transition filter

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Warn	—	Seq	Coul	—	Hum	Cal	BAV	RUF	RAV	Temp	—	—	Amp	Volt
Decimal Weighting	—	16384 (2 ¹⁴)	—	4096 (2 ¹²)	2048 (2 ¹¹)	—	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁸)	32 (2 ⁵)	16 (2 ⁴)	—	—	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	—	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1	—	—	0/1	0/1

Value : 1 = Enable Positive Transition
 0 = Disable Positive Transition

Events : Warn = Command Warning Cal = Calibration Summary
 Seq = Sequence Test Summary Temp = Temperature
 Coul = Coulombs Amp = Amps Summary
 Hum = Humidity Summary Volt = Volts Summary

A) Positive Transition (PTR) Filter

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Warn	—	Seq	Coul	—	Hum	Cal	BAV	RUF	RAV	Temp	—	—	Amp	Volt
Decimal Weighting	—	16384 (2 ¹⁴)	—	4096 (2 ¹²)	2048 (2 ¹¹)	—	512 (2 ⁹)	256 (2 ⁸)	128 (2 ⁷)	256 (2 ⁸)	32 (2 ⁵)	16 (2 ⁴)	—	—	2 (2 ¹)	1 (2 ⁰)
Value	—	0/1	—	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1	—	—	0/1	0/1

Value : 1 = Enable Negative Transition
 0 = Disable Negative Transition

Events : Warn = Command Warning Cal = Calibration Summary
 Seq = Sequence Test Summary Temp = Temperature Summary
 Coul = Coulombs Summary Amp = Amps Summary
 Hum = Humidity Summary Volt = Volts Summary

B) Negative Transition (NTR) Filter

Table 14-18
Positive transition effect on operation event register

Operation event	Positive transition effect on operation event register
Calibrating	Sets B0 at the start of calibration
Trigger layer	Sets B5 when waiting in the trigger layer
Arm layer	Sets B6 when waiting in an arm layer
Calculating	Sets B9 when a reading is being calculated
Idle	Sets B10 when entering the idle state
Sequence test running	Sets B11 when a sequence test is running

Figure 14-18
Operation transition filter

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Seq	Idle	Calc	—	—	Arm	Trig	—	—	—	—	Cal
Decimal Weighting	—	2048 (10 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	—	—	64 (2 ⁶)	32 (2 ⁵)	—	—	—	—	1 (2 ⁰)
Value	—	0/1	0/1	0/1	—	—	0/1	0/1	—	—	—	—	0/1

Value : 1 = Enable Positive Transition
 0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Seq	Idle	Calc	—	—	Arm	Trig	—	—	—	—	Cal
Decimal Weighting	—	2048 (10 ¹¹)	1024 (2 ¹⁰)	512 (2 ⁹)	—	—	64 (2 ⁶)	32 (2 ⁵)	—	—	—	—	1 (2 ⁰)
Value	—	0/1	0/1	0/1	—	—	0/1	0/1	—	—	—	—	0/1

Value : 1 = Enable Negative Transition
 0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Table 14-19
Positive transition effect on trigger event register

Trigger event	Positive transition effect on trigger event register
Sequence 1	Sets B1 when waiting in trigger layer

Figure 14-19
Trigger transition filter

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Table 14-20
Positive transition effect on arm event register

Arm event	Positive transition effect on arm event register
Sequence 1	Sets B1 when in an arm layer

Figure 14-20
Arm transition filter

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2 ¹)	—
Value	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Table 14-21
Positive transition effect on sequence event register

Sequence event	Positive transition effect on sequence event register
Layer 1	Sets B1 when in Arm Layer 1
Layer 2	Sets B2 when in Arm Layer 2

Figure 14-21
Sequence transition filter

Bit Position	B15 - B3	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2 ²)	2 (2 ¹)	—
Value	—	0/1	0/1	—

Value : 1 = Enable Positive Transition
 0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B3	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2 ²)	2 (2 ¹)	—
Value	—	0/1	0/1	—

Value : 1 = Enable Negative Transition
 0 = Disable Negative Transition

B) Negative Transition (NTR) Register

:NTRansition <NRf>

- :STATus:MEASurement:NTRansition <NRf>
 Program transition filter transition filter (NTR)
- :STATus:QUESTionable:NTRansition <NRf>
 Program questionable transition filter (NTR)
- :STATus:OPERation:NTRansition <NRf>
 Program operation transition filter (NTR)
- :STATus:OPERation:TRIGger:NTRansition <NRf>
 Program trigger transition filter (NTR)
- :STATus:OPERation:ARM:NTRansition <NRf>
 Program arm transition filter (NTR)
- :STATus:OPERation:ARM:SEQuence:NTRansition <NRf>
 Program sequence transition filter (NTR)

Parameters	<NRf> = 1	Set Bit B0
	2	Set Bit B1
	4	Set Bit B2
	8	Set Bit B3
	16	Set Bit B4
	32	Set Bit B5
	64	Set Bit B6
	128	Set Bit B7
	256	Set Bit B8
	512	Set Bit B9
	1024	Set Bit B10
	2048	Set Bit B11
	4096	Set Bit B12
	8192	Set Bit B13
	16384	Set Bit B14
	32768	Set Bit B15
65535	Set all bits	

Query :NTRansition? Query NTR register

Description These commands are used to program the negative transition (NTR) registers. A negative transition is defined as a 1 to 0 state change in the condition register. Thus, when an event is programmed for a negative transition, the appropriate bit in the corresponding event register sets when the corresponding bit in the condition register changes from 1 to 0. For example, if Bit B9 of the Negative Transition Register of the transition filter transition filter is set, then the buffer full event is programmed for a negative transition. The BFL bit (B9) in the transition filter event register sets when the trace buffer is no longer full. For details on register structure, see [Section 13](#).

The NTR registers are shown in [Figure 14-16](#) through [Figure 14-21](#). Included is the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program RAV (B5) and BFL (B9) measurement events for negative transitions, send the following command:

```
:stat:meas:ntr 544
```

Where: BFL (Bit B9) = Decimal 512
RAV (Bit B5) = Decimal 32
<NRf> = 544

Table 14-22

Negative transition effect on measurement event register

Measurement event	Negative transition effect on measurement event register
Reading overflow	Sets B0 when a reading has gone from overflow to normal
Low limit 1	Sets B1 when the reading is no longer less than the low limit 1 setting
High limit 1	Sets B2 when the reading is no longer greater than the low limit 1 setting
Low limit 2	Sets B3 when the reading is no longer less than the low limit 2 setting
High limit 2	Sets B4 when the reading is no longer greater than the high limit 2 setting
Reading available	Sets B5 when the next reading is being taken
Reading underflow	Sets B6 when the reading underflow condition has cleared
Buffer available	Sets B7 when the trace buffer has become empty
Buffer half-full	Sets B8 when the trace buffer is no longer half-full
Buffer full	Sets B9 when the trace buffer is no longer full
Sequence reading available	Sets B10 when an alternating polarity measurement is being read

Table 14-22 (continued)

Negative transition effect on measurement event register

Measurement event	Negative transition effect on measurement event register
Buffer pretriggered	Sets B11 when the trace buffer pretrigger operations are completed
Out of limits error	Sets B12 when the out of limits error has cleared
Fixture lid closed	Sets B13 when fixture lid is opened
V-source compliance	Sets B14 when V-source comes out of compliance

Table 14-23

Negative transition effect on questionable event register

Questionable event	Negative transition effect on questionable event register
Volts summary	Sets B0 when a subsequent valid volts measurement occurs
Amps summary	Sets B1 when a subsequent valid amps measurement occurs
Temperature summary	Sets B4 when a subsequent valid external temperature reading occurs
Humidity summary	Sets B9 when a subsequent valid relative humidity reading occurs
Ohms summary	Sets B10 when a subsequent valid ohms measurement occurs
Coulombs summary	Sets B11 when a subsequent valid coulombs measurement occurs
Sequence test summary	Sets B12 when the sequence test is re-started

Table 14-24

Negative transition effect on operation event register

Operation event	Negative transition effect on operation event register
Calibrating	Sets B0 at the end of calibration
Trigger layer	Sets B5 when leaving the trigger layer
Arm layer	Sets B6 when leaving an arm layer
Calculating	Sets B9 when the reading calculation is completed
Idle	Sets B10 when leaving the idle state
Sequence test running	Sets B11 when the aborted test is restarted

Table 14-25

Negative transition effect on trigger event register

Trigger event	Negative transition effect on trigger event register
Sequence 1	Sets B1 when leaving the trigger layer

Table 14-26

Negative transition effect on arm event register

Arm event	Negative transition effect on arm event register
Sequence 1	Sets B1 when leaving an arm layer

Table 14-27

Negative transition effect on sequence event register

Sequence event	Negative transition effect on sequence event register
Layer 1	Sets B1 when leaving arm layer 1
Layer 2	Sets B2 when leaving arm layer 2

:CONDition?

<code>:STATus:MEASurement:CONDition?</code>	Read transition filter condition register
<code>:STATus:QUEStionable:CONDition?</code>	Read questionable condition register
<code>:STATus:OPERation:CONDition?</code>	Read operation condition register
<code>:STATus:OPERation:TRIGger:CONDition?</code>	Read trigger condition register
<code>:STATus:OPERation:ARM:CONDition?</code>	Read arm condition register
<code>:STATus:OPERation:ARM:SEQuence:CONDition?</code>	Read sequence condition rtriggeregister

Description These query commands are used to read the contents of the condition registers. Each set of event registers (except the standard event register set) has a condition register. A condition register is similar to its corresponding event register, except that it is a real-time register that constantly updates to reflect the current operating status of the instrument.

See [[:EVENT?](#)]? for register bit descriptions. Note, from the status structure ([Section 13](#)), that the condition registers precede the transition filters. Thus, only the PTR descriptions apply to the condition registers.

After sending one of these commands and addressing the Model 6517B to talk, a decimal value is sent to the computer. The binary equivalent of this decimal value indicates which bits in the register are set.

For example, if sending `:stat:meas:cond?` returns a decimal value of 512 (binary 0000001000000000), Bit B9 of the transition filter condition register is set indicating that the trace buffer is full.

:PRESet

<code>:STATus:PRESet</code>	Return registers to default conditions
-----------------------------	--

Description When this command is sent, the SCPI event registers are affected as follows:

1. All bits of the positive transition filter registers are set to one (1)
2. All bits of the negative transition filter registers are cleared to zero (0)
3. All bits of the following registers are cleared to zero (0):
 - a. Operation event enable register
 - b. Questionable event enable register
 - c. Measurement event enable register
4. All bits of the following registers are set to one (1):
 - a. Trigger event enable register
 - b. Arm event enable register
 - c. Sequence event enable register

NOTE Registers not included in the above list are not affected by this command.

:QUEue commands**[[:NEXT]]?**

`:STATus:QUEue[:NEXT]?` Read error queue

Description As error and status messages occur, they are placed into the error queue. This query command is used to read those messages.

The error queue is a first-in, first-out (FIFO) register. Every time you read the queue, the oldest message is read and that message is then removed from the queue. The queue will hold up to 10 messages. If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the error queue is empty. When the error queue is empty, the message "0, 'No error'" is placed in the error queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley Instruments defined messages. The messages are listed in [Table 2-4](#).

After this command is sent and the Model 6517B is addressed to talk, the oldest message in the queue is sent to the computer.

NOTE The `:STATus:QUEue[:NEXT]?` query command performs the same function as the `:SYSTem:ERRor?` query command (*:SYSTEM subsystem* below).

ENABle <list>

`:STATus:QUEue:ENABle <list>` Enable messages for error queue

Parameters `<list> = (numlist)`

Where:

numlist is a specified list of messages that you wish to enable for the error queue

Query `:ENABle?` Query list of enabled messages

Description On power-up, all error messages are enabled and will go into the error queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want enabled. Messages not specified will be disabled and prevented from entering the queue.

When this command is sent, all messages will first be disabled, then the messages specified in the list will be enabled. Thus, the returned list (`:ENABle?`) will contain all the enabled messages.

Messages are specified by numbers (see [Table 2-4](#)). The following examples show various forms for expressing a message numlist:

<code>Numlist = -110</code>	Single message
<code>-110, -140, -222</code>	Messages separated by commas
<code>-110:-222</code>	Range of messages (-110 through -222)
<code>-110:-222, -230</code>	Range entry and single entry separated by a comma

NOTE To disable all messages from entering the error queue, send the following command:

`:stat:que:enab ()`

DISable <list>

	<code>:STATus:QUEue:DISable <list></code>	Disable messages for error queue
Parameters	<code><list> = (numlist)</code> Where: numlist is a specified list of messages that you wish to disable for the error queue	
Query	<code>:DISable?</code>	Query list of disabled messages
Description	On power-up, all error messages are enabled and will go into the error queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want disabled. Disabled messages are prevented from going into the error queue. Messages are specified by numbers (see Table 2-4). See ENABLE <list> for examples to express a numlist.	

:CLEar

	<code>:STATus:QUEue:CLEar</code>	Clear error queue
Description	This action command is used to clear the error queue of messages.	

:SYSTEM subsystem

The SYSTEM subsystem contains miscellaneous commands that are summarized in [Table 14-11](#).

:PRESet

	<code>:SYSTEM:PRESet</code>	Return to <code>:SYSTEM:PRESet</code> defaults
Description	This command returns the instrument to states optimized for front panel operation. <code>:SYSTEM:PRESet</code> defaults are listed in the SCPI tables (Table 14-3 through Table 14-15).	

:POSetup <name>

	<code>SYSTEM:POSetup <name></code>	Program power-on defaults
Parameters	<code><name> = RST</code> <code>PRESet</code> <code>SAVX</code>	Select <code>*RST</code> defaults on power-up Select <code>:SYSTEM:PRESet</code> defaults on power-up Select saved defaults on power-up where; X = 0 to 9
Query	<code>:POSetup?</code>	Query power-on setup
Description	This command is used to select the power-on defaults. With <code>RST</code> selected, the instrument powers up to the <code>*RST</code> default conditions. With <code>PRESet</code> selected, the instrument powers up to the <code>:SYSTEM:PRESet</code> default conditions. Default conditions are listed in the SCPI tables (Table 14-3 through Table 14-15). With one of the <code>SAV</code> parameters selected, the instrument powers-on to the setup that is saved in the specified memory location using the <code>*SAV</code> command.	

:VERSion?

	<code>:SYSTEM:VERSion?</code>	Read SCPI version
Description	This query command is used to read the version of the SCPI standard being used by the Model 6517B. Example code: 1996.0	

The above response message indicates the version of the SCPI standard.

:ERRor?

:SYSTem:ERRor? Read error queue

Description As error and status messages occur, they are placed into the error queue. This query command is used to read those messages. The error queue is a first-in, first-out (FIFO) register that can hold up to 10 messages. Every time you read the queue, the oldest message is read and that message is then removed from the queue.

If the queue becomes full, the message "350, 'Queue Overflow'" occupies the last memory location in the register. On power-up, the queue is empty. When the error queue is empty, the message "0, 'No error'" is placed in the error queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley Instruments defined messages. [Table 2-4](#) lists the messages.

NOTE The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command ([:STATus subsystem](#)).

**:LSYNc:STATe **

:SYSTem:LSYNc:STATe Control line synchronization

Parameters = 0 or OFF Disable line synchronization
 1 or ON Enable line synchronization

Query :STATe? Query line synchronization

Description This command is used to enable or disable line synchronization. When enabled, the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero.

With line synchronization disabled, the integration period starts when the reading is triggered.

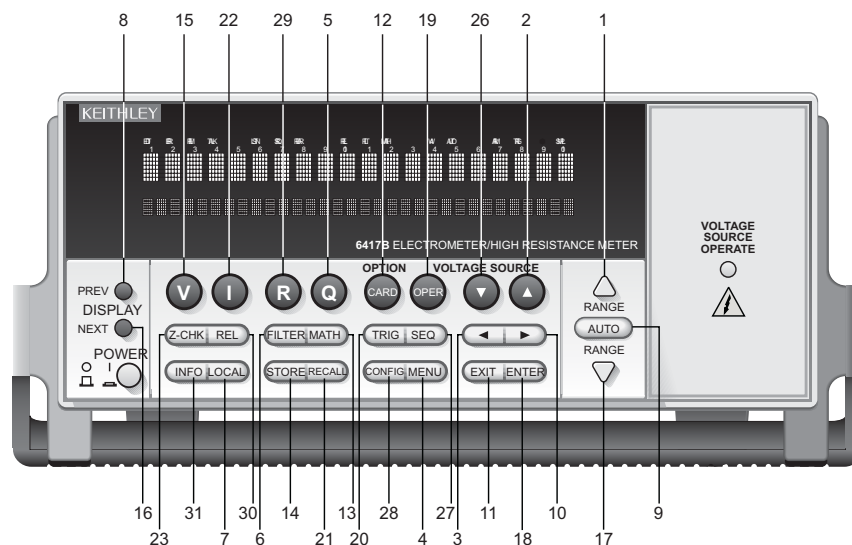
:KEY <NRf>

:SYSTem:KEY <NRf> Simulate key-press (see [Figure 14-22](#))

Parameters <NRf> = 1 Range Up Arrow <NRf> = 16NEXT
 2 V-source Up Arrow 17 Range Down Arrow
 3 Left Arrow 18 ENTER
 4 MENU 19 OPER
 5 Q 20 TRIG
 6 FILTER 21 RECALL
 7 LOCAL 22 I
 8 PREV 23 Z-CHK
 9 AUTO 26 V-source Down Arrow
 10 Right Arrow 27 SEQ
 11 EXIT 28 CONFIG
 12 CARD 29 R
 13 MATH 30 REL
 14 STORE 31 INFO
 15 V

- Query** :KEY? Query last pressed key
- Description** This command is used to simulate front panel key presses. For example, to select V (volts) you can send the following command to simulate pressing the **V** key:
- ```
:syst:key 15
```
- The parameter listing provides the key-press code in numeric order. [Figure 14-22](#) also provides the key-press code.
- The :KEY command allows you to select the NEXT displays over the bus. Sending :SYSTEM:KEY 16 over the bus is same as a single press of the **NEXT** key. Sending :SYSTEM:KEY 8 is the same as a single press of the **PREV** key. The NEXT display that is selected depends on how many times the **NEXT** key is pressed using the :KEY command. The instrument can always be returned to the normal display by pressing the **PREV** key a similar number of times, or by sending the :DISPLAY:CNDisplay command.
- For example, you can display the bar graph by pressing the **NEXT** key twice as follows:
- ```
:syst:key 16; key 16
```
- To return to the normal display, press the **PREV** key twice as follows:
- ```
:syst:key 8; key 8
```
- The queue for the :KEY? query command can only hold one key-press. When :KEY? is sent over the bus, and the Model 6517B is addressed to talk, the key-press code number for the last key pressed (either physically or with :KEY) is sent to the computer.

Figure 14-22  
**Key-press codes**



- :CLEAr**
- ```
:SYSTEM:CLEAr                           Clear error queue
```
- Description** This action command is used to clear the error queue of messages.

:DATE <yr>, <mo>, <day>

:SYSTem:DATE <yr>, <mo>, <day> Set date for clock

Parameters <yr> = 2005 to 2104 Specify year
 <mo> = 1 to 12 Specify month
 <day> = 1 to 31 Specify day

Query :DATE? Query the date

Description This command is used to set the date for the real-time clock. Setting an invalid date (for example, February 30, 2007) result in an error and the previous date is retained.

:TIME <hr>, <min>, <sec>

:SYSTem:TIME <hr>, <min>, <sec> Set time for clock

Parameters <hr> = 0 to 23 Specify hour (24 hr format)
 <min> = 0 to 59 Specify minute
 <sec> = 0.00 to 59.9 Specify second (rounded to 1/100 seconds)

Query :TIME? Query the time

Description This command is used to set the time for the real-time clock. Note that the time must be set using the 24-hour format (for example, hour 13 is 1PM). Setting an invalid time results in an error, and the previous time is retained.

:TIME? returns the time to the nearest hundredth of a second.

:TSTamp commands

The following commands are used to configure and control the time stamp.

:TYPE <name>

:SYSTem:TSTamp:TYPE <name> Select time stamp type

Parameters <name> = RELative Select relative-time time stamp
 RTClock Select real-time time stamp

Query :TYPE? Query Time stamp type

Description This command is used to select the time stamp type. RTClock selects the real-time clock time stamp. Readings are reference to the date and time. RTClock is a 100-year (max) calendar with 10msec resolution.

RELative selects the relative-time time stamp. Readings are referenced (in seconds) to a timer. The timer starts at zero seconds when the instrument is turned on or when the time stamp is reset (see :RELative:RESet). RELative is a 55-day (max) clock with 1μsec resolution.

:RELative:RESet

:SYSTem:TSTamp:RELative:RESet Reset relative time stamp to 0

Description This action command is used to reset the relative-time time stamp to zero seconds.

Zero correction can then be performed with zero check disabled. The description for `:ZCORrect[:STATE]` provides a command sequence using an acquired zero correction value.

A/D controls

:ARSPeed <name>

`:SYSTEM:ARSPeed <name>` Control autoranging speed

Parameters `<name> = FAST` Fast autoranging
`NORMal` Normal autoranging

Query `:ARSPeed?` Query current autoranging speed setting

Description This command is used to control autoranging speed. If the autoranging causes the instrument to rapidly alternate between ranges, changing the speed to `NORMal` will delay measurements after changing ranges to help avoid oscillating between ranges.

:TSControl

`:SYSTEM:TSControl ` Control external temperature readings

Parameters ` = 0 or OFF` Disable external temperature readings
`1 or ON` Enable external temperature readings

Query `:TSControl?` Query state of temperature readings

Description This command is used to control external temperature readings. When enabled (and the Model 6517-TP connected to the instrument), the Model 6517B will make external temperature readings. Note that `ETEMPerature` has to be a selected data element in order to include the temperature reading in the data string.

:HSControl

`:SYSTEM:HSControl ` Control humidity readings

Parameters ` = 0 or OFF` Disable humidity readings
`1 or ON` Enable humidity readings

Query `:HSControl?` Query state of humidity readings

Description This command is used to control humidity readings. When enabled (and the Model 6517-RH connected to the instrument), the Model 6517B will make humidity readings. Note that `HUMidity` has to be a selected data element in order to include the humidity reading in the data string.

