Model 6517
Electrometer

User's Manual

Contains Operating and Programming Information

KEITHLEY

WARRANTY

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

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

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

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

LIMITATION OF WARRANTY

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

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Model 6517 Electrometer
User's Manual

Manual Print History

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

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Safety Precautions

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

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

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.**

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

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.

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 rear panel, or switching card.

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

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

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

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using #18 AWG or larger wire.

The ⚡ symbol on an instrument or accessory indicates that 1000V or more may be present on the terminals. Refer to the product manual for detailed operating information.

Instrumentation and accessories should not be connected to humans.

Maintenance should be performed by qualified service personnel. Before performing any maintenance, disconnect the line cord and all test cables.

Table of Contents

3   IEEE-488 Reference

A   **Specifications**

B   **Interface Functions Codes**

C   **ASCII Character Codes and IEEE-488 Multiline Interface Command Messages**

D   **IEEE-488 Bus Overview**

E   **IEEE-488 Conformance Information**

F   **SCPI Conformance Information**

G   **Device Dependent Command Summary**

List of Illustrations

2   Calibration

3   IEEE-488 Reference

x

List of Tables

1

General Information

1.1 Introduction

This section contains general information about the Model 6517 Electrometer/High Resistance System. It is arranged in the following manner:

1.2 Features

1.3 Warranty information

1.4 Manual addenda

1.5 Safety symbols and terms

1.6 Specifications

1.7 Inspection

1.8 Options and accessories

1.2 Features

Some important Model 6517 features include:

- Full range of functions — Exceptional sensitivity and accuracy for voltage, current, charge, and V/I resistance and resistivity (surface and volume) measurements. With the Models 6517-RH and 6517-TP, relative humidity and external temperature can be measured.

- Voltage source — The internal 1000V V-Source can be configured with the ammeter to make V/I resistance/resistivity measurements, and to force voltage, measure current.

- Two-line display — Readings and front panel messages are provided on the top line (primary) 20-character, and bottom line (secondary) 32-character alphanumeric display. The multiple display provides supplemental infor-

mation about the reading, such as min/max readings, bar graphs for the reading, and time and date.

- Reading and setup storage — Readings and setup data can be stored and recalled from memory. Over 15,000 readings can be stored in the buffer, and up to 10 instrument setups can be stored in memory.

- Test sequences — Built-in tests for the following applications: device characterization, resistivity, surface insulation resistance, and voltage sweeps.

- GPIB interface — Accommodates two separate languages for IEEE-488 operation. The SCPI language conforms to the IEEE-488.2 and SCPI standards. The 617 emulation mode (DDC language) allows the instrument to be controlled using device-dependent command programming.

- RS-232 interface — The instrument can instead be controlled over this serial interface using SCPI commands.

- Talk-only mode — From the front panel, you can set the instrument to send readings to a printer. Talk-only is available over both the GPIB and RS-232 interfaces.

- Scanning — The Model 6517 has an option slot that will accommodate an optional scanner card (Models 6521 and 6522). The instrument can also be configured to operate with an external switching system (i.e., Model 7001 or 7002) to scan external channels.

- Trigger link — This is a new trigger concept that provides more versatile and precise external triggering. It is in addition to the standard Trigger In/Meter Complete Out BNC external triggering techniques.

- Digital calibration — The instrument may be digitally calibrated from either the front panel, or over the RS-232 interface or GPIB bus (SCPI language).

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 6517 require warranty service, contact the Keithley 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.

1.4 Manual addenda

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

1.5 Safety symbols and terms

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

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

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

The ⏚ symbol indicates that the test fixture (i.e. Model 8009) must be connected to a safety earth ground using #18 AWG wire or larger.

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

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

1.6 Specifications

Full Model 6517 specifications may be found immediately preceding the table of contents in this manual.

1.7 Inspection

The Model 6517 was carefully inspected, both 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. (Note: 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 reshipment.

If an additional manual is required; order the appropriate manual package:

- Model 6517 User's Manual — Keithley P/N 6517-900-00
- Model 6517 Repair Manual — Keithley P/N 6517-902-00
- Model 6517 Getting Started Manual — Keithley P/N 6517-903-00
- Model 6517 Calibration Manual — Keithley P/N 6517-905-00

1.8 Options and accessories

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

Model 237-ALG-2 Triax Cable: This is a 2-meter (6.6 ft.) low noise triax cable terminated with a 3-slot male triax connector on one end and 3 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 6517 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 7078-TRX triax cables. Suitable for use with the Model 6517 V-Source in high voltage applications.