:HLControl

`:SYSTEM:HLControl ` Control A/D hardware limit

Parameters ` = 0 or OFF` Disable A/D hardware limit
`1 or ON` Enable A/D hardware limit

Query `:HLControl?` Query state of A/D hardware limit

Description This command is used to control the A/D hardware limit. With the hardware limit `ON`, the "OutOfLimit" error message is enabled to indicate that an out of range noise spike has occurred.

Disabling the hardware limit disables the error message. With the hardware limit `OFF`, noise spikes may cause the reading to be erroneous.

1 = Interlock cable connected to the 6517B and fixture, or not connected to 6517B at all.

0 = Interlock cable connected to 6517B but not connected to fixture, or interlock cable connected to 6517B but fixture lid is open.

If the interlock cable is not connected, the Model 6517B cannot determine the state of the test fixture lid (open or closed) or read the test fixture switch settings. A potential safety hazard is present when the fixture lid is open.

:TRACe subsystem

The commands in this subsystem are used to configure and control data storage into the buffer. The commands are summarized in [Table 14-12](#). See [Section 8](#) for more information about the buffer.

:TRACe|:DATA

The bar (|) indicates that :TRACe or :DATA can be used as the root command for this subsystem. From this point on, the documentation in this manual uses :TRACe. If you prefer to use :DATA, simply replace all the :TRACe command words with :DATA.

:CLEAr

:TRACe:CLEAr

Clear buffer

Description This action command is used to clear the buffer of readings. If you do not clear the buffer, a subsequent store will overwrite the old readings. If the subsequent store is aborted before the buffer becomes full, you could end up with some old readings still in the buffer.

:FREE?

:TRACe:FREE?

Read status of memory

Description This command is used to read the status of storage memory. After sending this command and addressing the Model 6517B to talk, two values separated by commas are sent to the computer. The first value indicates how many bytes of memory are available, and the second value indicates how many bytes are reserved to store readings.

:POINTs <n>

:TRACe:POINTs <n>

Specify buffer size

Parameters	<n> =	1 to 50000 DEFault MAXimum MINimum	Specify number or readings 100 See Table 8-1 1
Query	:POINTs?		Query buffer size

Description This command is used to specify the size of the buffer. When the specified number of readings are stored in the buffer, the buffer is considered to be full.

NOTE For compatibility with the 6517A, the `MAX` parameter results in buffer sizes that match the 6517A. The Model 6517B will allow up to 50,000 points to be used if specified.

**:AUTO **

`:TRACe:POINts:AUTO ` Control auto buffer sizing

Parameters `` = 0 or OFF Disable auto buffer sizing
 1 or ON Enable auto buffer sizing

Query `:AUTO?` Query state of auto buffer sizing

Description This command is used to enable or disable auto buffer sizing. When enabled, the buffer size defaults to the measure count value in the trigger model (see `:COUNT <n>` in `:TRIGger subsystem`). With auto buffer enabled, changing the trigger model's measure count value changes the buffer size to that value. If the `:TRIGger:COUNT` is greater than the maximum buffer size, the buffer is adjusted to the maximum size and the following message is displayed:

+314 "Buffer sizing error; sized to MAX" (MAX may be to 50,000 readings).

Disabling auto buffer sizing does not affect the size of the buffer. It simply means that you must then use the `:POINts` command to change the buffer size.

If you use the `:POINts` command to change the buffer size while auto is enabled, the buffer size changes to that value and auto buffer sizing disables.

If you try to enable auto buffer sizing while the measure count is programmed for infinite, an error will occur and the command will be ignored. You cannot have an infinite buffer size.

:ACTual?

`:TRACe:POINts:ACTual?` Query number of readings in buffer

Description This query command returns the number of readings that are currently stored in the buffer. After sending this command, the number of readings stored in the buffer will be sent to the computer when the Model 6517B is addressed to talk. This command can be used to monitor the storage process.

:FEED Commands

:[PERCent] <n>

`:TRACe:FEED:PRETrigger:AMOUNT:[PERCent] <n>` Specify percent of pre-trigger readings

Parameters `<n>` = 0 to 100 % of buffer for pre-trigger readings
 DEFault 50% of buffer for pre-trigger readings
 MINimum 0% of buffer for pre-trigger readings
 MAXimum 100% of buffer for pre-trigger readings

Query `:[PERCent]?` Query percent of pre-trigger readings

Description This command is used to specify how much of the defined buffer (`:POINts`) will be used to store pre-triggered readings (see `:POINts <n>`). When a pre-trigger store is started (see `:CONTRol <name>` for `:FEED:CONTRol`), readings are continuously stored in the buffer. When the pre-trigger event occurs (see

`:SOURce <name>` for `:PRETrigger:SOURce`), post-trigger readings will then fill the part of the buffer that is not reserved for pre-trigger readings.

For example, assume 25% of a 100-point buffer is reserved for pre-trigger readings. When the pre-trigger store is started, readings continuously fill the buffer. When the pre-trigger event occurs, subsequent readings will then be stored starting at buffer location 26 and continue until buffer location 100 is filled. Storage stops after buffer location 100 is filled. The result is 25 pre-trigger readings and 75 post-trigger readings (see [Configuring data storage](#) for more information).

:READings <n>

`:TRACe:FEED:PRETrigger:AMOUNT:READings <n>`

Specify number of pre-trigger readings

Parameters	<code><n> = 0 to MAXimum</code>	Specify number or readings
	<code>DEFault</code>	Half of <code>MAXimum</code>
	<code>MAXimum</code>	Buffer size as programmed by <code>:TRACe:POINTs</code>
	<code>MINimum</code>	0
Query	<code>:READings?</code>	Queries number of pre-trigger readings
	<code>:READings? DEFault</code>	Queries <code>*RST</code> default number of readings
	<code>:READings? MAXimum</code>	Queries largest allowable number of readings
	<code>:READings? MINimum</code>	Queries lowest allowable number of readings
Description	This command is used to specify how much of the defined buffer (<code>:POINTs</code>) will be used to store pre-triggered readings (see <code>:POINTs <n></code>). This command is essentially the same as the previous <code>:PERCent</code> command except the amount is expressed as an exact value rather than a percent.	
	Sending a value that exceeds the defined size of the buffer (see <code>:POINTs <n></code>) generates an error. The command is ignored.	

:SOURce <name>

`:TRACe:FEED:PRETrigger:SOURce <name>` Specify pre-trigger event

Parameters	<code><name> = TLINK</code>	Use trigger link as pre-trigger event
	<code>BUS</code>	Use bus trigger as pre-trigger event
	<code>MANual</code>	Use TRIG key as pre-trigger event
Query	<code>:SOURce?</code>	Query pre-trigger event source
Description	This command is used to specify the event for the pre-trigger storage mode. With the pre-trigger mode selected (see <code>:CONTRol <name></code> for <code>PRETrigger</code>), readings are continuously stored in the buffer while waiting for the pre-trigger source event.	
	With <code>TLINK</code> selected, an input trigger through the trigger link provides the pre-trigger event. The trigger link line used for the input trigger is programmed from the trigger subsystem (see <code>:PROTocol <name> :TRIGGER:TCONfigure</code> command path, on page 14-99).	
	With <code>BUS</code> selected, a GPIB bus trigger (<code>GET</code> or <code>*TRG</code>) provides the pre-trigger event.	
	With <code>MANual</code> selected, pressing the front panel TRIG key provides the pre-trigger event.	

:CONTRol <name>

	<code>:TRACe:FEED:CONTRol</code>	<code><name></code>	Specify buffer control
Parameters	<code><name> =</code>	<code>NEVer</code>	Disables buffer storage
		<code>NEXt</code>	Fills buffer and stops
		<code>ALWayS</code>	Continuously stores readings in buffer
		<code>PRETrigger</code>	Use Pretrigger mode to store readings
Query	<code>:CONTRol?</code>		Query buffer control
Description	<p>This command is used to select the buffer control. With <code>NEVer</code> selected, storage into the buffer is disabled. With any of the other selections, storage is performed as long as buffer feed is not set for <code>NEVer</code>. When <code>NEXt</code> is selected, the storage process starts, fills the buffer and then stops. The buffer size is specified by the <code>:POINTs</code> command (see :POINTs <n>).</p> <p>When <code>ALWayS</code> is selected, the storage process starts and continues to store readings even after the buffer fills. After the buffer fills, readings overwrite the previously stored readings.</p> <p>When <code>PRETrigger</code> is selected, the buffer stores readings continuously (like <code>ALWayS</code>) until the programmed pre-trigger event occurs. When the pre-trigger event occurs, the section of the buffer specified for post-trigger readings fills with new readings. The storage process stops when the post-trigger portion of the buffer becomes full with new readings (see <code>:TRACe:FEED:PRETrigger</code> parameter).</p>		

:DATA?

	<code>:TRACe:DATA?</code>		Send buffer readings
Description	<p>When this command is sent and the Model 6517B is addressed to talk, all the readings stored in the buffer are sent to the computer. The format that readings are sent over the bus is controlled by the FORMat subsystem.</p> <p>Note that the buffer elements selected by <code>:TRACe:ELEMents</code> (see :ELEMents <item list>) must match the bus elements selected by <code>:FORMat:ELEMents</code> (see FORMat subsystem for more information). Otherwise, the following error will occur when using this command to send buffer readings over the bus.</p> <p>+313 Buffer & format element mismatch</p>		

:LAST?

	<code>:TRACe:LAST?</code>		Read last alternating polarity reading stored in buffer.
Description	<p>When this query command is sent and the Model 6517B is addressed to talk, the last reading stored in the buffer from the alternating polarity resistance/resistivity test sequence is sent to the computer. The format that the reading is sent over the bus is controlled from the <code>:FORMat</code> subsystem.</p> <p>Note that this command only works while the alternating polarity test sequence is running or waiting for a control source event to start the test sequence.</p>		

:TSTamp:FORMat <name>

	<code>:TRACe:TSTamp:FORMat</code>	<code><name></code>	Select time stamp format
Parameters	<code><name> =</code>	<code>ABSolute</code>	Reference to first buffer reading
		<code>DELTA</code>	Time between buffer readings
Query	<code>:FORMat?</code>		Query time stamp format

Description This command is used to select the time stamp format for buffer readings. With ABSolute selected, each time stamp is referenced to the first reading stored in the buffer. With DELTA selected, time stamps provide the time between each buffer reading. See [:ELEMENTs <item list>](#), [:TSTamp commands](#), and [:TYPE <name>](#) ([:TSTamp commands](#)) for more information.

:ELEMENTs <item list>

	<code>:TRACe:ELEMENTs <item list></code>	Select elements for buffer
Parameters	<code><item list> =TSTamp</code>	Includes time stamp
	<code>HUMidity</code>	Includes humidity
	<code>CHANnel</code>	Includes channel number
	<code>ETEMPerature</code>	Includes external temperature
	<code>VSource</code>	Includes V-source
	<code>NONE</code>	None of the above elements

NOTE Items in the list must be separated by commas (,).

Query `:ELEMENTs?` Query selected elements

Description READING, STATUS, RNUMBER (reading number) and UNIT are always enabled for the buffer and are included in the response for the query (`:ELEMENTs?`).

This command is used to include additional elements for each buffer reading. The [:ELEMENTs <item list>](#) command (under [FORMat subsystem](#)) provides a detailed description for each element.

:TRIGger subsystem

The trigger subsystem is made up of a series of commands and subsystems to configure the three layers of the trigger model (see [Trigger models](#) for more information) These commands and subsystems are summarized in [Table 14-13](#).

:INITiate commands

[:IMMediate]

`:INITiate[:IMMediate]` Take 6517B out of idle

Description This command takes the Model 6517B out of the idle state. After all programmed operations are completed, the instrument leaves the trigger layers and returns to the idle state if continuous initiation is disabled (see [:CONTinuous](#)).

**:CONTinuous **

`:INITiate:CONTinuous ` Control continuous initiation

Parameters ` =`

<code>0 or OFF</code>	Disable continuous initiation
<code>1 or ON</code>	Enable continuous initiation

Query `:CONTinuous?` Query continuous initiation

Description When continuous initiation is selected (ON), the instrument is taken out of the idle state. At the conclusion of all programmed operations, the instrument returns to Arm Layer 1.

:POFLag <name>

	:INITiate:POFLag <name>	Control no-operation-pending flag
Parameters	<name> = INCLude EXCLude	Include no-operation-pending flag Exclude no-operation-pending flag
Query	:POFLag?	Query Pending operation flag status
Description	This command is used to include or exclude the no-operation-pending flag in the internal process of determining whether all pending operations of an initiate command are completed. For more information on the no-operation-pending flag, see the <i>*OPC (operation complete)</i> and <i>*OPC? (operation complete query)</i> commands in Section 12 .	

:ABORt

	:ABORt	Abort operation
Description	When this action command is sent, the Model 6517B aborts operation and returns to the top of the trigger model. If continuous initiation is disabled, the instrument goes the idle state. If continuous initiation is enabled, operation continues on into Arm Layer 1.	
	The abort command resets the source bypasses of the trigger model. If scanning, the scan pointer resets back to the first channel in the scan list.	

:IMMediate

	:ARM[:SEquence[1]][:LAYer[1]]:IMMediate	Bypass arm control source
	:ARM[:SEquence[1]]:LAYer2:IMMediate	Bypass scan control source and delay
	:TRIGger[:SEquence[1]]:IMMediate	Bypass measure control source and delay
Description	These action commands are used to bypass the specified control source of the trigger model. They are used when you do not wish to wait for the programmed event. Note from the <i>IEEE-488 trigger model (Figure 11-5)</i> that :ARM:LAY2:IMM and :TRIG:IMM also bypass the delay.	
	The instrument must be waiting for the appropriate event when this command is sent. Otherwise, an error occurs and the command is ignored. When the command is sent, the bypass occurs and operation continues on.	

:COUNT <n>

	:ARM[:SEquence[1]][:LAYer[1]]:COUNT <n>	Set arm layer count
	:ARM[:SEquence[1]]:LAYer2:COUNT <n>	Set scan layer count
	:TRIGger[:SEquence[1]]:COUNT <n>	Set measure layer count
Parameters	<n> = 1 to 99999 INF DEFault MINimum MAXimum	Specify count Sets count to infinite Sets count to 1 Sets count to 1 Sets count to 99999
Query	:COUNT? :COUNT? DEFault :COUNT? MINimum :COUNT? MAXimum	Queries programmed count Queries *RST default count Queries lowest allowable count Queries largest allowable count

Description These commands are used to specify how many times operation loops around in the specified layer of operation. For example, if the measure count is set to 10, operation continues to loop around in the measure layer until 10 measurements are performed. After the 10th measurement, operation proceeds back up to the scan layer.

:DElay <n>

:ARM[:SEquence[1]]:LAYer2:DElay <n> Set scan layer delay
 :TRIGger[:SEquence[1]]:DElay <n> Set measure layer delay

Parameters <n> = 0 to 999999.999 Specify delay in seconds
 DEFault 0 second delay
 MINimum 0 second delay
 MAXimum 999999.999 second delay

Query :DElay? Query the programmed delay
 :DElay? DEFault Query the *RST default delay
 :DElay? MINimum Query the lowest allowable delay
 :DElay? MAXimum Query the largest allowable delay

Description These delay periods are used to delay operation in the specified layer. After the programmed event occurs, the instrument waits until the delay period expires before proceeding on in the trigger model (see [IEEE-488 trigger model, Figure 11-5](#)). Note that the arm layer (Arm Layer 1) does not use a delay.

:SOURce <name>

:ARM[:SEquence[1]][:LAYer[1]]:SOURce <name> Specify arm event control source
 :ARM[:SEquence[1]]:LAYer2:SOURce <name> Specify scan event control source
 :TRIGger[:SEquence[1]]:SOURce <name> Specify measure event control source

Parameters <name> = HOLD Hold operation in specified layer
 IMMEDIATE Pass operation through specified layer
 RTCLock Select real-time clock as event (Arm Layer 1 only)
 MANual Select manual event
 BUS Select GPIB trigger as event
 TLINk Select trigger link as event
 EXTernal Select external triggering as event
 TIMer Select timer as event (not available for Arm Layer 1)

Query :SOURce? Query programmed control source.

Description These commands are used to select the event control source for the specified layer. With **HOLD** selected, operation stops and waits indefinitely in the specified layer. While in **HOLD**, operation can be continued by sending the **:IMMEDIATE** command or the **:SIGNal** command. Keep in mind however, that if the layer count is >1, **HOLD** is again enforced when operation loops back around.

With **IMMEDIATE** selected (do not confuse **:SOURce IMMEDIATE** with **:IMMEDIATE**), operation immediately passes through the specified layer.

A specific event can be used to control operation through a layer. With **BUS** selected, operation continues when a GPIB trigger (**GET** or ***TRG**) is sent. With **TLINk** selected, operation continues when an input trigger through the trigger link is received.

:OLINe <NRf>

```
:ARM[:SEquence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:OLINe <NRf>
    Select output trigger line; arm layer
:ARM[:SEquence[1]]:LAYer2:TCONfigure:ASYNchronous:OLINe <NRf>
    Select output trigger line; scan layer
:TRIGger[:SEquence[1]]:TCONfigure:ASYNchronous:OLINe <NRf>
    Select output trigger line; measure layer
```

Parameters <NRf> = 1 Line #1 4 Line #4
 2 Line #2 5 Line #5
 3 Line #3 6 Line #6

Query :OLINe? Query programmed output line #

Description These commands are used to select an output line for the asynchronous trigger link of the specified layer. Keep in mind that asynchronous trigger link input and output cannot share the same line. If you assign the output to a line that is already being used for the input, an error occurs and the command is ignored.

:SSYNchronous:LINE <NRf>

```
:TRIGger[:SEquence[1]]:TCONfigure:SSYNchronous :LINE <NRf>
    Specify semi-synchronous trigger link line for measure layer
```

Parameters <NRf> = 1 Line #1 4 Line #4
 2 Line #2 5 Line #5
 3 Line #3 6 Line #6

Query :LINE? Query programmed output line #

Description This command is used to select one of the six trigger lines for the semi-synchronous trigger link.

RTCLock commands

The following commands are used to specify the date and time for the RTCLock control source (see [:TSTamp commands](#) for more information).

:DATE <yr>, <mo>, <day>

```
:ARM[:SEquence[1]][:LAYer[]]:RTCLock:DATE <yr>, <mo>, <day>
    Set date for RTCLock control source
```

Parameters <yr> = 2005 to 2104 Specify year
 <mo> = 1 to 12 Specify month
 <day> = 1 to 31 Specify day

Query :DATE? Query the date

Description This command is used to set the date for the RTCLock control source. Setting an invalid date (for example, February 30, 2007) for the clock event results in an error and the previous date is retained.

:TIME <hr>, <min>, <sec>

```
:ARM[:SEquence[1]][:LAYer[]]:RTCLock:TIME <hr>, <min>, <sec>
    Set time for RTCLock control source
```

Parameters <hr> = 0 to 23 Specify hour (24 hour format)
 <min> = 0 to 59 Specify minute
 <sec> = 0.00 to 59.99 Specify second (round to 1/100 seconds)

Query	:DATE?	Query the time
Description	This command is used to set the time for the RTCLock control source. Note that the time must be set using the 24-hour format (for example, hour 13 is 1pm). Setting an invalid time results in an error, and the previous time is retained.	
	:TIME?	returns the time to nearest hundredth of a second.

:TSEquence subsystem

The commands in this subsystem are used to configure and control the built-in test sequences, and are summarized in [Table 14-14](#). Detailed information on the test sequences is provided in [Section 6](#).

In your test programs, use the *OPC? command before arming (:TSEquence:ARM) the test. The *OPC? command allows previous command operations to finish before arming the test. Failure to do so may cause unfavorable results. The programming example at the end of this subsystem demonstrates how to use the *OPC? command.

You should use SRQ to indicate when a test sequence is finished. The programming example at the end of this subsystem generates an SRQ when the buffer is full (test sequence finished). The readings are then sent to the computer where they are displayed.

General test sequence commands

:ARM

	:TSEquence:ARM	Arm selected test sequence
Description	This action command is used to arm the selected test sequence (see :TYPE <name>). The test will start when the programmed source event occurs (see :TSource <name>). When using this command for the alternating polarity High resistance/resistivity transition filters, wait at least 0.3 seconds before using the *TRG trigger command.	

:ABORt

	:TSEquence:ABORt	Step test sequence in process
Description	This command is used to stop a test sequence that is in process. You can start it again by arming (see :ARM) the test and providing the programmed source event (see :TSource <name>).	

:TYPE <name>

	:TSEquence:TYPE <name>	Select test sequence
Parameters	<name> =	
	DLEakage	Diode leakage test
	CLEakage	Capacitor leakage test
	CIResistance	Cable insulation resistance test
	RVCoefficient	Resistor voltage coefficient test
	SRESistivity	Surface resistivity test
	VRESistivity	Volume resistivity test
	SIResistivity	Surface insulation resistance test
	SQSweep	Square wave sweep test
	STSweep	Staircase sweep test
	ALTPolarity	Alternating polarity resistance/resistivity test
Query	:TYPE?	Query selected test sequence

Description This command is used to select the desired test sequence. When test sequence is started (see [:TSource <name>](#)), the selected test will run according to how it is configured. The commands in the following paragraphs configure the test sequences.

:TSource <name>

:TSequence:TSource <name> Select control source to start test

Parameters <name> = MANual Manual control source
 IMMEDIATE Immediate control source
 BUS Bus trigger control source
 EXTERNAL External trigger control source
 TLINK Trigger link control source
 LCLOSURE Test fixture lid closure

Query :TSource? Query control source to start test

Description This command is used to select the event that will start the selected test sequence. When the selected control source event occurs, the test will start.

With MANual selected, the test will start when the **SEQ** key is pressed. With IMMEDIATE selected, the test will start as soon as the instrument is taken out of the idle state. The :INITiate and :INITiate:CONTinuous ON commands will take the instrument out of the idle state. Note that if the instrument is already in the continuous measurement mode (not in idle), the test will start as soon as IMMEDIATE is selected.

With BUS selected, the test will start when a bus trigger (*TRG or GET) is sent over the bus.

With TLINK selected, the test will start when an external trigger is received through the TRIG LINK connector on the rear panel. The :TLINe command is used to select which trigger link line to use for the input trigger.

With LCLOSURE selected, the test will start when the test fixture lid is closed. This will only work for test fixtures (such as the Model 8009) that incorporate the safety interlock feature. If any sequence is armed when this command is sent, it will not take effect until the next sequence arm event.