Model 237-TRX-NG Adapter: This is a 3-slot male triax to female BNC adapter (guard removed) for non-guarded measurements. This adapter allows you to connect a BNC cable to the triax input of the Model 6517. Suitable for use with the Model 6517 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 6517 V-Source in high voltage applications.

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

Model 4288-1 Single Fixed Rack Mount Kit: Mounts a single Model 6517 in a standard 19-inch rack.

Model 4288-2 Side-by-side Rack Mount Kit: Mounts two instruments (Models 182, 428, 486, 487, 2001, 2002, 6517, 7001) side-by-side in a standard 19-inch rack.

Model 4288-3 Side-by-side Rack Mount Kit: Mounts a Model 6517 and a Model 199 side-by-side in a standard 19-inch rack.

Model 4288-4 Side-by-side Rack Mount Kit: Mounts a Model 6517 and a 5¼-inch instrument (Models 195A, 196, 220, 224, 230, 263, 595, 614, 617, 705, 740, 775, etc.) side-by-side in a standard 19-inch rack.

Model 5156 Electrometer Calibration Standard Set: This calibration fixture contains standardized resistors and capacitors needed to calibrate the Model 6517.

Model 6517-ILC-3 Safety Interlock Cable: Designed to connect the lid interlock circuit of the Model 8009 test fixture to the interlock circuit of the Model 6517.

Model 6517-RH Humidity Probe with Cable: This sensor allows the Model 6517 to make relative humidity measurements (0 to 100%).

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

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 6517.

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 6517.

Models 7007-1 and 7007-2 Shielded IEEE-488 Cables: Connect the Model 6517 to the IEEE-488 bus using shielded cables and connectors to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter long; the Model 7007-2 is two meters long.

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. The -3 model is 3 ft. (0.9m) in length, the -10 model is 10 ft. (3m) in length, and the -20 model is 20 ft. (6m) in length.

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 6517 V-Source in high voltage applications.

Model 8002-ILC-3 Safety Interlock Cable: Designed to connect the lid interlock circuit of the Model 8002A test fixture to the interlock circuit of the Model 6517.

Model 8002A High Resistance Test Fixture: Used with the Model 6517 to make accurate high resistance measurements of DUT. Designed to minimize leakage currents that can corrupt the integrity of the measurement.

Model 8009 Resistivity Test Fixture: This is a guarded test fixture for measuring volume and surface resistivities. It can accommodate sheet samples 64 to 102mm (2-1/2 to 4 in.) in diameter and up to 3.175mm (1/8 in.) thick.

Models 8501-1 and 8501-2 Trigger Link Cables: Connect the Model 6517 to other instruments with Trigger Link connectors (e.g., Model 7001 Switch System). The Model 8501-1 is one meter long; the Model 8501-2 is two meters long.

Model 8502 Trigger Link Adapter: Allows you to connect the Trigger Link of the Model 6517 to instruments that use the standard BNC (In/Out) external triggering technique.

Model 8503: Extension cable for the Model 6517-RH relative humidity sensor.

Model 8530 IEEE-488 to Centronics Printer Adapter Cable: Translates the IEEE-488 connector pinout and signal level to a Centronics termination. This permits a standard Centronics parallel printer to be connected to a Model 6517 in TALK-ONLY mode.

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 High 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.

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.

2

Front Panel Operation

2.1   Introduction

This section contains detailed information for front panel operation of the Model 6517. It is organized as follows:

2.2   Power-up — Covers information on connecting the instrument to line power, warm-up period, default conditions, and the power-up sequence.

2.3   Display — Covers display formats, and messages associated with operation.

2.4   Connections — Electrometer input and voltage source output: Provides basic information on the connections used for typical electrometer and high-resistance meter measurements. Summarizes guarding and shielding techniques, and explains the potential hazards presented by floating circuits. Recommends cables and test fixtures that can be used, and provides guidelines for building a test fixture.

2.5   Voltage measurements — Provides the basic procedure to measure voltage. Includes configuration information and measurement considerations for the volts function.

2.6   Current measurements — Provides the basic procedure to measure current. Includes configuration information and measurement considerations for the amps function.

2.7   Resistance measurements — Provides the basic procedures to perform resistance and resistivity measurements. Includes configuration information, the multiple display and measurement considerations for the ohms function.