:TLIne <NRf>

:TSequence:TLIne <NRf> Specify trigger link line

Parameters <NRf> = 1 Line #1 4 Line #4
 2 Line #2 5 Line #5
 3 Line #3 6 Line #6

Query :TLINe? Query trigger link line

Description This command is used to specify the input trigger link line for the TLINK control source. This command is not used if a different control source is selected (see [:TSource <name>](#)).

:START <NRf>

:TSequence:DLEakage:START <NRf> Start voltage; diode leakage test
 :TSequence:STSweep:START <NRf> Start voltage; staircase sweep test

Parameters <NRf> = -100.0 to 100.0 Volts; 100V range
 -1000 to 1000 Volts; 1000V range

:SVOLtage <NRf>

- :TSEquence:CLEakage:SVOLtage <NRf> Bias voltage; capacitor leakage test
- :TSEquence:CIResistance:SVOLtage <NRf> Bias voltage; cable insulation resistance test
- :TSEquence:RVCoefficient:SVOLtage[1] <NRf> Bias voltage 1; resistor voltage coefficient test
- :TSEquence:RVCoefficient:SVOLtage2 <NRf> Bias voltage 2; resistor voltage coefficient test
- :TSEquence:SRESistivity:SVOLtage <NRf> Bias voltage; surface resistivity test
- :TSEquence:VRESistivity:SVOLtage <NRf> Bias voltage; volume resistivity test
- :TSEquence:SIResistance:SVOLtage <NRf> Bias voltage; surface insulation resistivity test

Parameters <NRf> = -100.0 to 100.0 Volts; 100V range
 -1000 to 1000 Volts; 1000V range

Query :SVOLtage? Query soak voltage

Description This configuration command is used for the following tests:

- Capacitor leakage test
- Cable insulation resistance test
- Resistor voltage coefficient test
- Surface resistivity test
- Volume resistivity test
- Surface insulation resistance test

This command is used to specify the bias voltage for the specified test. Note that the resistor voltage coefficient test uses two bias voltages; bias voltage 1 and bias voltage 2.

:STIME <NRf>

- :TSEquence:SRESistivity:STIME <NRf> Bias time; surface resistivity test
- :TSEquence:VRESistivity:STIME <NRf> Bias time; volume resistivity test
- :TSEquence:SIResistance:STIME <NRf> Bias time; sur insul resistance test
- :TSEquence:STSweep:STIME <NRf> Bias time; staircase sweep test

Parameters <NRf> = 0 to 9999.9 Delay in seconds (Staircase Sweep test)
 0 to 99999.9 Delay in seconds (all others)

Query :STIME? Query soak time

Description This configuration command is used for the following tests:

- Surface resistivity test
- Volume resistivity test
- Surface insulation resistance test
- Staircase sweep test

This command is used to specify the bias time for the specified test.

:DTIME <NRf>

:TSEquence:SRESistivity:DTIME <NRf> Discharge time; surface resistivity test
 :TSEquence:VRESistivity :DTIME <NRf> Discharge time; volume resistivity test

Parameters <NRf> = 0 to 99999.9 (seconds)

Query :DTIME? Query discharge time

Description This configuration command is used for the following tests:

Surface resistivity test
 Volume resistivity test

This command is used to specify the discharge time for the specified test.

:PDTime <NRf>

:TSEquence:SRESistivity:PDTime <NRf> Pre-discharge time; surface resistivity test
 :TSEquence:VRESistivity:PDTime <NRf> Pre-discharge time; volume resistivity test

Parameters <NRf> = 0 to 99999.9 (seconds)

Query :PDTime? Query pre-discharge time

Description This configuration command is used for the following tests:

Surface resistivity test
 Volume resistivity test

This command is used to specify the pre-discharge time for the specified test.

:MVOLTage <NRf>

:TSEquence:SRESistivity:MVOLTage <NRf> Measure voltage; surface resistivity test
 :TSEquence:VRESistivity:MVOLTage <NRf> Measure voltage; volume resistivity test
 :TSEquence:SIResistance:MVOLTage <NRf> Measure voltage; surface insulation resistance test

Parameters <NRf> = -100.0 to 100.0 Volts; 100V range
 -1000 to 1000 Volts; 1000V range

Query :MVOLTage? Query measure voltage

Description This configuration command is used for the following tests:

Surface resistivity test
 Volume resistivity test
 Surface insulation resistance test

This command is used to specify the measure voltage for the specified test.

:MTIME <NRf>

:TSEquence:SRESistivity:MTIME <NRf>
 Measure time; surface resistivity test

:TSEquence:VRESistivity:MTIME <NRf>
 Measure time; volume resistivity test

:TSEquence:SIResistance:MTIME <NRf>
 Measure time; surface insulation resistance test

:TSEquence:ALTPolarity:MTIME <NRf>
 Measure time; alternating polarity test

Parameters <NRf> = 0 to 9999.9 (seconds)

NOTE <NRf> = 0.5 to 9999.9 (seconds) for alternating polarity resistance/resistivity test.

Query :MTIME? Query measure time

Description This configuration command is used for the following tests:

Surface resistivity test
 Volume resistivity test
 Surface insulation resistance test
 Alternating polarity resistance/resistivity test

This command is used to specify the measure time for the specified test.

:HLEVEL <NRf>

:TSEquence:SQSweep:HLEVEL <NRf>
 High-level voltage; square wave sweep test

Parameters <NRf> = -100.0 to 100.0 Volts; 100V range
 -1000 to 1000 Volts; 1000V range

Query :HLEVEL? Query high-level voltage

Description This configuration command is used for the following test:

Square wave sweep test

This command is used to specify the high-level voltage for the square wave sweep test.

:HTIME <NRf>

:TSEquence:SQSweep:HTIME <NRf> High-level time; square wave sweep test

Parameters <NRf> = 0 to 9999.9 (seconds)

Query :HTIME? Query high-level time

Description This configuration command is used for the following tests:

Square wave sweep test

This command is used to specify the high-level time for the square wave sweep test.

:LLEVel <NRf>

:TSEquence:SQSWEEP:LLEVel <NRf> Low-level voltage; square wave sweep test

Parameters <NRf> = -100.0 to 100.0 Volts; 100V range
-1000 to 1000 Volts; 1000V range

Query :LLEVel? Query low-level voltage

Description This configuration command is used for the following test:
Square wave sweep test
This command is used to specify the low-level voltage for the square wave sweep test.

:LTIMe <NRf>

:TSEquence:SQSWEEP:LTIMe <NRf> Low-level time; square wave sweep test

Parameters <NRf> = 0 s to 9999.9 s

Query :LTIMe? Query low-level time

Description This configuration command is used for the following tests:
Square wave sweep test
This command is used to specify the low-level time for the square wave sweep test.

:COUNT <NRf>

:TSEquence:SQSWEEP:COUNT <NRf> Specify cycle count

Parameters <NRf> = 1 to MAX/2 See [Table 8-2](#)

Query :COUNT? Query cycle count

Description This command is used to specify how many times to repeat the programmed square wave cycle.

:OFSVoltage <NRf>

:TSEquence:ALTPolarity:OFSVoltage <NRf> Specify offset voltage

Parameters <NRf> = -1000 to 1000 Offset voltage

Query :OFSVoltage? Query offset voltage

Description This command is used to specify the offset voltage for the alternating polarity resistance/resistivity test.

:ALTVoltage <NRf>

:TSEquence:ALTPolarity:ALTVoltage <NRf> Specify alternating voltage

Parameters <NRf> = -1000 to 1000 Alternating voltage

Query :ALTVoltage? Query alternating voltage

Description This command is used to specify the alternating voltage for the alternating polarity resistance/resistivity test.

:READings <NRf>

:TSEquence:ALTPolarity:READings <NRf>
Specify number of readings to store

Parameters <NRf> = 1 to MAXimum Specify number of readings
 DEFAULT 1
 MAXimum See [Table 8-2](#)
 MINimum 1

Query :READings? Query number of readings to store

Description This command is used to specify the number of readings to store for the alternating polarity resistance/resistivity test.

:DISCard <NRf>

:TSEquence:ALTPolarity:DISCard <NRf>
Specify number of readings to initially discard

Parameters <NRf> = 0 to 9999 Number of readings to discard

Query :DISCard? Query number of discarded readings

Description This command is used to specify the number of initial readings to discard for the alternating polarity resistance/resistivity test.

:SPOints <NRf>

:TSEquence:CLEakage:SPOints <NRf> Specify leakage test points
 :TSEquence:CIResistance:SPOints <NRf> Specify resistance test points

Parameters <NRf> = 1 to Max Buffer Size Number of points in test sequence

Query :SPOints? Query number of points

Description This command specifies the number of measurement points for the following tests:

- Capacitor leakage test
- Cable insulation resistance test

:SPINterval <NRf>

:TSEquence:CLEakage:SPINterval <NRf> Specify leakage test interval
 :TSEquence:CIResistance:SPINterval <NRf>
 Specify resistance test interval

Parameters <NRf> = 0 s to 99999.9 s Interval between measurement points

Query :SPINterval? Query interval

Description This command specifies the time interval between measurement points for the following tests:

- Capacitor leakage test
- Cable insulation resistance test

:UNIT subsystem

The UNIT subsystem (see [Table 14-15](#)) is used to select measurement units for temperature readings.

:TEMPerature <name>

	:UNIT:TEMPerature <name>	Select temperature units
Parameters	<name> = C or CEL	°C temperature units
	F or FAR	°F temperature units
	K	K temperature units
Query	:TEMPerature?	Query temperature units
Description	This command is used to select the units for temperature readings (internal and external). This command controls the temperature reading units for the multiple displays, buffer readings and readings sent out over the bus.	

Section 15

Calibration Procedure

In this section:

Topic	Page
Introduction	15-2
Calibration procedure	
Environmental conditions.....	15-2
Warm-up period	15-2
Recommended calibration equipment	15-2
Comprehensive calibration procedure	15-2
Restoring factory defaults	15-3
Unlocking calibration.....	15-3
Voltage offset calibration.....	15-3
Current offset calibration.....	15-5
Current ranges calibration	15-6
Coulombs ranges calibration	15-8
Partial calibration	15-12
Calibration command reference	15-14
Voltage offset calibration commands	15-14
Current offset calibration commands	15-14
Error codes.....	15-20

Introduction

This section discusses the calibration procedure for the Keithley Instruments Model 6517B.

WARNING *The information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages, which could cause personal injury or death if contacted. Use appropriate safety precautions when working with hazardous voltages.*

NOTE If the instrument is still under warranty and its performance is outside specified limits, contact your Keithley Instruments representative or the factory to determine the correct course of action.

Calibration procedure

This section describes the four-part procedure for calibrating the Model 6517B:

- Meter calibration (voltage, current, and charge ranges)
- Temperature calibration
- Humidity calibration
- Voltage source calibration

Because the calibration procedure must be performed remotely using SCPI commands, a computer with suitable software for controlling the instrument over RS-232 or GPIB is required.

Environmental conditions

Calibration should be performed at an ambient temperature of 23 °C +/- 5 °C and a relative humidity of 70% or less.

Warm-up period

The Model 6517B must be allowed to warm up for at least two hours before calibration is performed. If the instrument has been subjected to temperature extremes (outside those specified in the topic [Environmental conditions](#)), allow additional time for the temperature to stabilize. Typically, it takes one additional hour to stabilize a unit that is 10° outside the specified temperature range.

Recommended calibration equipment

The equipment listed in [Equipment needed for verification](#) on [page 16-2](#) should be used to perform calibration.

Comprehensive calibration procedure

The following calibration procedure should only be performed by qualified service personnel, and only after the instrument has met the warm-up criteria described in [Warm-up period](#).

The following steps are for a complete calibration. For a partial calibration, please see the [Partial calibration](#) topic for considerations when performing a subset of the complete calibration.

Restoring factory defaults

To restore the Model 6517B factory-default settings, send the following remote command:

```
:SYST:PRES
```

Unlocking calibration

To unlock the Model 6517B, send the following remote command:

```
:CAL:PROT:CODE 'KI006517'
```

Note that 006517 is the default password. Supply the appropriate password if it has been changed.

Voltage offset calibration

The following steps calibrate the internal voltage offsets of the electrometer input. Connect the digital multimeter to the **PREAMP OUT** terminals of the Model 6517B. Ensure that the ground link is attached to **INPUT LO**.

20 pA to 200 pA range voltage offset

To calibrate the voltage offset for each range:

1. Set the DMM range to 1 V DC, with an integration rate of 10 NPLC with a repeating filter count of 10. Connect a 10 G Ω resistor between the Model 6517B input HI and input LO.

```
:CAL:PROT:VOFF:STEP 1
```

```
:CAL:PROT:VOFFSETZ
```

2. Allow the input to settle for 120 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFFZERO <dmm voltage reading>
```

3. Connect a 1 G Ω resistor between the Model 6517B input HI and input LO.

```
:CAL:PROT:VOFF1
```

4. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

5. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

2 n A to 200 n A range voltage offset

To calibrate the voltage offset for each range:

1. Connect a 10 M Ω resistor between the Model 6517B input HI and input LO. Set the DMM range to 1 VDC.

```
:CAL:PROT:VOFF:STEP 2
```

```
:CAL:PROT:VOFFSETZ
```

2. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFFZERO <dmm voltage reading>
```

3. Connect a 1 M Ω resistor between the Model 6517B input HI and input LO.

```
:CAL:PROT:VOFF1
```

4. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

5. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

2 uA to 200 uA range voltage offset

To calibrate the voltage offset for each range:

1. Connect a 10 K Ω resistor between the Model 6517B input HI and input LO. Set the DMM range to 1 VDC.

```
:CAL:PROT:VOFF:STEP 3
```

```
:CAL:PROT:VOFFSETZ
```

2. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFFZERO <dmm voltage reading>
```

3. Connect a 1 K Ω resistor between the Model 6517B input HI and input LO. Set the DMM range to 1 V DC.

```
:CAL:PROT:VOFF1
```

4. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

5. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

2 mA to 20 mA range voltage offset

To calibrate the voltage offset for each range:

1. Connect a 10 Ω resistor between the Model 6517B input HI and input LO. Set the DMM range to 1 V DC.

```
:CAL:PROT:VOFF:STEP 4
```

```
:CAL:PROT:VOFFSETZ
```

2. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFFZERO <dmm voltage reading>
```

3. Connect a 1 Ω resistor between the Model 6517B input HI and input LO. Set the DMM range to 1 V DC.

```
:CAL:PROT:VOFF1
```

4. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

5. Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

Voltage ranges voltage offset

To calibrate the voltage offset for each range:

Connect the DMM to the Model 6517B preamp output. Set the DMM range to 1 V DC. Connect the Model 6517B input HI to input LO (short the input).

```
:CAL:PROT:VOFF:STEP 5
```

```
:CAL:PROT:VOFF1
```

Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

Coulombs ranges voltage offset

To calibrate the voltage offset for each range:

Connect the DMM to the Model 6517B preamp output. Set the DMM range to 1 V DC. Place the triax cap on the Model 6517B input.

```
:CAL:PROT:VOFF:STEP 6
```

```
:CAL:PROT:VOFF1
```

Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF2 <dmm voltage reading>
```

```
:CAL:PROT:VOFF3
```

Allow the input to settle for 10 seconds, then take the DMM voltage reading.

```
:CAL:PROT:VOFF4 <dmm voltage reading>
```

Current offset calibration

NOTE

The following three commands are automated and require extra time to complete:

- :CAL:PROT:IOFF:STEP 3 takes approximately two minutes
 - :CAL:PROT:IOFF:STEP 4 takes approximately five minutes
 - :CAL:PROT:IOFF:STEP 5 takes approximately two minutes
-

2 nA to 200 nA range current offset

To calibrate the current offset for each range:

1. Connect the DMM to the Model 6517B preamp output, and place the triax cap on the Model 6517B input.

```
:CAL:PROT:IOFF:STEP 1
```

```
:CAL:PROT:IOFF1
```

2. Allow the input to settle for 120 seconds, then take the DMM voltage reading.

```
:CAL:PROT:IOFF2 <dmm voltage reading>
```

```
:CAL:PROT:IOFF3
```

3. Allow the input to settle for 120 seconds, then take the DMM voltage reading.

```
:CAL:PROT:IOFF4 <dmm voltage reading>
```

20 pA to 200 pA range current offset

1. Connect the DMM to the Model 6517B preamp output, and place the triax cap on the Model 6517B input.

```
:CAL:PROT:IOFF:STEP 2
```

```
:CAL:PROT:IOFF1
```

2. Allow the input to settle for 120 seconds, then take the DMM voltage reading.

```
:CAL:PROT:IOFF2 <dmm voltage reading>
```

```
:CAL:PROT:IOFF3
```

3. Allow the input to settle for 120 seconds, then take the DMM voltage reading.

```
:CAL:PROT:IOFF4 <dmm voltage reading>
```

4. Disconnect the DMM from the preamp output, and place a triax cap on the Model 6517B input.

2 nC to 20 nC ranges current offset

To calibrate the current offset for each range:

```
:CAL:PROT:IOFF:STEP 3
```

200 nC to 2 uC ranges current offset

To calibrate the current offset for each range:

```
:CAL:PROT:IOFF:STEP 4
```

Voltage ranges current offset

To calibrate the current offset for each range:

```
:CAL:PROT:IOFF:STEP 5
```

Current ranges calibration

Current range zeros

To calibrate the zero for each current range, place the triax cap on the Model 6517B input terminal. Send the following commands to calibrate each current zero.

Table 15-1: Current Range Calibration Commands

Command	Description
:CAL:PROT:AZERO20M	Obtains measured A/D zero for 20 mA Range, 1 s delay
:CAL:PROT:AZERO2M	Obtains measured A/D zero for 2 mA Range, 1 s delay
:CAL:PROT:AZERO200U	Obtains measured A/D zero for 200 μ A Range, 3 s delay

Command	Description
:CAL:PROT:AZERO20U	Obtains measured A/D zero for 20 μA Range, 3 s delay
:CAL:PROT:AZERO2U	Obtains measured A/D zero for 2 μA Range, 3 s delay
:CAL:PROT:AZERO200N	Obtains measured A/D zero for 200 nA Range, 10 s delay
:CAL:PROT:AZERO20N	Obtains measured A/D zero for 20 nA Range, 10 s delay
:CAL:PROT:AZERO2N	Obtains measured A/D zero for 2 nA Range, 10 s delay
:CAL:PROT:AZERO200P	Obtains measured A/D zero for 200 pA Range, 30 s delay
:CAL:PROT:AZERO20P	Obtains measured A/D zero for 20 pA Range, 30 s delay

Current ranges

To calibrate each current range:

1. Determine the appropriate calibration current for the range.
 - a. For the ±20 pA to ±2 μA current ranges, use [Table 15-2](#) to determine the appropriate calibration current. Calculate the actual current using the formula

$$I = V / R$$

where:

- I = Actual current
- V = Calibrator voltage
- R = Measured value of the calibrated precision resistor:

Table 15-2: Detailed calibration information for the ±20 pA to ±2 μA ranges

Model 6517B range	Calibrator voltage	Resistance standard	Nominal current
20 pA	2.0 V	100 GΩ	20 pA
200 pA	2.0 V	10 GΩ	200 pA
2 nA	2.0 V	1 GΩ	2 nA
20 nA	2.0 V	100 MΩ	20 nA
200 nA	20.0 V	100 MΩ	200 nA
2 μA	200.0 V	100 MΩ	2 μA

2. When calibrating the ±20 μA to ±20 mA ranges:
 - a. Turn the Model 6517B zero-check on
 - b. Turn the DC current calibrator output on
 - c. Send the calibration command from [Table 15-3](#)
3. For each polarity, apply the current in the [Model 6517B range/full scale current](#) column of [Table 15-3](#) to the Model 6517B input.

NOTE All currents applied to the input of the 6517B during calibration must be within ±5% of the nominal value.

4. Calculate (±20 pA to ±2 μA ranges) or note (±20 μA to ±20 mA) the actual current

- Send the command in the *Model 6517B range/full scale current* column of *Table 15-3* with the actual current value to the Model 6517B.

Table 15-3: Calibration currents and commands

Model 6517B range/full scale current	Negative polarity calibration command	Positive polarity calibration command
±20 pA	:CAL:PROT:AN20P <value>	:CAL:PROT:A20P <value>
±200 pA	:CAL:PROT:AN200P <value>	:CAL:PROT:A200P <value>
±2 nA	:CAL:PROT:AN2N <value>	:CAL:PROT:A2N <value>
±20 nA	:CAL:PROT:AN20N <value>	:CAL:PROT:A20N <value>
±200 nA	:CAL:PROT:AN200N <value>	:CAL:PROT:A200N <value>
±2 µA	:CAL:PROT:AN2U <value>	:CAL:PROT:A2U <value>
±20 µA	:CAL:PROT:AN20U <value>	:CAL:PROT:A20U <value>
±200 µA	:CAL:PROT:AN200U <value>	:CAL:PROT:A200U <value>
±2 mA	:CAL:PROT:AN2M <value>	:CAL:PROT:A2M <value>
±20 mA	:CAL:PROT:AN20M <value>	:CAL:PROT:A20M <value>

Coulombs ranges calibration

To calibrate each coulomb range:

- Determine the calibration charge to be used during calibration. For the 2 nC to 2 µC coulomb ranges, use *Table 15-4* to calculate the appropriate calibration charge. Calculate the actual charge using the formula

$$Q = C V$$

where

- Q = Actual charge in coulombs
- C = Measured value of the precision capacitor
- V = Calibrator voltage

Table 15-4: Coulomb range calibration values

Model 6517B coulombs range	Calibrator voltage	Standard capacitance	Nominal charge
2 nC	2.0 V	1 nF	2 nC
20 nC	20.0 V	1 nF	20 nC
200 nC	2.0 V	100 nF	200 nC
2 µC	20.0 V	100 nF	2 µC

- Connect the capacitor stated in the *Standard capacitance* column of *Table 15-4*.
- Set the calibrator voltage output to 0.0 V.

4. Calculate the actual charge (see Step 1) and send the command in the *Coulomb zero calibration command* column from [Table 15-5 Set the calibrator voltage to the value in the Coulomb full scale calibration command of Table 15-5.](#)
5. Set the calibrator voltage to the value in the *Coulomb full scale calibration command* of [Table 15-5.](#)

Table 15-5: Coulomb range calibration commands

Model 6517B coulombs range	Calibrator voltage	Coulomb zero calibration command	Coulomb full scale calibration command
-2 μ C	-20.0 V	:CAL:PROT:CZEROB2U	:CAL:PROT:CN2U <value>
2 μ C	20.0 V	:CAL:PROT:CZEROA2U	:CAL:PROT:C2U <value>
-200 nC	-2.0 V	:CAL:PROT:CZEROB200N	:CAL:PROT:CN200N <value>
200 nC	2.0 V	:CAL:PROT:CZEROA200N	:CAL:PROT:C200N <value>
-20 nC	-20.0 V	:CAL:PROT:CZEROB20N	:CAL:PROT:CN20N <value>
20 nC	20.0V	:CAL:PROT:CZEROA20N	:CAL:PROT:C20N <value>
-2 nC	-2.0 V	:CAL:PROT:CZEROB2N	:CAL:PROT:CN2N <value>
2 nC	2.0 V	:CAL:PROT:CZEROA2N	:CAL:PROT:C2N <value>

Voltage measurement ranges calibration

To calibrate the voltage measurement ranges:

1. Connect the DC voltage calibrator to the Model 6517B input.
2. Apply 0.0 V
3. Send the following commands to:
 - :CAL:PROT:VZERO2
 - :CAL:PROT:VZERO20
 - :CAL:PROT:VZERO200
4. Leaving the DC voltage calibrator connected, calibrate each polarity of each range:
 - a. Apply the voltage listed in the *Model 6517B Range/Full-scale voltage* column of [Table 15-6.](#)
 - b. Send the calibration command listed in the *Voltage range calibration command* column of [Table 15-6](#) with the voltage reading from the DC voltage calibrator.

Table 15-6: Model 6517 voltage range calibration commands

Model 6517B Range/Full-scale voltage	Voltage range calibration command
+2 V	:CAL:PROT:V2 <actual voltage value>
-2 V	:CAL:PROT:VN2 <actual voltage value>
+20 V	:CAL:PROT:V20 <actual voltage value>

Model 6517B Range/Full-scale voltage	Voltage range calibration command
-20 V	:CAL:PROT:VN20 <actual voltage value>
+200 V	:CAL:PROT:V200 <actual voltage value>
-200 V	:CAL:PROT:VN200 <actual voltage value>

Voltage source calibration

For all voltage source ranges, connect the DMM to the voltage source output. Set the DMM to measure DC voltage, and then turn auto ranging on.

100 V range calibration

To calibrate the 100 V source range:

1. Send this command to the Model 6517B to select the voltage source range:

```
:CAL:PROT:VSETZ100
```

2. Take the DMM voltage reading, and then send the following commands:

```
:CAL:PROT:VSRCZ100 <DMM voltage reading>
```

```
:CAL:PROT:VSET100
```

3. Take the DMM voltage reading, and then send the following commands:

```
:CAL:PROT:VSRC100 <DMM voltage reading>
```

```
:CAL:PROT:VSETN100
```

4. Take the DMM voltage reading, and then send the following commands:

```
:CAL:PROT:VSRCN100 <DMM voltage reading>
```

```
:CAL:PROT:VSET40
```

5. Take the DMM voltage reading, and then send the following command:

```
:CAL:PROT:VSRC40 <DMM voltage reading>
```

1000 V range calibration

To calibrate the 1000 V source range:

1. Send this command to the Model 6517B to select the 1000 V source range:

```
:CAL:PROT:VSETZ1000
```

2. Take the DMM voltage reading, and then send the following commands:

```
:CAL:PROT:VSRCZ1000 <DMM voltage reading>
```

```
:CAL:PROT:VSET1000
```

3. Take the DMM voltage reading, and then send the following commands:

```
:CAL:PROT:VSRC1000 <DMM voltage reading>
```

```
:CAL:PROT:VSETN1000
```

4. Take the DMM voltage reading, and then send the following command:

```
:CAL:PROT:VSRCN1000 <DMM voltage reading>
```

```
:CAL:PROT:VSET400
```

5. Take the DMM voltage reading, and then send the following command:

```
:CAL:PROT:VSRC400 <DMM voltage reading>
```

Humidity calibration

To calibrate humidity measurements:

1. Connect the DC voltage calibrator to the humidity input connector.
2. Apply 0.0 V.

```
:CAL:PROT:HUMZERO
```

3. Apply +1.0 V.

```
:CAL:PROT:HUM1 <actual voltage value>
```

Temperature calibration

To calibrate temperature measurements:

1. Connect the thermocouple calibrator to the temperature input connector using a type K input connector. Allow the input connector to stabilize in temperature for five minutes.
2. Set the calibrator to 100° C and then send the following command to calibrate +100° C (4.096 mV):

```
:CAL:PROT:T100 0.004096
```

3. Set the calibrator to 0° C and then send the following command to calibrate 0° C:

```
:CAL:PROT:TZERO
```

4. Set the calibrator to -25° C and then send the following command to calibrate -25° C (-0.968 mV):

```
:CAL:PROT:TN25 -0.000968
```

Set calibration dates

To set the calibration dates:

1. Use the following command to set the date the unit was calibrated:

```
:CAL:PROT:DATE yyyy,mm,dd
```

2. Use the following command to set the due date for the next calibration:

```
:CAL:PROT:NDUE yyyy,mm,dd
```

Save calibration

To save the calibration information:

1. Use the following command to save the calibration after completing all calibration steps:

```
:CAL:PROT:SAVE
```

Lock calibration

To prevent changes to the calibration information:

1. Use the following command to lock the calibration after saving the calibration:

```
:CAL:PROT:LOCK
```

Partial calibration

Perform all calibration steps if possible. You can calibration individual ranges if the following requirements are met:

- The instrument has been completely calibrated once already.
- All required steps of a partial calibration are performed without error.

NOTE

If you perform a partial calibration without meeting these conditions, you will not be able to save the calibration information.

Once a partial calibration is performed, the calibration date and the next calibration due date must be set before the calibration can be saved.

Voltage offset partial calibration

All calibration steps are to be performed if performing individual voltage offset steps. If a single voltage offset step is performed, the ranges affected by the voltage offset calibration will require recalibration before a valid calibration can be saved.

Table 15-7: Ranges affected by partial voltage offset calibration

Voltage offset step performed	Ranges that require recalibration
1	20 pA and 200 pA current ranges
2	2 nA, 20 nA, and 200 nA current ranges
3	2 μ A, 20 μ A, and 200 μ A current ranges
4	2 mA and 20 mA current ranges
5	2 V, 20 V, and 200 V voltage ranges
6	2 nC, 20 nC, 200 nC, and 2 μ C charge ranges

Current offset partial calibration

It is recommended that all calibration steps be performed if performing individual current offset steps. If a single current offset step is performed, the ranges affected by the voltage offset calibration will require re-calibration before a valid calibration can be saved.

Table 15-8: Ranges affect by partial current offset calibration

Current offset step performed	Ranges that require recalibration
1	All current ranges except 20 pA and 200 pA
2	20 pA and 200 pA current ranges
3	2 nC and 20 nC charge ranges
4	200 nC and 2 uC charge ranges
5	2 V, 20 V, and 200 V voltage ranges

Current ranges partial calibration

If an individual current range of the Model 6517B is calibrated, the three steps corresponding to a single current range need to be performed:

1. Calibration of the range zero
2. Calibration of the positive full scale range
3. Calibration of the negative full scale range

Voltage ranges partial calibration

If an individual voltage range of the Model 6517B is calibrated, the three steps corresponding to a single voltage range need to be performed:

1. Calibration of the range zero
2. Calibration of the positive full scale range
3. Calibration of the negative full scale range

Charge ranges partial calibration

If an individual charge range of the Model 6517B is calibrated, the four steps corresponding to a single charge range need to be performed:

1. Starting the positive full scale calibration step
2. Calibration of the positive full scale range
3. Starting the negative full scale calibration step
4. Calibration of the negative full scale range

Voltage source partial calibration

If an individual range of the Model 6517B voltage source is calibrated, the eight steps corresponding to a single voltage source range need to be performed:

1. Starting the voltage source zero calibration step
2. Calibrating the voltage source zero point
3. Starting the voltage source positive full scale calibration step
4. Calibrating the voltage source positive full scale point
5. Starting the voltage source negative full scale calibration step
6. Calibrating the voltage source negative full scale point
7. Starting the voltage source positive 40% calibration step
8. Calibrating the voltage source positive 40% calibration point

Humidity partial calibration

The humidity input has two calibration points, both which need to be performed.

1. Calibration of the humidity zero point
2. Calibration of the humidity +1 V point

Temperature partial calibration

The temperature input has three calibration points, all of which need to be performed.

- Calibration of the temperature +100° C point
- Calibration of the temperature zero point
- Calibration of the temperature -25° C point

Calibration command reference

Voltage offset calibration commands

Set the step for the voltage offset calibration with this command:

```
:CAL:PROT:VOFF:STEP <step number>
```

The steps are numbered from 1 through 6, and correspond to the following instrument ranges:

1. 20 pA and 200 pA current ranges
2. 2 nA, 20 nA and 200 nA current ranges
3. 2 μ A, 20 μ A, and 200 μ A current ranges
4. 2 mA and 20 mA current ranges
5. 2 V, 20 V, and 200 V voltage ranges
6. 2 nC, 20 nC, 200 nC, and 2 μ C charge ranges

Note that for each voltage offset calibration step, the following commands need to be executed after setting the voltage offset calibration step:

```
:CAL:PROT:VOFF1
```

Start the first measurement for the voltage offset calibration

```
:CAL:PROT:VOFF2 <preamp out voltage reading>
```

Calibrate the first voltage offset point

```
:CAL:PROT:VOFF3
```

Start the second measurement for the voltage offset calibration

```
:CAL:PROT:VOFF4 <preamp out voltage reading>
```

Calibrate the second voltage offset point

Current offset calibration commands

Set the current offset calibration step by sending the following command:

```
:CAL:PROT:IOFF:STEP <step number>
```

This sets the step of the current offset calibration procedure. Steps are numbered from 1 to 5, and correspond to the following instrument ranges:

1. All current ranges except 20 pA and 200 pA

2. 20 pA and 200 pA current ranges
3. 2 nC and 20 nC charge ranges
4. 200 nC and 2 μ C charge ranges
5. 2 V, 20 V, and 200 V voltage ranges

NOTE For current offset calibration steps 1 and 2 only, the commands in [Table 15-9](#) need to be executed after setting the current offset calibration step.

Table 15-9: Current offset calibration commands for steps 1 and 2

Command	Description
:CAL:PROT:IOFF1	Start the first measurement for the current offset calibration
:CAL:PROT:IOFF2 <preamp out voltage reading>	Calibrate the first current offset point
:CAL:PROT:IOFF3	Start the second measurement for the current offset calibration
:CAL:PROT:IOFF4 <preamp out voltage reading>	Calibrate the second current offset point

Charge calibration commands

When calibrating the 20 μ A to 20 mA ranges, use a DC current calibrator. For all current ranges, the actual current supplied must be within $\pm 5\%$ of the nominal value otherwise a calibration error will occur.

Table 15-10: Charge calibration commands

Command	Description
:CAL:PROT:CZEROA2N	Start +2 nC range calibration
:CAL:PROT:C2N <+2nC value>	Calibrate the +2 nC range
:CAL:PROT:CZEROB2N	Start -2 nC range calibration
:CAL:PROT:CN2N <-2nC value>	Calibrate the -2 nC range
:CAL:PROT:CZEROA20N	Start +20 nC range calibration
:CAL:PROT:C20N <+20nC value>	Calibrate the +20 nC range
:CAL:PROT:CZEROB20N	Start -20 nC range calibration
:CAL:PROT:CN20N <-20nC value>	Calibrate the -20 nC range
:CAL:PROT:CZEROA200N	Start +200 nC range calibration
:CAL:PROT:C200N <+200nC value>	Calibrate the +200 nC range
:CAL:PROT:CZEROB200N	Start -200 nC range calibration
:CAL:PROT:CN200N <-200nC value>	Calibrate the -200 nC range
:CAL:PROT:CZEROA2U	Start +2 μ C range calibration

Command	Description
:CAL:PROT:C2U <+2uC value>	Calibrate the +2 uC range
:CAL:PROT:CZEROB2U	Start -2 uC range calibration
:CAL:PROT:CN2U <-2uC value>	Calibrate the -2 uC range

Current calibration commands

This is a list of all current calibration commands. For all current ranges, the actual current supplied must be within $\pm 5\%$ of the nominal value otherwise a calibration error will occur.

Table 15-11: Current calibration commands

Command	Description
:CAL:PROT:AZERO20p	Calibrate the 20 pA range zero
:CAL:PROT:A20P <+20 pA value>	Calibrate the +20 pA range
:CAL:PROT:AN20P <-20 pA value>	Calibrate the -20 pA range
:CAL:PROT:AZERO200P	Calibrate the 200 pA range zero
:CAL:PROT:A200P <+200 pA value>	Calibrate the +200 pA range
:CAL:PROT:AN200P <-200 pA value>	Calibrate the -200 pA range
:CAL:PROT:AZERO2N	Calibrate the 2 nA range zero
:CAL:PROT:A2N <+2 nA value>	Calibrate the +2 nA range
:CAL:PROT:AN2N <-2 nA value>	Calibrate the -2 nA range
:CAL:PROT:AZERO20N	Calibrate the 20 nA range zero
:CAL:PROT:A20N <+20 nA value>	Calibrate the +20 nA range
:CAL:PROT:AN20N <-20 nA value>	Calibrate the -20 nA range
:CAL:PROT:AZERO200N	Calibrate the 200 nA range zero
:CAL:PROT:A200N <+200 nA value>	Calibrate the +200 nA range
:CAL:PROT:AN200N <-200 nA value>	Calibrate the -200 nA range
:CAL:PROT:AZERO2U	Calibrate the 2 μ A range zero
:CAL:PROT:A2U <+2 uA value>	Calibrate the +2 μ A range
:CAL:PROT:AN2U <-2 uA value>	Calibrate the -2 μ A range
:CAL:PROT:AZERO20U	Calibrate the 20 μ A range zero
:CAL:PROT:A20U <+20 uA value>	Calibrate the +20 μ A range
:CAL:PROT:AN20U <-20 uA value>	Calibrate the -20 μ A range
:CAL:PROT:AZERO200U	Calibrate the 200 μ A range zero
:CAL:PROT:A200U <+200 uA value>	Calibrate the +200 μ A range

Command	Description
:CAL:PROT:AN200U <-200 uA value>	Calibrate the -200 μ A range
:CAL:PROT:AZERO2M	Calibrate the 2 mA range zero
:CAL:PROT:A2M <+2 mA value>	Calibrate the +2 mA range
:CAL:PROT:AN2M <-2 mA value>	Calibrate the -2 mA range
:CAL:PROT:AZERO20M	Calibrate the 20 mA range zero
:CAL:PROT:A20M <+20 mA value>	Calibrate the +20 mA range
:CAL:PROT:AN20M <-20 mA value>	Calibrate the -20 mA range

Voltage measurement calibration commands

This is a list of all Model 6517B voltage measurement calibration commands.

Table 15-12: Voltage measurement calibration commands

Command	Description
:CAL:PROT:VZERO2	Calibrate the 2 V range zero
:CAL:PROT:V2 <+2 V value>	Calibrate the +2 V range
:CAL:PROT:VN2 <-2 V value>	Calibrate the -2 V range
:CAL:PROT:VZERO20	Calibrate the 20 V range zero
:CAL:PROT:V20 <+20 V value>	Calibrate the +20 V range
:CAL:PROT:VN20 <-20 V value>	Calibrate the -20 V range
:CAL:PROT:VZERO200	Calibrate the 200 V range zero
:CAL:PROT:V200 <+200 V value>	Calibrate the +200 V range
:CAL:PROT:VN200 <-200 V value>	Calibrate the -200 V range

Voltage source calibration commands

This is a list of all voltage source calibration commands for the Model 6517B.

Table 15-13: Voltage source calibration commands

Command	Description
:CAL:PROT:VSETZ100	Start the 100 V range zero calibration
:CAL:PROT:VSRCZ100 <measured voltage>	Calibrate the 100 V range zero
:CAL:PROT:VSET100	Start the +100 V range calibration
:CAL:PROT:VSRC100 <measured voltage>	Calibrate the +100 V range
:CAL:PROT:VSETN100	Start the -100 V range calibration
:CAL:PROT:VSRCN100 <measured voltage>	Calibrate the -100 V range
:CAL:PROT:VSET40	Start the +40 V calibration
:CAL:PROT:VSRC40 <measured voltage>	Calibrate the +40 V output
:CAL:PROT:VSETZ1000	Start the 1000 V range zero calibration
:CAL:PROT:VSRCZ1000 <measured voltage>	Calibrate the 1000 V range zero
:CAL:PROT:VSET1000	Start the +1000 V range calibration
:CAL:PROT:VSRC1000 <measured voltage>	Calibrate the +1000 V range
:CAL:PROT:VSETN1000	Start the -1000 V range calibration
:CAL:PROT:VSRCN1000 <measured voltage>	Calibrate the -1000 V range
:CAL:PROT:VSET400	Start the +400 V calibration
:CAL:PROT:VSRC400 <measured voltage>	Calibrate the +400 V output

Humidity calibration commands

This is a list of all Model 6517B humidity calibration commands

Table 15-14: Humidity calibration commands

Command	Description
:CAL:PROT:HUMZERO	Calibrate the humidity input zero
:CAL:PROT:HUM1 <1 volt value>	Calibrate the humidity +1 V range

Temperature calibration commands

This is a list of all Model 6517B temperature calibration commands.

Table 15-15: Temperature calibration commands

Command	Description
:CAL:PROT:TZERO	Calibrate the temperature input zero
:CAL:PROT:T100 0.004096	Calibrate the temperature 100 °C range
:CAL:PROT:TN25 -0.000968	Calibrate the temperature -25 °C range

Miscellaneous calibration commands

This is a list of the remaining Model 6517B calibration commands.

Table 15-16: Miscellaneous calibration commands

Command	Description
:CAL:PROT:COUNT?	Query the number of times the instrument has been calibrated.
:CAL:PROT:DATE yyyy,mm,dd	Set the calibration date
:CAL:PROT:DATE?	Query the calibration date
:CAL:PROT:NDUE yyyy,mm,dd	Set the calibration due date
:CAL:PROT:NDUE?	Query the next calibration due date
:CAL:PROT:CODE 'KInnnnnn'	Unlock the calibration using the password (default is 006517)
:CAL:PROT:SAVE	Save the calibration
:CAL:PROT:LOCK	Lock the calibration

Error codes

Commands that did not work as described return a numeric error code. Refer to [Table Calibration Errors](#) for a textual description

Table Calibration Errors

Error Code	Description
-430	Query deadlocked
-420	Query unterminated
-410	Query interrupted
-363	Input buffer overrun
-350	Queue overflow
-314	Save/recall memory lost
-259	Expression error
-241	Hardware missing
-230	Data corrupt or stale
-225	Out of memory
-224	Illegal parameter value
-223	Too much data
-222	Parameter data out of range
-221	Settings conflict
-220	Parameter error
-215	Arm deadlock
-214	Trigger deadlock
-213	Init ignored
-212	Arm ignored
-211	Trigger ignored
-210	Trigger error
-203	Command protected
-200	Execution error
-171	Invalid expression
-170	Expression error
-161	Invalid block data
-160	Block data error

Error Code	Description
-154	String too long
-151	Invalid string data
-150	String data error
-148	Character data not allowed
-144	Character data too long
-141	Invalid character data
-140	Character data error
-124	Too many digits
-123	Exponent too large
-121	Invalid character in number
-120	Numeric data error
-113	Undefined header
-112	Program mnemonic too long
-111	Header separator error
-110	Command header error
-109	Missing parameter
-108	Parameter not allowed
-105	GET not allowed
-104	Data type error
-102	Syntax error
-101	Invalid character
-100	Command error
+000	No error
+101	Operation complete
+121	Device calibrating
+122	Device settling
+123	Device ranging
+124	Device sweeping
+125	Measuring event
+126	Device calculating

Error Code	Description
+161	Program running
+171	Waiting in trigger layer
+172	Waiting in arm layer 1
+173	Waiting in arm layer 2
+174	Re-entering idle layer
+301	Reading overflow
+302	Low limit 1 event
+303	High limit 1 event
+304	Low limit 2 event
+305	High limit 2 event
+306	Reading available
+307	Reading underflow
+308	Buffer available
+309	Buffer half full
+310	Buffer full
+311	Test Sequence Measurement Done
+312	Buffer Pretriggered
+313	Reading out of limit
+314	8009 fixture lid open
+315	V-source compliance detected
+320	Buffer and format element mismatch
+321	Buffer sizing error; set to MAX
+322	Buffer sizing error; set to MIN
+350	2 V offset out of specification
+351	2 V positive gain out of specification
+352	2 V negative gain out of specification
+353	20 V offset out of specification
+354	20 V positive gain out of specification
+355	20 V negative gain out of specification
+356	200 V offset out of specification

Error Code	Description
+357	200 V positive gain out of specification
+358	200 V negative gain out of specification
+359	20 pA offset out of specification
+360	20 pA positive gain out of specification
+361	20 pA negative gain out of specification
+362	200 pA offset out of specification
+363	200 pA positive gain out of specification
+364	200 pA negative gain out of specification
+365	2 nA offset out of specification
+366	2 nA positive gain out of specification
+367	2 nA negative gain out of specification
+368	20 nA offset out of specification
+369	20 nA positive gain out of specification
+370	20 nA negative gain out of specification
+371	200 nA offset out of specification
+372	200 nA positive gain out of specification
+373	200 nA negative gain out of specification
+374	2 μ A offset out of specification
+375	2 μ A positive gain out of specification
+376	2 μ A negative gain out of specification
+377	20 μ A offset out of specification
+378	20 μ A positive gain out of specification
+379	20 μ A negative gain out of specification
+380	200 μ A offset out of specification
+381	200 μ A positive gain out of specification
+382	200 μ A negative gain out of specification
+383	2 mA offset out of specification
+384	2 mA positive gain out of specification
+385	2 mA negative gain out of specification
+386	20 mA offset out of specification

Error Code	Description
+387	20 mA positive gain out of specification
+388	20 mA negative gain out of specification
+389	2 nC positive gain out of specification
+390	2 nC negative gain out of specification
+391	20 nC positive gain out of specification
+392	20 nC negative gain out of specification
+393	200 nC positive gain out of specification
+394	200 nC negative gain out of specification
+395	2 μ C positive gain out of specification
+396	2 μ C negative gain out of specification
+397	Charge zero excessive
+399	Temp offset out of specification
+400	Temp gain out of specification
+410	Humidity offset out of specification
+412	Humidity gain out of specification
+413	Int. Temp out of specification
+415	VSRC 100 V offset out of specification
+416	VSRC 100 V positive gain out of specification
+417	VSRC 100 V negative gain out of specification
+418	VSRC 1000 V offset out of specification
+419	VSRC 1000 V positive gain out of specification
+420	VSRC 1000 V negative gain out of specification
+421	Current offset not converging
+422	Voltage offset not converging
+423	Date of calibration not set
+424	Next date of calibration not set
+425	Calibration data invalid
+426	Not permitted with calibration locked

Error Code	Description
+427	Not permitted with calibration unlocked
+510	Reading buffer data lost
+511	GPIB address lost
+512	Power-on state lost
+514	DC calibration data lost
+515	Calibration dates lost
+516	Calibration tables lost
+610	Questionable calibration
+611	Questionable temperature
+612	Questionable humidity
+613	Questionable voltage
+614	Questionable current
+615	Questionable ohms
+616	Questionable charge
+617	Questionable test sequence
+618	Resistivity: current out of limits
+700	Low battery detected
+800	RS-232 framing error detected
+802	RS-232 overrun detected
+803	RS-232 break detected
+805	Invalid system communication
+808	ASCII only with RS-232
+809	Not allowed with RS-232
+850	Invalid sequence settings
+851	Test sequence running
+860	Interlock violation error
+861	Vsource limit too low for auto-ohms
+900	Internal system error

In this section:

Topic	Page
Introduction	16-2
Equipment needed for verification	16-2
Warm up time and environment.....	16-3
Considerations.....	16-3
Verification Procedures	16-3
DC voltage verification.....	16-4
DC amps verification.....	16-5
Coulombs verification	16-7
Voltage source verification.....	16-8
Temperature verification	16-9
Humidity verification.....	16-10

Introduction

Use the procedures in this section to verify that the Keithley Instruments Model 6517B Electrometer accuracy is within the limits stated in the instrument's one-year accuracy specifications. Perform the verification procedures:

- When you first receive the instrument to make sure that it was not damaged during shipment
- To verify that the unit meets factory specifications
- To determine if calibration is required
- Following calibration to make sure it was performed properly

WARNING *The information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages, which could cause personal injury or death if contacted. Use appropriate safety precautions when working with hazardous voltages.*

NOTE If the instrument is still under warranty and its performance is outside specified limits, contact your Keithley Instruments representative or the factory to determine the correct course of action.

Equipment needed for verification

- Fluke 5700A calibrator with user documentation
- Keithley Model 2002 Digital Multimeter
- Thermocouple calibrator
- Precision resistors with a value known to the listed uncertainty:
 - 100 G Ω , 850 ppm
 - 10 G Ω , 550 ppm
 - 1 G Ω , 550 ppm
 - 100 M Ω , 250 ppm
- Uncalibrated precision resistors:
 - 10 M Ω
 - 1 M Ω
 - 10 K Ω
 - 1 K Ω
 - 10 Ω
 - 1 Ω
- Precision capacitors with a value known to the listed uncertainty:
 - 1 nF, 1000 ppm
 - 100 nF, 1000 ppm
- Triax shielding cap

Warm up time and environment

The Model 6517B should be turned on and allowed to warm up for at least two hours, at an ambient temperature of 18° C to 28° C, 70 percent or lower relative humidity.

Considerations

Always use fixed ranges for verifying voltage, current, and charge, because autoranging hysteresis may cause the instrument to be on the incorrect range.

To restore the instrument to factory defaults:

1. Press the **MENU** key; the following menu will be displayed:

```
MAIN MENU
SAVESETUP COMMUNICATION CAL
```

2. Select **SAVESETUP** using the left or right arrow keys, and then press **ENTER**. The following menu will be displayed:

```
SETUP MENU
SAVE RESTORE POWERON RESET
```

3. Select **RESET** using the left or right arrow keys, and then press **ENTER**. The following menu will be displayed:

```
RESET ORIGINAL DFLTS
BENCH GPIB
```

4. Select **BENCH** using the left or right arrow keys, and press then **ENTER**. The following menu will be displayed:

```
Restoring PRESET
```

Verification Procedures

NOTE

All test configurations must be properly grounded. If the triax to BNC adapter ties the BNC ground to the triax inner shield, the **DC Volts Guard** must be off for the operation to be correct. If the triax to BNC adapter ties the BNC ground to the outer shield of the triax connector, a separate path to ground must be supplied to obtain the correct measurement. This can be accomplished two different ways:

1. Take the ground lead (located on the back of the Model 6517B, connected to the ground screw next to the Keithley logo) and plug it into the common terminal of the Model 6517B (located between **Preamp Out** and **2V Out**). This is preferred as it minimizes the loop area for noise pickup.

OR

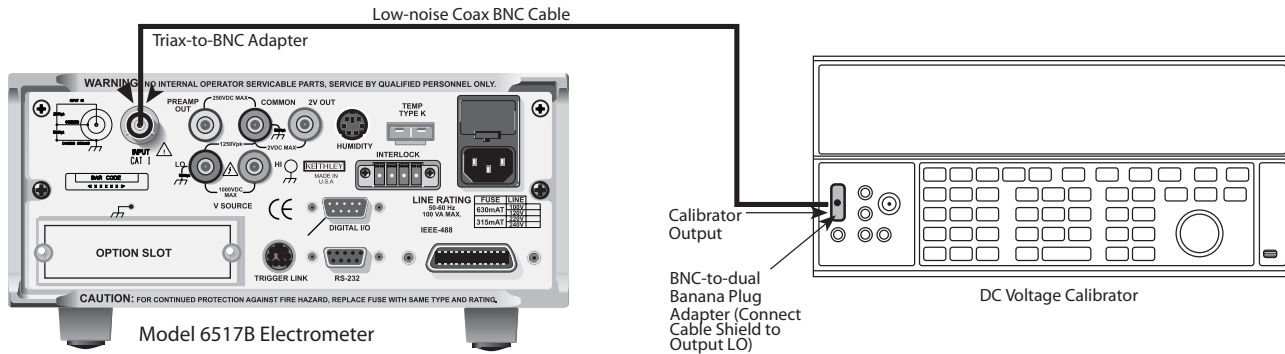
2. Connect a separate wire from the Model 6517B electrometer common to the low terminal of the DC voltage calibrator.
-

DC voltage verification

To verify DC voltage:

1. Connect the calibrator output to the Model 6517B as shown in *Figure 16-1*. Ensure that the configuration is properly grounded as noted at the beginning of this section.

Figure 16-1: DC voltage verification configuration



2. Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
3. Restore the instrument to factory default settings using the procedure described under *Considerations*.
4. Select the DCV 2 V range from the front panel. *See “Measurement range” on page 5-17 for more information.*
5. With zero check enabled, press **REL** to turn on the zero correct function. *See “Zero check, relative, and zero correct” on page 5-18 for more information.*
6. Set the calibrator to 0.0 V and then turn off zero check. Allow the reading to settle completely before continuing.
7. Press **REL** to enable the Model 6517B REL function.
8. Set the calibrator to the voltages in the *Table 16-1*, and set the Model 6517B range according to *Table 16-1*. Verify the reading is within the range specified.
9. Press **REL** to turn off the REL function, and then turn zero check on. Repeat steps 4, 6, 7, and 8 for the 20 V and 200 V ranges.

Table 16-1: Limits for DC voltage verification

Calibrator output	Model 6517B range	Allowed reading range 18° C to 28° C, 1 year
+1.9 V	2 V	+1.89949 V to +1.900515 V
-1.9 V	2 V	-1.900515 V to -1.89949 V
+19 V	20 V	+18.9950 V to +19.0050 V
-19 V	20 V	-19.0050 V to -18.9950 V
+190 V	200 V	+189.883 V to +190.117 V
-190 V	200 V	-190.117 V to -189.883 V

NOTE Allowed reading limits are calculated from the Model 6517B one year uncertainty, and do not include test equipment uncertainties

DC amps verification

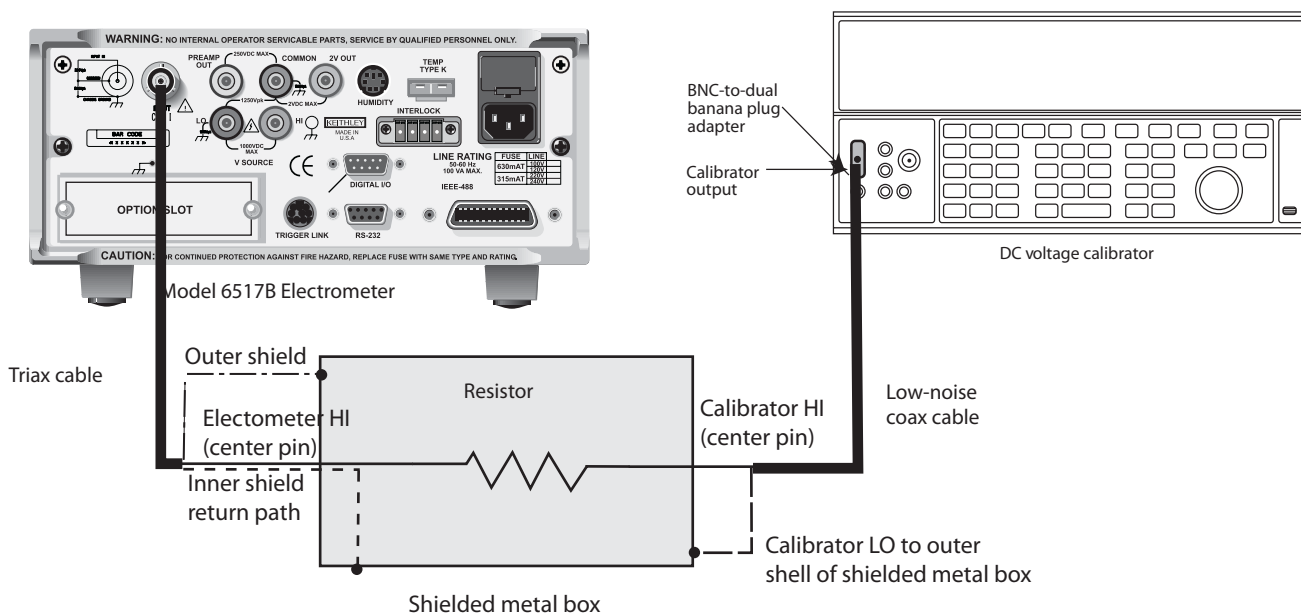
The DC amps verification procedure is performed by applying known currents to the Model 6517B input, and verifying that the reading falls within acceptable limits. There are two procedures used. The procedure for the 20 pA to 2 μA ranges uses a DC voltage calibrator and precision resistors; the procedure for the 20 μA-20 mA ranges uses a DC current calibrator.

20 pA to 2 μA ranges

To verify the current ranges from 20 pA to 2 μA:

1. Connect the Model 6517B according to [Figure 16-2](#), using the corresponding [Standard resistor value](#) from [Table 16-2](#).

Figure 16-2: Model 6517B 20 pA to 2 μA current range verification configuration



2. Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
3. Restore the Model 6517B to factory default settings using the procedure described in the topic [Considerations](#).
4. Select the amps function and the 20 pA range on the Model 6517B. [See “Amps configuration” on page 4-11 for more information.](#)
5. With zero check enabled, press **REL** to turn on the zero correct function.
6. Set the calibrator to 0.0 V, and then turn off zero check. Allow the reading to stabilize completely before continuing.
7. Press **REL** to enable the Model 6517B REL function.
8. Using the formula:

$$V = I R$$

calculate the actual calibrator voltage to achieve the desired current using the known value of the precision resistors. Record the calibrator voltage.

9. Set the calibrator to the actual voltage. See the calibrator documentation for detailed instructions.

10. Make sure the calibrator is in operate.
11. Allow the reading to settle completely, and note the reading on the Model 6517B. Verify that the reading is within the limits specified in [Table 16-2](#).

Table 16-2: Reading limits for verification of 20 pA to 2 μ A ranges

Model 6517B range	Nominal DC voltage value	Standard resistor value	Applied current	Reading limits 18° C to 28° C, 1 year
20 pA	1.9 V	100 G Ω	19 pA	18.8070 pA to 19.1930 pA
200 pA	1.9 V	10 G Ω	190 pA	188.095 pA to 191.905 pA
2 nA	1.9 V	1 G Ω	1.9 nA	1.89590 nA to 1.91410 nA
20 nA	1.9 V	100 M Ω	19 nA	18.9615 nA to 19.0385 nA
200 nA	19 V	100 M Ω	190 nA	189.615 nA to 190.385 nA
2 μ A	190 V	100 M Ω	1.9 μ A	1.89800 μ A to 1.90200 μ A

12. Reverse the calibrator polarity, and verify the magnitude of the current reading is within the limits.
13. Turn zero-check on.
14. Repeat steps 4 through 13 for the 200 pA to 2 μ A ranges using the appropriate DC voltage and standard resistor listed in [Table 16-2](#).

20 μ A to 20 mA ranges

1. Connect the Model 6517B to the DC current calibrator as shown in [Figure 16-1 on page 16-4](#).
2. Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
3. Restore the Model 6517B to factory default settings using the procedure described in the topic [Considerations](#).
4. Select the amps function and 20 μ A range on the Model 6517B.
5. With zero check enabled, press **REL** to turn on the zero correct function.
6. Set the calibrator to 0.0 amps, then turn off zero check. Allow the reading to stabilize completely before continuing.
7. Press **REL** to enable the Model 6517B REL function.
8. Set the calibrator to output +19.0 μ A.
9. Allow the reading to settle completely, and note the reading on the Model 6517B. Verify that the reading is within the limits specified in [Table 16-3](#).

Table 16-3: Limits for 2 μ A to 20 mA range verification

Model 6517B range	Applied DC current	Reading limits 18° C to 28° C, 1 year
20 μ A	19 μ A	18.9805 μ A to 19.0195 μ A
200 μ A	190 μ A	189.805 μ A to 190.195 μ A
2 mA	1.9 mA	1.89800 mA to 1.90200 mA
20 mA	19 mA	18.9805 mA to 19.0195 mA

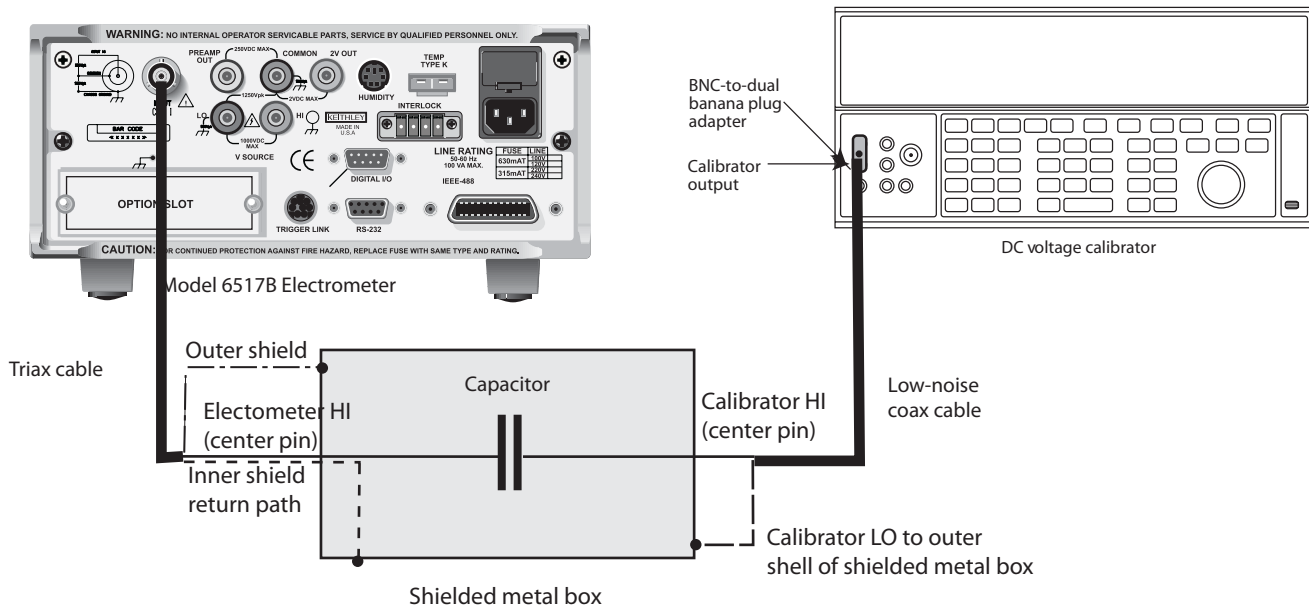
- Reverse the calibrator polarity, then verify the magnitude of the current reading is within the specified limits.
- Repeat steps 4 through 10 for the 200 μ A, 2 mA, and 20 mA ranges.

Coulombs verification

Coulombs verification is performed by applying accurately known charge values (derived from a voltage source and capacitor) to the Model 6517B input jack, and then verifying that the Model 6517B readings fall within specified limits.

- Connect the Model 6517B to the calibrator and capacitor as shown in *Figure 16-3*, using the appropriate capacitor value from *Standard capacitor* column in *Table 16-4*:

Figure 16-3: Model 6517B coulombs verification



- Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
- Restore the Model 6517B to factory default settings using the procedure described in the topic *Considerations*.

4. Select the coulombs function and 2 nC range on the Model 6517B. [See “Coulombs configuration” on page 4-33 for more information.](#)
5. Compute the desired calibrator voltages using the formula:

$$V = Q / C$$

where:

V = is the calibrator voltage

Q = charge in coulombs

C = capacitance in farads

6. With zero check enabled, press **REL** to turn on the zero correct function.
7. Set the calibrator to 0.0 V, using the same range as the nominal value to be used.
8. Turn off zero check, and then set the calibrator output to the desired voltage. Allow the reading to settle completely.
9. Verify that the Model 6517B reading is within the limits specified in [Table 16-4](#).

Table 16-4: Limits for 2 nC to 2 μ C range verification

Model 6517B range	Standard capacitor	Nominal voltage value	Charge	Reading Limits 18° C to 28° C, 1 year
2 nC	1 nF	1.9 V	1.9 nC	1.89235 nC to 1.90765 nC
20 nC	1 nF	19 V	19 nC	18.9235 nC to 19.0765 nC
200 nC	100 nF	1.9 V	190 nC	189.235 nC to 190.765 nC
2 μ C	100 nF	19 V	1.9 μ C	1.89235 μ C to 1.90765 μ C

10. Set the calibrator to 0.0 V, and turn on zero check.
11. Turn off zero check, and then set the calibrator to the reverse polarity of the desired voltage. Allow the reading to settle completely.
12. Verify that the Model 6517B reading magnitude is within the specified limits.
13. Turn zero check on.
14. Repeat steps 4 through 13 for the 20 nC, 200 nC, and 2 μ C ranges.

Voltage source verification

Voltage source output accuracy is verified by programming the voltage source to specific voltage values and measuring the output voltage using a precision digital multimeter.

To verify the voltage source:

1. Turn on the Model 6517B and the digital multimeter, and allow both to warm up for at least two hours before making measurements.
2. Set the DMM to the VDC function, and then turn autoranging on.

3. Temporarily short the DMM input leads together, and then enable the DMM REL mode. Leave REL enabled for the remainder of the voltage source verification.
4. With the Model 6517B voltage source turned off, connect the DMM input leads to the Model 6517B **V-SOURCE OUT** connector. Be sure to connect the DMM input HI to the output HI, and the DMM input LO to the output LO.
5. Set the Model 6517B voltage source range to the 100 V range, and turn the voltage source on.
6. Set the voltage source to 0.0 V, and then verify the readings are within the range specified in [Table 16-5](#).

Table 16-5: Voltage source verification limits

Model 6517B voltage source range	Model 6517B programmed source output	Reading limits 18 °C to 28 °C, 1 year
100 V	0.0 V	-0.01 V to 0.01 V
100 V	25 V	24.9525 V to 25.0475 V
100 V	50 V	49.915 V to 50.085 V
100 V	75 V	74.8775 V to 75.1225 V
100 V	100 V	99.84 V to 100.16 V
1000 V	0 V	-0.1 V to 0.1 V
1000 V	250 V	249.525 V to 250.475 V
1000 V	500 V	499.15 V to 500.85 V
1000 V	750 V	748.775 V to 751.225 V
1000 V	1000 V	998.4 V to 1001.6 V

7. Repeat step 6 for each voltage listed in the 100 V range of [Table 16-5](#).
8. Set the Model 6517B voltage source operate off.
9. Set the Model 6517B voltage source range to the 1000 V range, and turn the voltage source operate on.
10. Program the voltage source to 0.0 V, and verify the readings are within the range specified in [Table 16-5](#).
11. Repeat step 10 for each voltage listed in the 1000 V range of [Table 16-5](#).
12. Repeat the procedure for negative output voltages using the same magnitudes given in [Table 16-5](#).

Temperature verification

Accuracy of the Model 6517B temperature measurement is verified by connecting a thermocouple calibrator to the Model 6517B and verifying that the temperature readings are within specified limits.

1. Connect a K-type thermocouple calibrator to the Model 6517B EXT TEMP terminal.
2. Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
3. Enable the Model 6517B temperature measurements by turning on the temperature data stamp. Press **MENU**, use the right arrow key to select **GENERAL** on the second page of the lower display, and press **ENTER**. Use the right arrow key to select **A/D-CONTROLS**, and press **ENTER**. Select **DATA-STAMP**, and press **ENTER**. Use the left or right arrow keys to

select **TEMPERATURE**, and use the range up or range down key to select **ON**. Press **ENTER**, then press **EXIT** three times to return to the measurement display. Press **PREV** to view the external temperature.

4. Set the thermocouple calibrator to output -25° C, and allow the reading to stabilize.
5. Verify the Model 6517B temperature reading is within the limits specified in [Table 16-6](#).
6. Repeat Steps 4 and 5 for each temperature listed in [Table 16-6](#).

Table 16-6: Temperature verification limits

Calibration temperature	Reading limits 18° C to 28° C, 1 year
-25 °C	-26.42 °C to -23.58 °C
0 °C	-1.5 °C to 1.5 °C
50 °C	48.35 °C to 51.65 °C
100 °C	98.2 °C to 101.8 °C
150 °C	148.05 °C to 151.95 °C

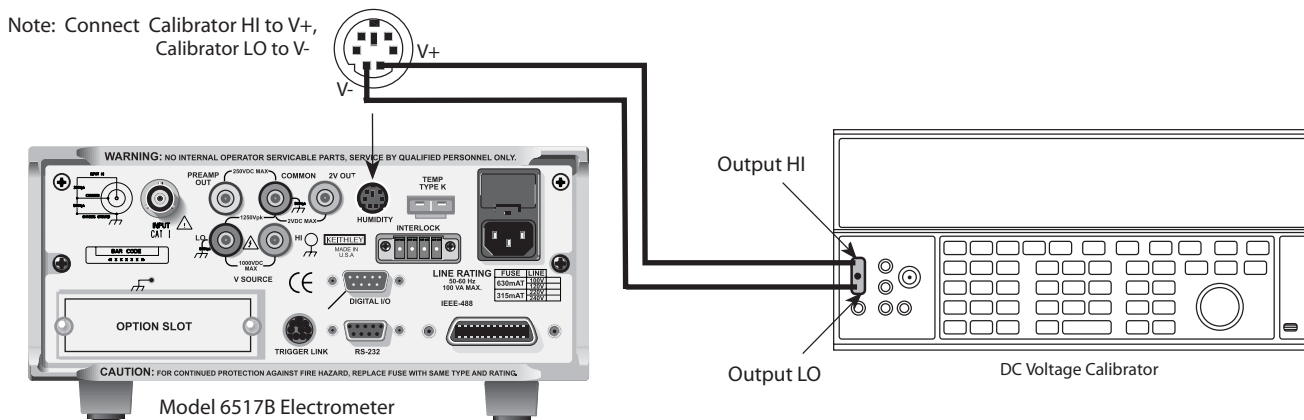
Humidity verification

Humidity measurement accuracy is verified by applying an accurate 0 V to 1 V DC to the Model 6517B and then verifying that the humidity readings are within specified limits.

To verify humidity readings:

1. With the power off, connect the DC calibrator to the Model 6517B **HUMIDITY** connector as shown in [Figure 16-4](#):

Figure 16-4: Model 6517B humidity verification configuration



2. Turn on the Model 6517B and allow it to warm up for at least two hours before making measurements.
3. Enable the Model 6517B humidity measurements by turning on the humidity data stamp.
 - a. Press **MENU**, use the right arrow key to select **GENERAL** on the second page of the lower display, and then press **ENTER**.
 - b. Use the right arrow key to select **A/D-CONTROLS**, and then press **ENTER**.
 - c. Select **DATA-STAMP**, and then press **ENTER**.
 - d. Use the left or right arrow keys to select **HUMIDITY**, and then use the range up or range down key to select **ON**.
 - e. Press **ENTER**, and then press **EXIT** three times to return to the measurement display. Press **PREV** to view the relative humidity (RH) reading.
4. Set the calibrator output to 0.0 V.
5. Allow the reading to settle, and then verify that the Model 6517B humidity reading is within the limits specified in [Table 16-7](#)

Table 16-7: Humidity verification limits

Applied voltage	Reading limits 18 °C to 28° C, 1 year
0.0 V	0% to 1%
0.25 V	24% to 26%

Applied voltage	Reading limits 18 °C to 28° C, 1 year
0.5 V	49% to 51%
0.75 V	74% to 76%
1.0 V	99% to 100%

6. Repeat step 5 for each voltage setting listed in [Table 16-7](#)

In this appendix:

Topic	Page
Specifications	A-2
Volts	A-2
Amps	A-2
Coulombs	A-3
Ohms (normal method)	A-3
Ohms (alternating polarity method)	A-4
Voltage source	A-4
Temperature (thermocouple)	A-4
Humidity	A-5
General	A-5

Specifications

Volts

Range	5½-digit resolution	Accuracy (1 year) ¹ 18°C - 28°C ±(%rdg + counts)	Temperature coefficient 0°C - 18°C and 28°C - 50°C ±(%rdg + counts) / °C
2V	10µV	0.025+4	0.003+2
20V	100µV	0.025+3	0.002+1
200V	1mV	0.06+3	0.002+1

¹ When properly zeroed, 5½-digit, 1 power line cycle (PLC), median filter on, digital filter = 10 readings.

- NMRR: 2V and 20V range > 60 dB, 200V range > 55dB, 50Hz, or 60Hz
- CMRR: >120dB at DC, 50Hz or 60Hz
- Input Impedance: > 200TΩ in parallel with 20pF, < 2pF guarded (1MΩ with zero check on)
- Small signal bandwidth at preamp output: Typically 100kHz (-3dB)

Amps

Range	5½-digit resolution	Accuracy (1 year) ² 18°C - 28°C ±(%rdg + counts)	Temperature coefficient 0°C - 18°C and 28°C - 50°C ±(%rdg + counts) / °C
20pA	100aA ³	1+30	0.1+5
200pA	1fA ³	1+5	0.1+1
2nA	10fA	0.2+30	0.1+2
20nA	100fA	0.2+5	0.03+1
200nA	1pA	0.2+5	0.3+1
2µA	10pA	0.1+10	0.005+2
20µA	100pA	0.01+5	0.005+1
200µA	1nA	0.1+5	0.005+1
2mA	10nA	0.1+10	0.008+2
20mA	100nA	0.1+5	0.008+1

² When properly zeroed, 5½-digit, 1 power line cycle (PLC), median filter on, digital filter = 10 readings

³ aA = 10 - 18A, fA - 1 - = 15A

- Input bias current: < 3fA at T_{CAL}. Temperature coefficient - 0.5fA / °C.
- Input bias current noise: < 750aA p-p (capped input), 0.1 Hz to 10Hz bandwidth, damping on, digital filter = 40 readings.
- Input voltage burden at T_{CAL} ±1°C: < 20µV on 20pA, 2nA, 20nA, 2µA, 20µA ranges. < 100µV on 200pA, 200nA, 200µA ranges. < 2mV on 2mA range. < 4mV on 20mA range.
- Temperature coefficient of input voltage burden: < 10µV/°C on pA, n A, µA ranges.
- Preamp settling time (to 10% of final value): 2.5s typical on pA ranges, damping off, 4s typical on pA ranges damping on, 15ms on n A ranges, 2ms on µA and mA ranges.
- NMRR: > 95dB on pA, 60dB on n A, µ A, and m A ranges at 50 Hz or 60 Hz

Coulombs

Range	5½-digit resolution	Accuracy (1 year) ^{4, 5} 18°C - 28°C ±(%rdg + counts)	Temperature coefficient 0°C - 18°C and 28°C - 50°C ±(%rdg + counts) / °C
20nC	10fC	0.4+5	0.04+3
20nC	100fC	0.4+5	0.04+1
200nC	1pC	0.4+5	0.04+1
2µC	10pC	0.4+5	0.04+1

⁴ When properly zeroed, 5½-digit, 1 PLC, median filter on, digital filter = 10 readings.

⁵ Specifications apply immediately after charge acquisition. Add:

- Input bias current: < 4fA at T_{CAL}. Temperature coefficient - 0.5fA / °C.

Ohms (normal method)

Range	5½-digit resolution	Accuracy ⁶ (10 - 100% range) 18°C - 28°C (1 year) ±(%rdg + counts)	Temperature coefficient (10 - 100% range) 0°C - 18°C and 28°C - 50°C ±(%rdg + counts) / °C	Auto V source	Amps Range
2MΩ	10Ω	0.125+1	0.01+1	40V	200µA
20MΩ	100Ω	0.125+1	0.01+1	40V	20µA
200MΩ	1kΩ	0.15+1	0.015+1	40V	2µA
2GΩ	10kΩ	0.225+1	0.035+1	40V	200nA
20GΩ	100kΩ	0.225+1	0.035+1	40V	20nA
200GΩ	1MΩ	0.035+1	0.110+1	40V	2nA
2TΩ	10MΩ	0.035+1	0.110+1	400V	2nA
20TΩ	100MΩ	1.025+1	0.105+1	400V	200pA