2.8   Charge measurements — Provides the basic procedure to measure charge. Includes configuration infor-

mation, multiple displays and measurement considerations for the coulombs function.

2.9   Voltage source — Covers V-source operation including how to use the safety interlock.

2.10   Analog outputs — Provides information needed to use the 2V analog output and the preamp output.

2.11   Using external feedback — Explains how to use external feedback to extend the capabilities of the Model 6517.

2.12   Range and resolution — Covers both manual and auto ranging and resolution.

2.13   Zero check and relative — Provides details on the zero check and relative (REL) features.

2.14   Test sequences — Covers the test sequences that can be configured and run.

2.15   Triggering — Details types of trigger modes as well as trigger sources that can be used.

2.16   Buffer — Covers use of the reading buffer including programming the buffer size, recalling data and time stamp.

2.17   Filter — Covers the use of the digital filter types that can be used to reduce reading noise.

2.18   Math — Describes the calculations that can be performed on readings.

2.19   Menu — Covers selections controlled from the main menu, such as saving instrument setups, communication configuration (GPIB and RS-232), and limits.

2.20   Scanning — Summarizes internal scanning using one of the optional scanner cards, and explains how to use the Model 6517 in an external scanning system.

2.21 Other measurement considerations — Covers the measurement considerations that generally apply to all measurements.

2.22 Relative humidity and external temperature readings — Explains how to include these readings with each volts, amps, ohms and coulombs measurement.

2.2 Power-up

2.2.1 Line power connections

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

1. First check to see that the line voltage selection switch (see Figure 2-1) on the rear panel is in the correct position for the operating voltage in your area. The 115V position is for line power in a voltage range from 90V to 125V. The 230V position is for line power in a voltage range from 180V to 250V. The instrument will operate at a line frequency of 50Hz, 60Hz or 400Hz.

CAUTION

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

SELECTED LINE VOLTAGE

| 90-110V | 180-220V |
| 105-125V | 210-250V |
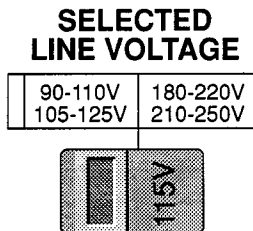
Figure 2-1
Line voltage switch

2. Before plugging in the power cord, make sure the front panel power switch is in the off (0) position.
3. 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 6517 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.

2.2.2 Line fuse replacement

A rear panel fuse located below the AC receptacle protects the power line input of the instrument. If the fuse needs to be replaced, perform the following steps:

WARNING

Make sure the instrument is disconnected from the line and other equipment before replacing the line fuse.

1. With the power off, place the end of a flat-blade screwdriver into the rear panel LINE FUSE holder. Push in gently and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse carrier out of the holder.
2. Remove the fuse and replace it with the type recommended in Table 2-1.

CAUTION

Do not use a fuse with a higher current rating than specified, or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse. See the optional Model 6517 Repair Manual for troubleshooting information.

Install the new fuse and fuse carrier into the holder by reversing the above procedure.

Table 2-1
Line fuse selection

Line voltage	Fuse type	Keithley part no.
90-125V	1/2A, 250V, Slo Blo	FU-71
180-250V	1/4A, 250V, Slo Blo	FU-96-4

2.2.3 Power-up sequence

On power-up, the Model 6517 performs self-tests on its EPROM and RAM, and checksum tests on data stored in non-volatile memory. (See Table 2-2.) If a failure is detected, the instrument momentarily displays an error message and the ERR annunciator turns on. (Messages are listed in Table 2-3.)

NOTE

If a problem develops while the instrument is under warranty, return it to Keithley Instruments, Inc. 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 6517
Rev. B01 B01 IEEE Addr=27 SCPI

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. DDC will be displayed if the DDC language is selected instead. If the RS-232 interface is selected, the message "RS-232 enabled" is displayed instead of the IEEE-488 address.

Next, if the unit is configured to display the calibration due date at power-up, the unit shows the following:

Model 6517
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. (See the Model 6517 Calibration Manual to set the calibration due date and paragraph 2.19.3 of this manual to set the display option.)

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 power-up are summarized in Table 2-3. These are shown when one of the checksum tests of Table 2-2 fails.

Table 2-2
Data checked on power-up

Data	Type of storage
IEEE-488 address	Electrically-erasable PROM
Power-on 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 2-3
Power-up error messages

Message	Action
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.
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 +512, Power-on state lost	Power-on defaults are reset to factory defaults (bench) and stored into EEPROM.
Error +511, GPIB address lost	GPIB address is reset to factory default (27) and stored into 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 -314, Save/recall memory lost	Instrument setup is reset to bench defaults are stored in EEPROM.