200TΩ	1GΩ	1.15+1	0.125+1	400V	20pA

⁶ Specifications are for auto V-source ohms, when properly zeroed, 5½-digit, 1 PLC, median filter on, digital filter = 10 readings. If user selectable voltage is required, use manual mode. Manual mode displays resistance (up to 10¹⁸Ω) calculated from measured current. Accuracy is equal to the accuracy of V-source plus accuracy of selected amps range.

- Preamp settling time: Add voltage source settling time to preamp settling time in Amps specification.

Ohms (alternating polarity method)

The alternating polarity sequence compensates for the background (offset) currents of the material or device under test. Maximum tolerable offset up to full scale of the current range used.

Using Keithley Instruments Model 8002A or Model 8009 fixture:

Repeatability: $\Delta I_{BG} \times R / V_{ALT} + 0.1\%$ (1σ) with instrument temperature constant $\pm 1^\circ\text{C}$.

Accuracy: $(V_{SRC\text{Err}} + I_{MEAS\text{Err}} \times R) / V_{ALT}$

- ΔI_{BG} is a measured, typical background current noise from the sample and fixture.
- V_{ALT} is the alternating polarity voltage used.
- $V_{SRC\text{Err}}$ is the accuracy (in volts) of the voltage source using V_{ALT} as the setting.
- $I_{MEAS\text{Err}}$ is the accuracy (in amps) of the ammeter using V_{ALT} / R as the reading.

Voltage source

Range	5½-digit resolution	Accuracy (1 year) 18°C - 28°C $\pm(\% \text{settling} + \text{offset})$	Temperature coefficient 0°C - 18°C and 28°C - 50°C $\pm(\% \text{settling} + \text{offset}) / ^\circ\text{C}$
100V	5mV	0.15+10mV	0.005+1mV
1000V	50mV	0.15+100mV	0.005+10mV

Maximum output current:

- $\pm 10\text{mA}$; active current limit at $< 11.5\text{mA}$ for 100V range.
- $\pm 1\text{mA}$; active current limit at $< 1.15\text{mA}$ for 1000V range.

Settling time:

- $< 8\text{ms}$ to rated accuracy for 100V range.
- $< 50\text{ms}$ to rated accuracy for 1000V range.

Noise:

- $< 150\mu\text{V}$ p-p from 0.1Hz to 10Hz for 100V range.
- $< 1.5\text{mV}$ p-p from 0.1Hz to 10Hz for 1000V range.

Temperature (thermocouple)

Thermocouple Type	Range	Accuracy (1 year) ⁷ 18°C - 28°C $\pm(\% \text{rdg} + ^\circ\text{C})$
K	-25°C to 150°C	$\pm(0.3\% + 1.5^\circ\text{C})$

⁷ Excluding probe errors, $T_{CAL} \pm 5^\circ\text{C}$, 1 PLC integration time.

Humidity

Range	Accuracy (1 year)⁸ 18°C - 28°C ±(%rdg + %RH)
-25°C to 150°C	±(0.3% + 1.5°C)

⁸ Humidity probe accuracy must be added. This is ±3% RH for Model 6517RH, up to 65°C probe environment, not to exceed 85°C.

IEEE-488 bus implementation:

- Implementation: SCPI (IEEE-488.2, SCPI-1999.0).
- Trigger to reading done: 150ms typical with external trigger.
- RS-232 implementation: Supports SCPI 1991.0, baud rates 300, 900, 1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, and 115.2k.
- Flow control: none, Xon/Xoff hardware.
- Connector: DB-9 TXD/RXD/GND.

General

Display: 6½-digit vacuum fluorescent multiline.

Overrange indication: Display reads "OVERFLOW."

Ranging: Automatic or manual.

Conversion time: Selectable 0.01 PLC to 10 PLC.

Programs: Provide front panel access to IEEE address, choice of engineering units or scientific notation, and digital calibration.

Maximum input: 250V peak, DC to 60Hz sine wave, 10s per minute maximum on mA ranges.

Maximum common mode voltage (DC to 60Hz sine wave): Electrometer 500V peak; V-source 750V peak.

Isolation (meter COMMON to chassis): > 10¹⁰Ω, < 500 p F.

Input connector: Three lug triaxial on rear panel.

2V analog output: Provides a guard output for voltage measurements. Can be used as an inverting output or with external feedback in Amps and Coulombs modes.

External trigger: TTL compatible external trigger and electrometer complete.

Guard: Switchable voltage guard available.

Digital I/O and trigger line: Available, see manual for usage.

EMC: Conforms to European Union Directive 2004/108/EC, EN 61326-1.

Safety: Conforms to European Union Directive 73/23/EEC, EN 61010-1.

Test sequences: Device characterization (diode, capacitor, cable, resistor), resistivity, surface-insulation resistance, sweep.

Reading storage: 50,000 in SCPI mode.

Reading rate:

- To internal buffer: 425 readings / second⁹
- To IEEE-488 bus: 400 readings / second^{9, 11}
- To front panel: 17 readings / second¹⁰
- Bus transfer: 3300 readings / second¹¹

Digital filter: Median and averaging.

Environment (for indoor use only):

- Operating: 0 to 50°C
- Relative humidity: 70% non-condensing, up to 35°C.
- Storage: -25° to + 65°C

Altitude: Maximum 2000 meters above sea level.

Warm up: 1 hour to rated accuracy (see manual for recommended procedure).

Power: User selectable 100, 120, 220, 240VAC, 50/60Hz, 100VA max.

Physical:

- Case dimensions: 90mm high x 214mm wide x 369mm deep (3.5 in. x 8.5 in. x 14.5 in.).
- Working dimensions: 395mm (15.5 in.) from front of case to rear, including power cord and IEEE-488 connector.
- Net weight: < 4.6kg (< 10.1lb.)
- Shipping weight: < 9.5kg (< 21lb.).

⁹ 0.01 PLC, digital filters off, front panel off, temperature + RH off.

¹⁰ 1.00 PLC, digital filters off, temperature + RH off.

¹¹ Binary transfer mode.

Accuracy Calculations

In this appendix:

Topic	Page
Introduction	B-2
Calculating volts accuracy	B-2
Calculating amps accuracy	B-2
Calculating ohms accuracy	B-2
Calculating coulombs accuracy	B-3
Calculating resistance/resistivity accuracy	B-3

Introduction

The information in this appendix shows how to calculate accuracy for volts, amps, ohms and coulombs.

Calculating volts accuracy

From the specifications, volts is calculated as follows:

$$\text{Accuracy} = \pm(\% \text{ rdg} + \text{counts})$$

The following example shows how to compute accuracy for the 2V range:

Assume that the voltage you are measuring is reading exactly 1.00000V on the 2V range.

From the specifications:

$$\begin{aligned} \text{Accuracy} &= \pm(0.025\% \text{ of } 1\text{V} + 4 \text{ counts}) \\ &= \pm(0.00025\text{V} + 4 \text{ counts}) \\ &= \pm(0.00025\text{V} + 0.00004\text{V}) \\ &= \pm 0.00029\text{V} \end{aligned}$$

NOTE Four counts on the 2V range equals 0.00004V.

Therefore, the accuracy range for the 1.00000V reading is 0.99971V to 1.00029V.

Calculating amps accuracy

From the specifications, amps is calculated as follows:

$$\text{Accuracy} = \pm(\% \text{ rdg} + \text{counts})$$

The following example shows how to compute accuracy for the 20mA range:

Assume that the current you are measuring is reading exactly 10.0000mA on the 20mA range.

From the specifications:

$$\begin{aligned} \text{Accuracy} &= \pm(0.1\% \text{ of } 10\text{mA} + 5 \text{ counts}) \\ &= \pm(0.01\text{mA} + 5 \text{ counts}) \\ &= \pm(0.01\text{mA} + 0.0005\text{mA}) \\ &= \pm 0.0105\text{mA} \end{aligned}$$

NOTE Five counts on the 20mA range equals 00.0005mA.

Therefore, the accuracy range for the 10.0000mA reading is 9.9895mA to 10.0105mA.

Calculating ohms accuracy

The following information shows how to calculate auto V-source ohms accuracy.

From the specifications, accuracy is calculated as follows:

$$\text{Accuracy} = \pm(\% \text{ rdg} + \text{counts})$$

The following example shows how to compute auto V-source ohms accuracy for the 2M Ω range:

Assume that the resistor you are measuring is reading exactly 1.00000M Ω on the 2M Ω range.

From the specs:

$$\begin{aligned}\text{Accuracy} &= \pm(0.125\% \text{ of } 1\text{M}\Omega + 1 \text{ count}) \\ &= \pm(1250\Omega + 1 \text{ count}) \\ &= \pm(1250\Omega + 10\Omega) \\ &= \pm 1260\Omega\end{aligned}$$

NOTE One count on the 2M Ω range (0.00001M Ω) equals 10 Ω .

Therefore, the accuracy range for the 1.00000M Ω auto V-source reading is 0.99874M Ω to 1.00126M Ω .

Calculating coulombs accuracy

From the specifications, coulombs is calculated as follows:

$$\text{Accuracy} = \pm(\% \text{ rdg} + \text{counts})$$

The following example shows how to compute accuracy for the 2 μC range:

Assume that the charge you are measuring is reading exactly 1.00000 μC on the 2 μC range.

From the specifications:

$$\begin{aligned}\text{Accuracy} &= \pm(0.4\% \text{ of } 1\mu\text{C} + 5 \text{ counts}) \\ &= \pm(0.004\mu\text{C} + 5 \text{ counts}) \\ &= \pm(0.004\mu\text{C} + 0.00005\mu\text{C}) \\ &= \pm 0.00405\mu\text{C}\end{aligned}$$

NOTE Five counts on the 2 μC range equals 0.00005 μC .

Therefore, the accuracy range for the 1.00000 μC reading is 0.99595 μC to 1.00405 μC .

Calculating resistance/resistivity accuracy and repeatability using the alternating polarity method

From the specifications, accuracy and repeatability when using a Model 8009 test fixture are calculated as follows:

$$\begin{aligned}\text{Repeatability: } \Delta I_{\text{BG}} \times R / V_{\text{ALT}} + 0.1\% (1\sigma) \\ (\text{instrument temp. constant } \pm 1^\circ\text{C})\end{aligned}$$

$$\text{Accuracy: } (V_{\text{SRC}}\text{Err} + I_{\text{MEAS}}\text{Err} \times R) / V_{\text{ALT}}$$

Where:

- ΔI_{BG} is a measured, typical background current noise from the sample and fixture over the measurement time programmed, under normal measurement conditions (1 PLC, same range, filters off, etc.)
- V_{ALT} is the alternating polarity voltage used
- $V_{\text{SRC}}\text{Err}$ is the accuracy (in volts) of the voltage source using V_{ALT} as the setting
- $I_{\text{MEAS}}\text{Err}$ is the accuracy (in amps) of the ammeter using V_{ALT}/R as the reading

The following example shows how to calculate accuracy and repeatability for a 10^{13} ohms sample measured in a Model 8009 test fixture, with 50V stimulus and a background current of 4pA. The user-selected measurement time for the alternating polarity measurement is 15 seconds.

ΔI_{BG} is measured with no voltage applied, under normal measurement conditions, and 15 seconds (according to the user's choice for the measurement) of readings are stored to the buffer. Normal conditions require 1 PLC, the same amps range that will be used for the alternating polarity

measurement and similar preconditioning to the normal measurements (if the samples are normally inserted into the fixture and immediately measured, the stored readings should be performed similarly after lid closure). After the storage is complete, the standard deviation (1 sigma) of these values is taken. This can be done by retrieving the standard deviation of the buffer over the bus or by pressing **RECALL** once and **NEXT** repeatedly, scrolling through the second-line displays to the standard deviation. This is ΔI_{BG} . Assume for example, that the result was 55fA or 5.5×10^{-14} A.

$$\text{Repeatability} = 5.5 \times 10^{-14} \text{ A} \times 10^{13} \Omega / 50\text{V} + 0.1\% = 0.011 + 0.1\% \text{ or } 1.2\%$$

Note that with normal ohms methods, the 4pA total background current contributes as much as 400% error.

$$V_{\text{SRC}}\text{Err} = 0.15\% \times 50\text{V} + 10\text{mV} = 0.085\text{V} \text{ (from } 100\text{V V-source range specs)}$$

$$I_{\text{MEAS}}\text{Err} = 1\% \times (50\text{V} / 10^{13} \Omega) + 30 \text{ counts} \times 10^{-16} \text{ A} / \text{count} = 5.3 \times 10^{-14} \text{ A} \text{ (from } 20\text{pA spec)}$$

$$\text{Accuracy} = (0.085\text{V} + 5.3 \times 10^{-14} \text{ A} \times 10^{13} \Omega) / 50\text{V} = 0.0123 \text{ or } 1.23\%$$

Interface Function Codes

In this appendix:

Topic	Page
Interface function codes	C-2
Code summary	C-2
Code descriptions	C-2

Interface function codes

Code summary

The interface function codes, which are part of the IEEE-488 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Keithley Instruments Model 6517B Electrometer are listed in [Table C-1](#).

Table C-1
Model 6517B interface function codes

Code	Interface function
SH1	Source handshake capability
AH1	Acceptor handshake capability
T5	Talker (basic talker, talk-only, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service request capability
RL1	Remote/local capability
PP0	No parallel poll capability
DC1	Device clear capability
DT1	Device trigger capability
C0	No controller capability
E1	Open collector bus drivers
TE0	No extended talker capability
LE0	No extended listener capability

Code descriptions

The codes define Model 6517B capabilities as follows:

SH (source handshake function): SH1 defines the ability of the instrument to initiate the transfer of message/data over the data bus.

AH (acceptor handshake function): AH1 defines the ability of the instrument to guarantee proper reception of message/data transmitted over the data bus.

T (talker function): The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities (T5) exist only after the instrument has been addressed to talk.

L (listener function): The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities (L4) of the instrument exist only after it has been addressed to listen.

SR (service request function): SR1 defines the ability of the instrument to request service from the controller.

RL (remote-local function): RL1 defines the ability of the instrument to be placed in the remote or local modes.

PP (parallel poll function): The instrument does not have parallel polling capabilities (PP0).

DC (device clear function): DC1 defines the ability of the instrument to be cleared (initialized).

DT (device trigger function): DT1 defines the ability of the Model 6517B to have readings triggered.

C (controller function): The instrument does not have controller capabilities (C0).

TE (extended talker function): The instrument does not have extended talker capabilities (TE0).

LE (extended listener function): The instrument does not have extended listener capabilities (LE0).

E (bus driver type): The instrument has open-collector bus drivers (E1).

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ASCII Character Codes

In this appendix:

Topic	Page
Introduction	D-2
Code summary	D-2

Introduction

This appendix summarizes ASCII character codes and corresponding IEEE-488 (GPIB) multiline messages for the Keithley Instruments Model 6517B Electrometer.

Code summary

ASCII character codes and corresponding IEEE-488 (GPIB) multiline messages are summarized in [Table D-1](#), [Table D-2](#), and [s](#).

Table D-1
ASCII character codes (decimal 0-31)

Decimal	Hexadecimal	ASCII	IEEE-488 messages*	Decimal	Hexadecimal	ASCII	IEEE-488 messages*
0	00	NUL		16	10	DLE	
1	01	SOH	GTL	17	11	DC1	LLO
2	02	STX		18	12	DC2	
3	03	ETX		19	13	DC3	
4	04	EOT	SDC	20	14	DC4	DCL
5	05	ENQ	PPC	21	15	NAK	PPU
6	06	ACK		22	16	SYN	
7	07	BEL		23	17	ETB	
8	08	BS	GET	24	18	CAN	SPE
9	09	HT	TCT	25	19	EM	SPD
10	0A	LF		26	1A	SUB	
11	0B	VT		27	1B	ESC	
12	0C	FF		28	1C	FS	
13	0D	CR		29	1D	GS	
14	0E	SO		30	1E	RS	
15	0F	SI		31	1F	US	

* Message sent or received with ATN true.

Numbers shown represent primary address resulting in MLA (My Listen Address).

Table D-2
ASCII character codes (decimal 32-95)

Decimal	Hexadecimal	ASCII	IEEE-488 messages*	Decimal	Hexadecimal	ASCII	IEEE-488 messages*
32	20	SP	MLA 0	64	40	@	MTA 0
33	21	!	MLA 1	65	41	A	MTA 1
34	22	"	MLA 2	66	42	B	MTA 2
35	23	#	MLA 3	67	43	C	MTA 3
36	24	\$	MLA 4	68	44	D	MTA 4
37	25	%	MLA 5	69	45	E	MTA 5
38	26	&	MLA 6	70	46	F	MTA 6
39	27	'	MLA 7	71	47	G	MTA 7
40	28	(	MLA 8	72	48	H	MTA 8
41	29	)	MLA 9	73	49	I	MTA 9
42	2A	*	MLA 10	74	4A	J	MTA 10
43	2B	+	MLA 11	75	4B	K	MTA 11
44	2C	,	MLA 12	76	4C	L	MTA 12
45	2D	-	MLA 13	77	4D	M	MTA 13
46	2E	.	MLA 14	78	4E	N	MTA 14
47	2F	/	MLA 15	79	4F	O	MTA 15
48	30	0	MLA 16	80	50	P	MTA 16
49	31	1	MLA 17	81	51	Q	MTA 17
50	32	2	MLA 18	82	52	R	MTA 18
51	33	3	MLA 19	83	53	S	MTA 19
52	34	4	MLA 20	84	54	T	MTA 20
53	35	5	MLA 21	85	55	U	MTA 21
54	36	6	MLA 22	86	56	V	MTA 22
55	37	7	MLA 23	87	57	W	MTA 23
56	38	8	MLA 24	88	58	X	MTA 24
57	39	9	MLA 25	89	59	Y	MTA 25
58	3A	:	MLA 26	90	5A	Z	MTA 26
59	3B	;	MLA 27	91	5B	[	MTA 27
60	3C	<	MLA 28	92	5C	\	MTA 28
61	3D	=	MLA 29	93	5D	]	MTA 29
62	3E	>	MLA 30	94	5E	«	MTA 30
63	3F	?	UNL	95	5F	æ	UNL

* Message sent or received with ATN true.
 Numbers shown represent primary address resulting in MLA (My Listen Address).

Table D-3
ASCII character codes (decimal 96-127)

Decimal	Hexadecimal	ASCII	IEEE-488 messages*	Decimal	Hexadecimal	ASCII	IEEE-488 messages*
96	60	«	MSA 0, PPE	112	70	p	MSA 16, PPD
97	61	a	MSA 1, PPE	113	71	q	MSA 17, PPD
98	62	b	MSA 2, PPE	114	72	r	MSA 18, PPD
99	63	c	MSA 3, PPE	115	73	s	MSA 19, PPD
100	64	d	MSA 4, PPE	116	74	t	MSA 20, PPD
101	65	e	MSA 5, PPE	117	75	u	MSA 21, PPD
102	66	f	MSA6, PPE	118	76	v	MSA 22, PPD
103	67	g	MSA 7, PPE	119	77	w	MSA 23, PPD
104	68	h	MSA 8, PPE	120	78	x	MSA 24, PPD
105	69	i	MSA 9, PPE	121	79	y	MSA 25, PPD
106	6A	j	MSA 10, PPE	122	7A	z	MSA 26, PPD
107	6B	k	MSA 11, PPE	123	7B	{	MSA 27, PPD
108	6C	l	MSA 12, PPE	124	7C	|	MSA 28, PPD
109	6D	m	MSA 13, PPE	125	7D	}	MSA 29, PPD
110	6E	n	MSA 14, PPE	126	7E	~	MSA 30, PPD
111	6F	o	MSA 15, PPE	127	7F	DEL	

* Message sent or received with ATN true.

Numbers shown represent primary address resulting in MLA (My Listen Address).

In this appendix:

Topic	Page
Introduction	E-2
Bus description	E-2
Bus lines	E-4
Data lines	E-4
Bus management lines	E-4
Handshake lines	E-4
Bus commands	E-5
Uniline commands	E-6
Universal multiline commands	E-6
Addressed multiline commands	E-7
Addressed commands	E-7
Unaddress commands	E-7
Common commands	E-7
SCPI commands	E-8
Command codes	E-8
Typical command sequences	E-9
IEEE command groups	E-10

Introduction