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

2.2.4 Power-on default conditions

Power-on default conditions are those conditions the instrument assumes when it is first turned on. You can change these power-on default conditions (except the primary address) by using the save setup feature that is available with the MENU key, as described in paragraph 2.19.2.

Depending on the installed memory option, either one, five, or ten user-defined setups can be stored, any one of which could be selected as the power-on default.

Table 2-29 in paragraph 2.19.2 lists the default conditions that are set at the factory to optimize bench and GPIB (IEEE-488) operation.

2.2.5 Warm-up period

The Model 6517 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.

2.2.6 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. Refer to paragraph 2.19.3 for step-by-step instructions on setting the primary address.

2.3 Display

The display of the Model 6517 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.

2.3.1 Exponent mode (Engineering or Scientific)

Readings on the display can be expressed in engineering units or in scientific notation as shown in Table 2-4. 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 (see paragraph 2.19.8 for details).

Table 2-4
Typical display exponent values

Engineering units		Scientific notation	
Value	Display	Value	Display
Picoamperes	pA	10^{-12}A	e-12A
Nanocoulombs	nC	10^{-9}C	e-9C
Microamperes	μA	10^{-6}A	e-6A
Milliamps	mA	10^{-3}A	e-3A
Kilo-ohms	kΩ	$10^{3}\Omega$	e3Ω
Mega-ohms	MΩ	$10^{6}\Omega$	e6Ω
Giga-ohms	GΩ	$10^{9}\Omega$	e9Ω
Tera-ohms	TΩ	$10^{12}\Omega$	e12Ω
Peta-ohms	PΩ	$10^{15}\Omega$	e15Ω

2.3.2 Information messages

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

2.3.3 Status and error messages

During Model 6517 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 2-5.

The most recent status or error messages can be momentarily displayed. Just enter a configuration menu or the main menu, and press the PREV range key. (The display is blank if no message is queued.)

Table 2-5
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
-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 rtl"	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

Table 2-5 (cont.)
Status and error messages

Number	Description	Event
-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
+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

Table 2-5 (cont.)
Status and error messages

Number	Description	Event
+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 (see Model 6517 Calibration Manual)	
+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"	EE
+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

Table 2-5 (cont.)
Status and error messages

Number	Description	Event
+700	"Low Battery detected"	EE
+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
+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

2.3.4 Multiple displays

Each measurement function has its own set of "multiple displays" shown in the bottom line of the front panel display. The PREVious 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 PREVious DISPLAY key does a reverse scroll through the displays. To return to the default reading display, just press and hold either key.

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 2-6 for paragraph references). 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). See paragraph 2.19.7 (CLOCK) for details.

Table 2-6
Multiple (Next) displays by function

Function	Next display	Paragraph reference
All	Time, day and date	2.3.4
	Bar graph	2.3.4
	Zero-centered bar graph	2.3.4
	Maximum and minimum values	2.3.4
	Relative and actual values	2.13.3
	Calculated and actual values	2.18.7
	Limits bar graph	2.19.5
	Relative humidity and external temperature stamp	2.3.4
R	Source (V) and measure (I) values	2.7.4

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 2-2.) 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 present range.
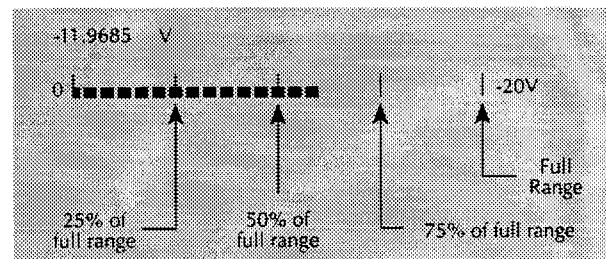
Figure 2-2
Bar graph (zero-at-left) multiple display

Zero-centered bar graph

The zero-centered bar graph is a graphical representation of a reading with plus and minus limits. (See Figure 2-3.) The limits are expressed in a user-selectable percentage of range.

The vertical lines displayed along the bar designate the plus and minus 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.
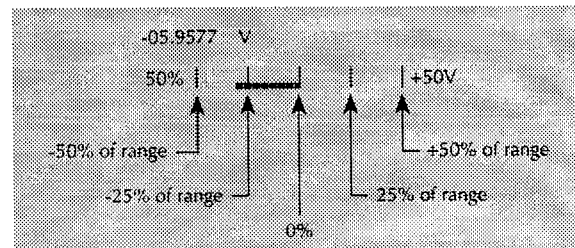
Figure 2-3
Zero-centered bar graph multiple display

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. The following is displayed:

   ZERO-BARGRAPH+/-50.00%

2. Change the percentage by using the cursor keys and the RANGE ▲ and ▼ keys 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 2-4.) 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.
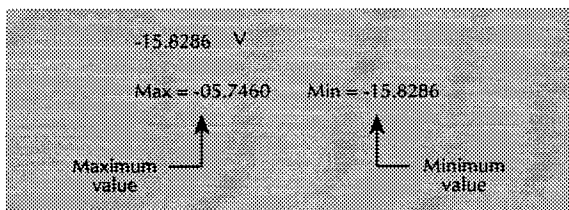
Figure 2-4
Maximum and minimum multiple display

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. (See paragraph 2.22 for details.)

Change from cal temp

The Model 6517 has an internal temperature sensor. When the instrument is calibrated, the internal temperature is measured and stored in memory. This display indicates the difference between the present internal temperature and the internal temperature when the instrument was last calibrated. Note that the temperature units (°C, °F or K) is selected from the DISPLAY (TEMP-UNITS) item on the GENERAL MENU (see paragraph 2.19.7).

2.3.5 Navigating menus

There are basically 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.

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, etc.) 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 2-7.
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 ▼ or ▲ displays the CONFIGURE V-SOURCE menu.

Table 2-7
EXIT key actions

Condition	EXIT key action
Temporary message displayed (e.g., 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.

2.4 Connections — electrometer, high-resistance meter and V-source

The following information provides basic information on electrometer, high-resistance meter, and V-source connections. Also covered is the use of low-noise cables and shielding. The concepts of guarding and floating circuits are introduced here.

NOTE

Detailed connection schemes are included with the measurement procedures (see paragraphs 2.5.1, 2.6.1, 2.7.1 and 2.8.1).

2.4.1 Electrometer input connector

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

Input configurations — As shown in Figure 2-5, the input connector can be configured in two ways. With GUARD off (Figure 2-5A), input low is connected to the inner shell of the connector. This configuration is used for current, resistance, coulombs and unguarded voltage measurements.

With GUARD on (Figure 2-5B), guard is connected to the inner shell of the triax connector. Input low is accessed via the COMMON binding post through an internal 10Ω resistor. 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 as explained in paragraph 2.5.2.

The INPUT triax connector is also used for the Force Voltage Measure Current configuration. This configuration utilizes the V-source to make resistance measurements (see paragraph 2.4.2) and current measurements (see paragraph 2.4.3).
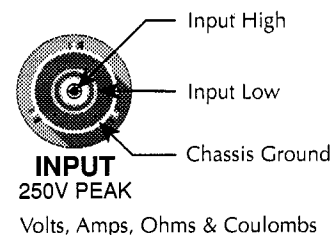
A. Unguarded (GUARD off)
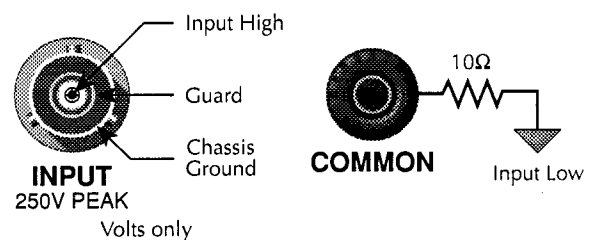
B. Guarded (GUARD on)

Figure 2-5
Input connector configurations

Maximum input levels — The maximum input levels to the Model 6517 are summarized in Figure 2-6.

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.

Input High

Max Input Signal *

Input Low   500V Peak

500V Peak

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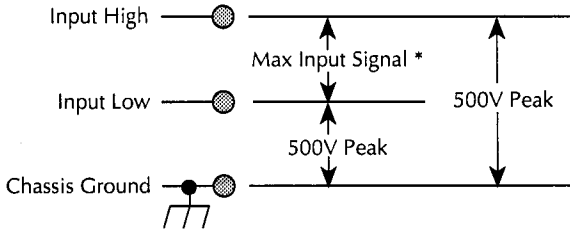
* Max Input Signal - 250VRMS, DC to 60Hz sine wave (10 seconds maximum in mA ranges).