The IEEE-488 bus is a communication system between two or more electronic devices. A device can be either an instrument or a computer. When a computer is used on the bus, it serves to supervise the communication exchange between all the devices and is known as the controller. Supervision by the controller consists of determining which device will talk and which device will listen. As a talker, a device will output information and as a listener, a device will receive information. To simplify the task of keeping track of the devices, a unique address number is assigned to each one.

On the bus, only one device can talk at a time and is addressed to talk by the controller. The device that is talking is known as the active talker. The devices that need to listen to the talker are addressed to listen by the controller. Each listener is then referred to as an active listener. Devices that do not need to listen are instructed to unlisten. The reason for the unlisten instruction is to optimize the speed of bus information transfer since the task of listening takes up bus time.

Through the use of control lines, a handshake sequence takes place in the transfer process of information from a talker to a listener. This handshake sequence helps ensure the credibility of the information transfer. The basic handshake sequence between an active controller (talker) and a listener is as follows:

1. The listener indicates that it is ready to listen.
2. The talker places the byte of data on the bus and indicates that the data is available to the listener.
3. The listener, aware that the data is available, accepts the data and then indicates that the data has been accepted.
4. The talker, aware that the data has been accepted, stops sending data and indicates that data is not being sent.
5. The listener, aware that there is no data on the bus, indicates that it is ready for the next byte of data.

Bus description

The IEEE-488 bus, which is also frequently referred to as the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and with most commands. Five bus management lines and three handshake lines round out the complement of bus signal lines.

A typical setup for controlled operation is shown in [Figure E-1](#). Generally, a system will contain one controller and a number of other instruments to which the commands are given. Device operation is categorized into three operators: controller, talker, and listener. The controller does what its name implies; it controls the instruments on the bus. The talker sends data while a listener receives data. Depending on the type of instrument, any particular device can be a talker only, a listener only or both a talker and listener.

There are two categories of controllers: System controller and basic controller. Both are able to control other instruments, but only the system controller has the absolute authority in the system. In a system with more than one controller, only one controller may be active at any given time. Certain protocol is used to pass control from one controller to another.

The IEEE-488 bus is limited to 15 devices, including the controller. Therefore, any number of talkers and listeners up to that limit may be present on the bus at one time. Although several devices may be commanded to listen simultaneously, the bus can have only one active talker, or communications will be scrambled.

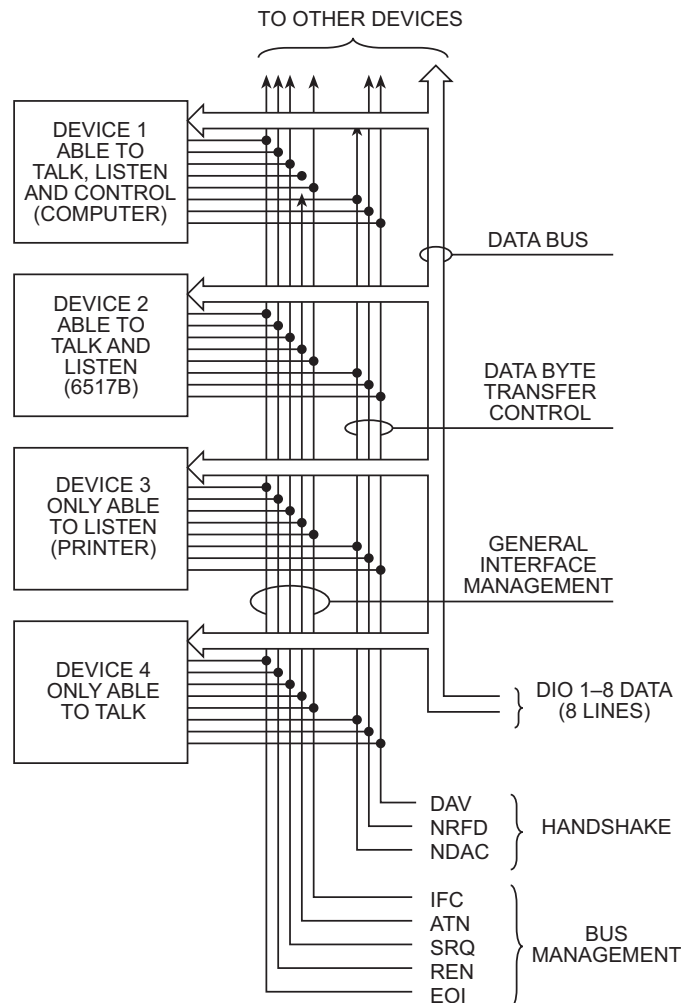
A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary address. The primary

address may have any value between 0 and 31, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by OR'ing the primary address with \$20. For example, if the primary address is \$27, the actual listen address is \$47 ($\$47 = \$27 + \20). In a similar manner, the talk address is obtained by ORing the primary address with \$40. With the present example, the talk address derived from a primary address of 27 decimal would be \$67 ($\$67 = \$27 + \40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of \$60-\$7F. Note, however, that many devices, including the Keithley Instruments Model 6517B Electrometer, do not use secondary addressing.

Once a device is addressed to talk or listen, the appropriate bus transactions take place. For example: If the instrument is addressed to talk, it places its data string on the bus one byte at a time. The controller reads the information and the appropriate software can be used to direct the information to the desired location.

Figure E-1
IEEE-488 bus configuration



Bus lines

The signal lines on the IEEE-488 bus are grouped into three different categories: Data lines, management lines, and handshake lines. The data lines handle bus data and commands, while the management and handshake lines ensure that proper data transfer and operation takes place. Each bus line is active low, with approximately zero volts representing a logic 1 (true). The following paragraphs describe the operation of these lines.

Data lines

The IEEE-488 bus uses eight data lines that transfer data one byte at a time. DIO1 (data input/output) through DIO8 (data input/output) are the eight bidirectional data lines used to transmit both data and multiline commands. The data lines operate with low true logic.

Bus management lines

The five bus management lines help to ensure proper interface control and management. These lines are used to send the uniline commands.

ATN (attention): The **ATN** line is one of the more important management lines because the state of this line determines how information on the data bus is interpreted.

IFC (interface clear): As the name implies, the **IFC** line controls clearing of instruments from the bus.

REN (remote enable): The **REN** line is used to place the instrument on the bus in the remote mode.

EOI (end or identify): The **EOI** is usually used to mark the end of a multi-byte data transfer sequence.

SRQ (service request): This line is used by devices when they require service from the controller.

Handshake lines

The bus handshake lines operate in an interlocked sequence. This method ensures reliable data transmission regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the three handshake lines is controlled by the source (the talker sending information), while the remaining two lines are controlled by accepting devices (the listener or listeners receiving the information). The three handshake lines are:

DAV (data valid): The source controls the state of the **DAV** line, which indicates whether data bus information is valid for any listening lines.

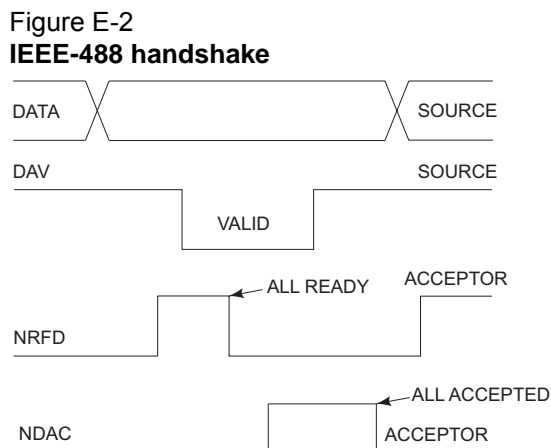
NRF (not ready for data): The acceptor controls the state of **NRF**. It is used to signal to the transmitting device to pause the byte transfer sequence until the accepting device is ready.

NDAC (not data accepted): **NDAC** is also controlled by the accepting device. The state of **NDAC** tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in [Figure E-2](#). Once data is placed on the data lines, the source checks to see that **NRF** is high, indicating that all active devices are ready. At the same time, **NDAC** should be low from the previous byte transfer. If these conditions are not met, the source must wait until **NDAC** and **NRF** have the correct status. If the source is a controller, **NRF** and **NDAC** must be stable for at least 100nsec after **ATN** is set true. Because of the possibility of a bus interruption, many controllers have time-out routines that display messages if case the transfer sequence stops for any reason.

Once all $NDAC$ and $NRFD$ are properly set, the source sets DAV low, signalling to accepting devices that the byte on the data lines is now valid. $NRFD$ will then go low, and $NDAC$ will go high once all devices have accepted the data. Each device will release $NDAC$ at its own rate, but $NDAC$ will not be released to go high until all devices have accepted the data byte.

The sequence just described is used to transfer both data, talk and listen addresses, as well as multiline commands. The state of the ATN line determines whether the data bus contains data, addresses, or commands (as described in the following paragraph).



Bus commands

The instrument may be given a number of special bus commands through the IEEE-488 interface. This section briefly describes the purpose of the bus commands, which are grouped into the following four categories:

1. **Uniline commands:** Sent by setting the associated bus lines true. For example, to assert REN (remote enable), the REN line would be set low (true).
2. **Multiline commands:** General bus commands that are sent over the data lines with the ATN line true (low).
3. **Common commands:** Commands that are common to all devices on the bus; sent with ATN high (false).
4. **SCPI commands:** Commands that are particular to each device on the bus; sent with ATN (false).

These bus commands and their general purposes are summarized in [Table E-1](#).

Table E-1
IEEE-488 bus command summary

Command type	Command	State of ATN line	Comments
Uniline	REN (remote enable)	X	Set up devices for remote operation
	EOI	X	Marks end of transmission
	IFC (interface clear)	X	Clears interface
	ATN (Attention)	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline Universal	LLO (local lockout)	Low	Locks out local operation
	DCL (device clear)	Low	Returns device to default conditions
	SPE (serial enable)	Low	Enables serial polling
	SPD (serial poll disable)	Low	Disables serial polling
Addressed	SDC (selective device clear)	Low	Returns unit to default conditions
	GTL (go to local)	Low	Returns device to local
Unaddressed	UNL (unlisten)	Low	Removes all listeners from the bus
	UNT (untalk)	Low	Removes any talkers from the bus
Common	—	High	Programs IEEE-488.2 compatible instruments for common operations
SCPI	—	High	Programs SCPI compatible instruments for specific operations

Uniline commands

ATN, IFC, and REN are asserted only by the controller. SRQ is asserted by an external device. EOI may be asserted either by the controller or other devices, depending on the direction of data transfer. The following is a description of each command. Each command is sent by setting the corresponding bus line true.

REN (remote enable): REN is sent to set up instruments on the bus for remote operation. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the **LOCAL** button (if the device is so equipped) may be locked out when REN is true. Generally, REN should be sent before attempting to program instruments over the bus.

EOI (end or identify): EOI is used to positively identify the last byte in a multi-byte transfer sequence, allowing data words of various lengths to be transmitted easily.

IFC (interface clear): IFC is used to clear the interface and return all devices to the talker and listener idle states.

ATN (attention): The controller sends ATN while transmitting addresses or multiline commands.

SRQ (service request): SRQ is asserted by a device when it requires service from a controller.

Universal multiline commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the commands are transmitted. All multiline commands are transmitted with ATN true.

LLO (local lockout): LLO is sent to the instrument to lock out the **LOCAL** key and all the instruments' front panel controls.

DCL (device clear): DCL is used to return instruments to a default state. Usually, instruments return to their power-up conditions.

SPE (serial poll enable): SPE is the first step in the serial polling sequence which is used to determine which device has requested service.

SPD (serial poll disable): *SPD* is used by the controller to remove all devices on the bus from the serial poll mode and is generally the last command in the serial polling sequence.

Addressed multiline commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands. Both the commands and the address preceding it are sent with *ATN* true.

SDC (selective device clear): The *SDC* command performs essentially the same function as the *DCL* command, except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the *SDC* command.

GTL (go to local): The *GTL* command is used to remove instruments from the remote mode. With some instruments, *GTL* also unlocks front panel controls if they were previously locked out with the *LLO* command.

GET (group execute trigger): The *GET* command is used to trigger devices to perform a specific action that depends on device configuration (for example, take a reading). Although *GET* is an addressed command, many devices respond to *GET* without addressing.

Addressed commands

Addressed commands include two primary command groups and a secondary address group. *ATN* is true when these commands are asserted. The commands include:

LAG (listen address group): These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with \$20.

TAG (talk address group): The talk commands are derived from the primary address by ORing the address with \$40. Talk commands are used to address devices to talk.

SCG (secondary command group): Commands in this group provide additional addressing capabilities. Many devices (including the Model 6517B) do not use these commands.

Unaddress commands

The two unaddress commands are used by the controller to remove any talkers or listeners from the bus. *ATN* is true when these commands are asserted.

UNL (unlisten): Listeners are placed in the listener idle state by the *UNL* command.

UNT (untalk): Any previously commanded talkers will be placed in the talker idle state by the *UNT* command.

Common commands

Common commands are commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a common operation, such as reset. The IEEE-488 bus treats these commands as data because *ATN* is false when the commands are transmitted.

Table E-2
Typical addressed command sequence

Step	Command	ATN state	Data bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	:	3B	59
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 27

Table E-3
Typical common command sequence

Step	Command	ATN state	Data bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	:	3B	59
3	Data	Set high	*	2A	42
4	Data	Stays high	R	52	82
5	Data	Stays high	S	53	83
6	Data	Stays high	T	54	84

*Assumes primary address = 27

Typical command sequences

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. [Table E-2](#) lists a typical bus sequence for sending the addressed multiline commands. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself.

[Table E-3](#) gives a typical common command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the common command string.

IEEE command groups

Command groups supported by the Model 6517B are listed in [Table E-4](#). Common commands and SCPI commands are not included in this list.

Table E-4
IEEE command groups

Handshake command group	
	NDAC = Not data accepted NRFD = Not ready for data DAV = Data valid
Universal command group	
	ATN = Attention DCL = Device clear IFC = Interface clear REN = Remote enable SPD = Serial poll disable SPE = Serial poll enable
Address command group	
LISTEN	LAG = Listen address group MLA = My listen address UNL = Unlisten
TALK	TAG = Talk address group MTA = My talk address UNT = Untalk OTA = Other talk address
Addressed command group	
	ACG = Addressed command group GTL = Go to local SDC = Selective device clear
Status command group	
	RQS = Request service SRQ = Serial poll request STB = Status byte EOI = End

In this appendix:

Topic	Page
Information	F-2

Information

The IEEE-488.2 standard requires specific information about how the Keithley Instruments Model 6517B Electrometer implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. [Table F-1](#) provides a summary of the requirements, and provides the information or references the manual for that information.

Table F-1
IEEE-488 documentation requirements

Item Number	Requirement	Description or reference
(1)	IEEE-488 interface function codes	See Appendix E
(2)	Behavior of 6517B when the address is set outside the range 0-30	Cannot enter an invalid address
(3)	Behavior of 6517B when valid address is entered	Address changes and bus resets
(4)	Power-on setup conditions	Determine by :SYSTem:POSetup (Section 14)
(5)	Message exchange options:	
(a)	Input buffer size	256 bytes
(b)	Queries that return more than one response message unit	None
(c)	Queries that generate a response when parsed	All queries (common commands and SCPI)
(d)	Queries that generate a response when read	None
(e)	Coupled commands	See Table F-2
(6)	Functional elements required for SCPI commands	Contained in SCPI command subsystems tables (see Section 14)
(7)	Buffer size limitations for block data	Block display messages: Top display = 20 characters max, bottom display = 32 characters max
(8)	Syntax restrictions	See Section 11
(9)	Response syntax for every query command	See Section 11
(10)	Device-to-device message transfer that does not follow rules of the standard	None
(11)	Block data response size	See Section 11
(12)	Common commands implemented by 6517B	See Section 12
(13)	Calibration query information	See Section 15
(14)	Trigger macro for *DDT	Not applicable
(15)	Macro information	Not applicable
(16)	Response to *IDN (identification)	See Section 12
(17)	Storage area for *PUD and *PUD?	Not applicable
(18)	Resource description for *RDT and *RDT?	Not applicable
(19)	Effects of *RST, *RCL, and *SAV	See Section 12 and Section 14
(20)	*TST information	See Section 12
(21)	Status register structure	See Section 13
(22)	Sequential or overlapped commands	All are sequential except :INIT and :INIT:CONT ON, which are overlapped
(23)	Operation complete messages	See Section 12

Table F-2
Coupled commands

Command	Also changes	To	If
:TRIG:COUN	:TRAC:POIN:AUTO :TRAC:POIN :TRAC:FEED:PRET:AMO:READ	OFF TRIG:COUN TRIG:COUN * TRAC:FEED:PRET:AMO:PERC / 100	TRAC:POIN:AUTO is ON and TRIG:COUN is an illegal buffer size TRAC:POIN:AUTO is ON TRAC:POIN:AUTO is ON
:TRAC:FEED:CONT	:TRIG:SOUR	TIM	TRAC:FEED:CONT is PRET and TRIG:SOUR is neither IMM nor TIM
:TRAC:POIN	:TRAC:POIN:AUTO :TRAC:FEED:CONT :TRAC:FEED:PRET:AMO:READ	OFF NEV TRAC:POIN * TRAC :FEED:PRET:AMO :PERC / 100	
:TRAC:FEED:PRET:AMO:PERC	:TRAC:FEED:PRET:AMO:READ :TRAC:FEED:CONT	TRAC:POIN * TRAC :FEED:PRET:AMO :PERC / 100 NEV	
:TRAC:FEED:PRET:AMO:READ	:TRAC:FEED:PRET:AMO:PERC :TRAC:FEED:CONT	TRAC:FEED:PRET: AMO:READ / TRAC :POIN * 100 NEV	
:TRAC:CLE	:TRAC:FEED:CONT	NEV	
...:APER	...:APER:AUTO ...:NPLC:AUTO ...:NPLC ...:DIG	OFF OFF APER*line-frequency varies per function	...:DIG:AUTO is ON
...:NPLC	...:APER:AUTO ...:NPLC:AUTO ...:APER ...:DIG	OFF OFF NPLC/line-frequency varies per function	...:DIG:AUTO is ON
...:DIG	...:DIG:AUTO ...:APER ...:NPLC	OFF varies per function varies per function	...:APER:AUTO is ON ...:NPLC:AUTO is ON
...:RANG:UPP	...:RANG:AUTO	OFF	
...:REF:ACQ	...:REF	presently displayed reading	
...:DET:FUNC	...:APER ...:DIG ...:AVER:STAT ...:AVER:COUN n ...:AVER:TCON n ...:AVER:ADV:STAT n ...:AVER:ADV:NTOL n	varies per function varies per function varies per function varies per function varies per function varies per function varies per function	...:APER:AUTO is ON ...:DIG:AUTO is ON ...:AVER:AUTO is ON ...:AVER:AUTO is ON ...:AVER:AUTO is ON ...:AVER:AUTO is ON ...:AVER:AUTO is ON
:RES:OCOM	:RES:RANG:UPP :RES:RANG:AUTO:ULIM :RES:RANG:AUTO:LLIM	200k 200k 200k	RES:OCOM is ON and RES:RANG:UPP > 200k RES:OCOM is ON and RES:RANG:AUTO:ULIM > 200k RES:OCOM is ON and RES:RANG:AUTO:LLIM > 200k
:CURR:DC:METH	:CURR:DC:RANG:UPP :CURR:DC:RANG:AUTO :CURR:DC:AVER:STAT :CURR:DC:AVER:COUN :CURR:DC:AVER:TCON :CURR:DC:AVER:ADV:STAT :CURR:DC:AVER:ADV:NTOL	12 OFF varies per function varies per function varies per function varies per function	CURR:DC:METH is ICIR CURR:DC:METH is ICIR CURR:DC:AVER:AUTO is ON CURR:DC:AVER:AUTO is ON CURR:DC:AVER:AUTO is ON CURR:DC:AVER:AUTO is ON
:FREQ:THR:VOLT:TTL	:FREQ:THR:VOLT:RANG :FREQ:THR:VOLT:LEV	10 0.8	
:TEMP:TRAN	:ROUT:SCAN:INT :ROUT:SCAN:INT:FUNC :TEMP:DIG	very complicated algorithm very complicated algorithm varies per transducer	TEMP:DIG:AUTO is ON
:TEMP:RTD:TYPE	:TEMP:RTD:ALPH :TEMP:RTD:BETA :TEMP:RTD:DELT :TEMP:RTD:RZER	varies per RTD type varies per RTD type varies per RTD type varies per RTD type	TEMP:RTD:TYPE is not USER TEMP:RTD:TYPE is not USER TEMP:RTD:TYPE is not USER TEMP:RTD:TYPE is not USER
:TEMP:RTD:ALPH	:TEMP:RTD:TYPE	USER	
:ROUT:CLOS	:ROUT:SCAN:LSEL	NONE	
:ROUT:OPEN	:ROUT:SCAN:LSEL	NONE	The command actually opens a channel
:ROUT:OPEN:ALL	:ROUT:SCAN:LSEL	NONE	
:ROUT:SCAN:INT	:ROUT:SCAN:LSEL	INT	

... = Valid function command words (for example, :VOLT:DC, :RESistance, etc.)

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In this appendix:

Topic	Page
Introduction	G-2

Introduction

The Keithley Instruments Model 6517B Electrometer complies with SCPI version 1996.0. The tables in [Section 14](#) of this manual list the SCPI confirmed commands, and the non-SCPI commands implemented by the Model 6517B. These tables are summarized by subsystem in [Table G-1](#) below.

Table G-1
SCPI table summary

Subsystem	Summary table
CALCulate	Table 14-3
CALibration	Table 14-4
DISPlay	Table 14-4
FORMat	Table 14-5
OUTPut	Table 14-6
ROUTE	Table 14-7
SENSE	Table 14-8
SOURce	Table 14-9
STATus	Table 14-10
SYSTEM	Table 14-11
TRACe	Table 14-12
Trigger	Table 14-13
TSEQence	Table 14-14
UNIT	Table 14-15

ADISChargE commands	14-58
AVERage commands	14-54
CALCulate2	14-27
CALCulate3	14-28
CLOSE	14-39
CURRent commands	14-63
DATA commands	14-42
DISPlay subsystem	14-32
FORMat subsystem	14-34
GUARd	14-58
INITiate commands	14-96
MEDian commands	14-56
OPEN	14-39
ALL	14-40
PRESet	14-82
QUEue commands	14-83
RESistivity commands	14-59
RNUMber	
RESet	14-88
ROUTe subsystem	14-39
SCAN commands	14-40
SENSe1 subsystem	14-42
SOURce subsystem	14-61
STATus subsystem	14-64
SYSTem subsystem	14-84
TRACe subsystem	14-92
TSEQuence Subsystem	14-102
UNIT Subsystem	14-109
USER commands	14-60

Symbols

*CLS — clear status	12-2
*ESR? — event status register query	12-4
*IDN? — identification query	12-5
*OPC — operation complete	12-5
*OPC? — operation complete query	12-6
*OPT? — option identification query	12-7
*RCL — recall	12-7
*RST — reset the Model 6517A	12-7
*SAV — save the current setup in memory	12-8
*SRE — service request enable	12-8
*STB? — status byte query	12-9
*TRG — trigger	12-10
*TST? — self-test query	12-11
*WAI — wait-to-continue	12-11

Numerics

CALCulate	14-25
2V analog output	5-9

A

A/D control commands	14-89
Accessories	1-3
Addenda, manual	1-5
Advanced trigger configuration	7-9
Alternating polarity resistance/resistivity test	6-7
Analog outputs	5-8
Annunciators	2-2
Arm layer	
Configuring	7-12
ASCII character codes	D-2, E-10
Asynchronous commands	14-100
Asynchronous example	7-15
Asynchronous operation	7-14
Auto discharge	4-31
Auto discharge hop	4-35
Auto V-Source	4-18

B

Bar graph	2-15
Basic measurement procedure	4-31
Basic trigger configuration	7-8
Buffer	8-2
Configuring	8-3
Data elements	8-2
maximum readings	8-2
Multiple displays	8-7
Storing and recalling readings	8-6
Buffer multiple displays	8-7
Bus commands	E-5

C

Cable insulation resistance test	6-4
Cable leakage resistance	4-7
Cables	
Low noise input	3-6
Cables and adapters	1-3
CAL	2-26
Calculate multiple display	9-10
Calculate subsystems	14-25
Calculating amps accuracy	B-2
Calculating coulombs accuracy	B-3
Calculating ohms accuracy	B-2
Calculating resistance/resistivity accuracy	B-3
Calculating volts accuracy	B-2
Calibration	15-2
Calibration, partial	15-12
Calibrator	16-2
Cancelling leakage current	4-22
Capabilities	1-2
Capacitor leakage current test	6-4
Charge measurement considerations	4-34

- Charge measurements 4-31
 - Auto discharge 4-31
 - Configuration 4-33
 - Considerations 4-34
 - Procedure 4-31
 - Charge measurements (Q) 4-31
 - Command words 11-8
 - Commands
 - Long forms 11-10
 - Short forms 11-10
 - Common commands
 - Descriptions 12-2
 - Summary 12-2, 13-2
 - COMMUNICATION 2-26
 - Communication menu 11-4
 - Condition commands 14-82
 - Condition registers 13-9
 - Configure sequence menu 6-11
 - Configure Test Sequence 6-11
 - Configuring the filters 9-5
 - Connections
 - High-resistance meter 3-4
 - IEEE-488 bus 11-2
 - Methods 3-4
 - RS-232 interface 11-4
 - Voltage source output 3-5
 - Connectors
 - 2V Analog Output 2-5
 - Chassis Ground 2-5
 - Common 2-5
 - Digital I/O 2-5
 - Guard 2-5
 - Humidity 2-5
 - IEEE-488 2-5
 - Input 2-4
 - Interlock 2-5
 - Preamp Out 2-4
 - RS-232 2-5
 - Temp Type K 2-5
 - Trig Link 2-5
 - V-Source HI and LO 2-5
 - Control sources 7-5
 - Coulombs configuration 4-32
 - Current limit 5-7
 - Current measurements 4-9
 - Configuration 4-11
 - Considerations 4-13
 - Floating 4-16
 - High impedance 4-16
 - Procedure 4-9
- D**
- Data elements 8-2
 - Data store
 - Configuring 8-3
 - Multiple displays 8-7
 - Storing and recalling readings 8-6
 - Data store (buffer) 8-2
 - DCL (device clear) 11-7
 - Default conditions 2-8
 - Deviation 9-8
 - Digital filter
 - Modes 9-2
 - Response time 9-3
 - Types 9-2
 - Digital filters 9-2
 - Digital I/O 10-5
 - Controlling digital circuits 10-7
 - External voltage supply 10-7
 - Logic inputs 10-7
 - Menu 10-5
 - Port 10-6
 - Digital output commands 14-61
 - Diode leakage current test 6-2
 - Display 2-8
 - Bar graph 2-15
 - Error messages 2-11
 - Exponent mode 2-8
 - Information messages 2-9
 - Maximum and minimum 2-16
 - Multiple 2-15
 - Range messages 2-9
 - Status messages 2-11
 - Display resolution 5-17
- E**
- Electrification time 4-31
 - Electrochemical effects 4-36
 - Electromagnetic interference (EMI) 4-38
 - Electrometer input circuitry 5-12
 - Electrostatic interference 4-37
 - Enable commands 14-69
 - Enable registers 13-10
 - Environment 15-2
 - Error and status messages 11-8
 - Error codes 15-20
 - Error messages 2-7
 - ESE — event enable 12-3
 - ESE? — event enable query 12-3
 - Event commands 14-64
 - Event registers 13-10
 - External feedback 5-12
 - Procedure 5-14
 - External feedback procedure 5-14
 - External scanning 10-9
 - External temperature measurement 4-38
 - External trigger 7-14
 - External voltage source 4-34
- F**
- Features 1-2
 - Filters 9-2, 10-10
 - Averaging 9-6
 - Configuring 9-5
 - Digital 9-2
 - Median 9-6
 - Floating
 - Circuits 3-9
 - Measurements 3-9
 - Voltage source 3-10
 - Front panel summary 2-2
 - Function commands 14-42
- G**
- GENERAL 2-26
 - General bus commands 11-6

General test sequence commands 14-102
 GET (group execute trigger) 11-7
 GPIB 11-4
 GPIB primary address 11-5
 GPIB primary address selection 11-5
 Ground loops 4-35
 GTL (go to local) 11-7
 Guarding 3-7, 4-7, 4-16

H

Handle 2-3
 Handling precautions 1-5
 Humidity 4-36

I

Idle 7-4, 7-5
 IEEE-488
 Primary address 2-8
 IEEE-488 bus
 Commands E-5
 Connections 11-2
 Data lines E-4
 Description E-2
 Front panel operation 11-7
 Handshake lines E-4
 Lines E-4
 Management lines E-4
 Primary address 11-5
 Standards 11-2
 Status indicators 11-8
 IEEE-488 Conformance Information F-2, G-2
 IEEE-488 front panel operation 11-7
 IEEE-488 multiline messages D-2, E-10
 IFC (interface clear) 11-6
 Input
 Configurations 3-2
 Connector 3-2
 Maximum levels 3-3
 Protection 3-4
 Input bias current 4-13, 4-34
 Input capacitance 4-7
 Inspection 1-5
 Interface function codes C-2, D-2, E-2, F-2, G-2
 Description C-2
 Summary C-2
 Interlock 5-7
 Interlock and test fixtures 5-7
 Internal scanning 10-9

K

Keys
 Display 2-3
 Function 2-3
 Operation 2-3
 Range 2-3
 Voltage source 2-3

L

Leakage resistance 4-30
 Light 4-37
 Limit
 Resistive 5-7
 Voltage 5-7

Limit sets 10-2
 LIMITS 2-26
 Limits 10-2, 11-11
 Example 10-4
 Pass pattern 10-4
 Setting 10-2
 Strobe control 10-4
 Line fuse replacement 2-6
 Line power connection 2-6
 Line voltage
 Input module 2-5
 LLO (local lockout) 11-7
 Loading effects 4-6
 LOCAL key 11-8
 Logarithm 9-8
 Logarithmic 9-8
 Logarithmic currents 5-15

M

Magnetic fields 4-37
 Manual addenda 1-5
 Match
 Percent 9-7
 Math 9-7
 Deviation 9-8
 Logarithmic 9-8
 Multiple display 9-10
 Percent deviation 9-8
 Polynomial 9-7
 Ratio 9-8
 Selecting and configuring 9-9
 Maximum and minimum 2-16
 Maximum readings 8-2
 Measure layer
 Configuring 7-9
 Measurement considerations 4-13, 4-35
 Auto discharge hop 4-35
 Cable leakage resistance 4-7
 Charge 4-34
 Current 4-31
 Electrification time 4-31
 Electrochemical effects 4-36
 Electromagnetic interference 4-38
 Electrostatic interference 4-37
 External voltage source 4-34
 Ground loops 4-35
 Guarding 4-7, 4-16
 Humidity 4-36
 Input bias current 4-13, 4-34
 Input capacitance 4-7
 Leakage resistance 4-30
 Loading effects 4-6
 Magnetic fields 4-37
 Measurement times 4-34
 Noise 4-14
 Piezoelectric effects 4-36
 Stored charge effects 4-36
 Test voltage 4-31
 Triboelectric effects 4-36
 Voltage burden 4-13
 Voltage coefficient 4-30
 Zero check hop 4-35
 Measurement range 5-17
 Measurement times 4-34

- Measurements
 - Current4-9
 - Voltage4-2
 - Median filter9-3
 - Menu2-18
 - GENERAL2-26
 - LIMITS2-26
 - SAVESETUP2-19
 - STATUS-MSG2-26
 - TEST2-26
 - Menus2-17
 - Navigation rules2-17
 - Types2-17
 - Message exchange protocol11-13
 - Messages
 - Error2-11
 - Information2-9
 - Range2-9
 - Status2-11
 - Multiple display4-30
 - Multiple displays2-15, 8-7
- N**
- Negative transition commands14-79
 - Noise4-14
 - Non-decade current gains5-16
 - Non-standard coulombs ranges5-15
- O**
- Ohms configuration4-27
 - Ohms measurement considerations4-30
 - Ohms ranges4-18
 - Operate5-8
 - Option slot2-5
 - Options1-3
 - Other measurement considerations4-35
 - Output subsystems14-38
 - Output triggers7-5
- P**
- Parameter types11-9
 - Pass pattern10-4
 - Percent9-7
 - Percent deviation9-8
 - Phone number1-2, 1-6
 - Piezoelectric and stored charge effects4-36
 - Piezoelectric effects4-36
 - Polynomial9-7
 - Positive transition commands14-73
 - Power switch2-2
 - Power-up2-2, 2-6
 - Error messages2-7
 - Sequence2-7
 - Preamp out5-11
 - Primary address2-8
 - Probes1-4
 - Program messages11-11
 - Programming syntax11-8, 11-17
- Q**
- Query commands11-10
 - Queues13-11
 - Error queue13-11
- R**
- Rack mount kits1-4
 - Range
 - Measurement5-17
 - Voltage source5-6
 - Range and resolution5-17
 - RANGe commands14-46
 - Ratio9-8
 - Readings
 - Recalling8-6
 - Storing8-6
 - Rear panel summary2-4
 - Relative (REL)5-19
 - Configuring5-19
 - Enabling5-20
 - Multiple display of5-20
 - Relative humidity measurement4-38
 - REN (remote enable)11-6
 - Repacking for shipment1-6
 - Resistance measurements4-18, 4-19
 - Configuration4-27
 - Considerations4-30
 - Ohms ranges4-18
 - Resistivity measurements4-18, 4-22
 - Procedure4-25
 - Surface4-22
 - Volume4-24
 - Resistor voltage coefficient test6-5
 - Resolution
 - Display5-17
 - Response messages11-13
 - RS-232 interface
 - Connections11-4
 - Menu11-5
 - RS-232 interface commands14-90
 - RS-232 Serial Interface14-110
 - RS-232 serial Interface11-17
 - RS-232 serial interface
 - Configuration11-17
 - Error messages11-19
 - Operating considerations11-18
 - RTCLock commands14-101
 - Running the selected test6-14
- S**
- Safety symbols and terms1-5
 - SAVESETUP2-19
 - Scan layer
 - Configuring7-11
 - Scanner cards1-4
 - Scanning10-9
 - External10-9
 - Internal10-9
 - SCPI Command Summary14-4
 - SCPI commands
 - Subsystems14-25
 - Summary14-4
 - SCPI Conformance InformationG-2
 - SDC (selective device clear)11-7
 - Selecting and configuring math9-9
 - Selecting interface parameters11-4
 - Semi-synchronous example7-19
 - Semi-synchronous operation7-18

- Serial poll 13-13
 - Service Request Enable Register 13-13
 - Setting voltage source value 5-6
 - Shield
 - Guard 3-8
 - Noise 3-7
 - Safety 3-8
 - Shielded fixture construction 5-13
 - Shielding 3-7
 - Signal oriented measurement commands 14-2
 - Software 1-5
 - Source
 - Capacitance 4-15
 - Resistance 4-14
 - Sourcing options 5-3
 - SPE, SPD (serial polling) 11-7
 - Specifications 5-20
 - SRE? — service request enable query .. 12-8
 - SRQ 13-13
 - Standard method resistivity tests 6-6
 - Status byte and service request (SRQ) 13-11
 - Status Byte Register 13-11
 - Status registers
 - Event registers 13-10
 - Conditions registers 13-9
 - Enable registers 13-10
 - Register sets 13-2
 - Transition filters 13-9
 - Status structure 13-2
 - STATUS-MSG 2-26
 - Stored charge effects 4-36
 - Storing and recalling readings 8-6
 - Strobe control 10-4
 - Surface insulation resistance test 6-8
 - Surface resistivity 4-22
 - Sweep tests (square wave and staircase) 6-9
- T**
- TCONfigure commands 14-99
 - Temperature (external) measurement 4-38
 - TEST 2-26
 - Test descriptions 6-2
 - Test fixture 1-4
 - Chassis 3-12
 - Custom built 3-11
 - Handling and cleaning 3-14
 - Model 8009 3-11
 - Test sequences 5-21, 6-2
 - Alternating polarity/resistivity 6-7
 - Cable insulation resistance 6-4
 - Capacitor leakage current 6-4
 - Configuration menu 6-11
 - Configuring 6-11
 - Descriptions 6-2
 - Diode leakage current 6-2
 - Resistor voltage coefficient 6-5
 - Running 6-12
 - Square wave and staircase sweep .. 6-9
 - Standard method resistivity 6-6
 - Surface insulation resistance 6-8
 - Test voltage 4-31
 - Time/day/date 2-15
 - Timestamp commands 14-87
- Transition filters 13-9
 - Triboelectric effects 4-36
 - Trigger
 - Advanced configuration 7-9
 - Basic configuration 7-8
 - Configuration 7-8
 - Configuration menu 7-2
 - Continuous initiation 7-13
 - External 7-14
 - halting 7-13
 - Mode 7-4
 - Models 7-4
 - Output 7-5
 - Trigger commands 14-90
 - Trigger Link 7-14
 - Asynchronous example 7-15
 - Asynchronous operation 7-14
 - Connector 7-14
 - Semi-synchronous example 7-19
 - Semi-synchronous operation 7-18
 - Trigger model 7-4
 - Advanced 7-5
 - Basic 7-4
 - Control sources 7-5
 - Idle 7-4
 - Layers 7-7, 11-14
 - Trigger Model (IEEE-488 operation) 11-14
 - Trigger subsystem 14-96
 - Triggering
 - IEEE-488 remote model 11-14
 - Triggers 6-14
- U**
- Unpacking 1-5
 - Using external feedback 5-12
- V**
- Voltage and current limit 5-7
 - Voltage burden 4-13
 - Voltage coefficient 4-30
 - Voltage limit 5-7
 - Voltage measurements 4-2, 5-2
 - Configuration 4-5
 - Considerations 4-6
 - Procedure 4-2
 - Voltage source 5-2
 - Adjusting value 5-6
 - Configuration 5-2
 - Displaying value 5-6
 - FVMI 5-3
 - Independent 5-3
 - Operate 5-8
 - Options 5-3
 - Selecting range 5-6
 - Setting value 5-6
 - Volts, Amps and Coulombs Ranges 14-46
 - Volume resistivity 4-24
 - V-Source
 - Auto 4-18
 - V-Source configuration commands 14-62
 - V-source probes and cables 3-6

W

- Warm-up period2-8
- Warranty information1-5

Z

- Zero check5-18
- Zero check and zero correct commands 14-88
- Zero check hop4-35
- Zero check, relative, and zero correct ...5-18
- Zero correct5-20
 - Effect on specifications5-20

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