Figure 2-6
Maximum input levels

Input protection — The Model 6517 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 2-7. 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 6517.

S   Capacitor Under Test

V

A   6517 Ammeter
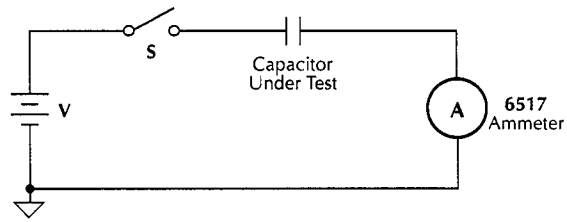
Figure 2-7
Capacitor test circuit without protection

Adding a resistor and two diodes (1N3595) as shown in Figure 2-8 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, destroying the electrometer input.

Protection Circuit

S   Capacitor Under Test   R   HI

V   D1   D2   A   6517 Ammeter

LO
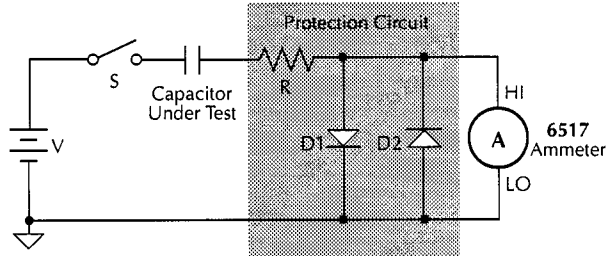
Figure 2-8
Capacitor test circuit with protection

2.4.2 High-resistance meter connections

The Model 6517 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 2-9A. This configuration assumes that V-Source LO is internally connected to ammeter LO via the METER-CONNECT option of the CONFIGURE V-SOURCE menu structure (see paragraph 2.9.1). The equivalent circuit for this configuration is shown in Figure 2-9B.

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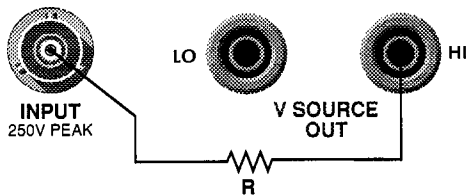
Note: V-SOURCE LO connected to ammeter input LO via METER-CONNECT option of CONFIGURE V-SOURCE Menu.

A. Basic connections
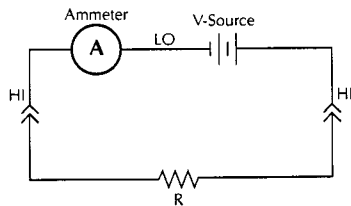
B. Equivalent circuit

Figure 2-9
Force voltage measure current

2.4.3 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 2-10A. Using these terminals simply places the independent V-Source in series with the external circuit (RL) as shown in Figure 2-10B.

The V-Source can also be used be with the Electrometer to form the Force Voltage Measure Current (FVMI) configuration as shown in Figure 2-9. This configuration is used for resistance measurements (see paragraph 2.4.2) and current measurements. For these measurements, V-Source LO and ammeter input LO can be connected internally via the METER-CONNECT option of the CONFIGURE V-SOURCE menu (see paragraph 2.9.1).

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.
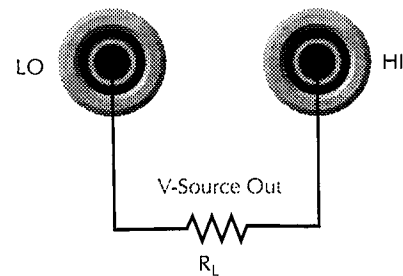
A. Basic connections
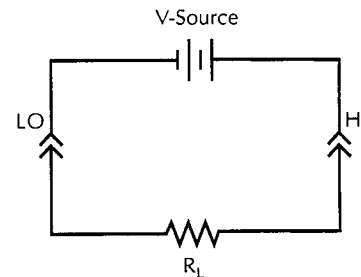
B. Equivalent Circuit

Figure 2-10
V-source output

V-source probes and cables

The following probe and cable sets are available from Keithley 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 Perofrmance Banana Cables:** Consists of two high voltage (1000V) banana cables. The cables are terminated with banana plugs that have retractable sheaths.

2.4.4 Low noise cables, shielding and guarding

When making precision measurements, you should always use low noise cables and, when feasible, 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. See paragraph 2.21.2 for more information on minimizing triboelectric currents.

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

- **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 on either 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.

Notes:

1. 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/or use guarding.

2. 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/or enable damping (see paragraphs 2.6.2 and 2.7.2). 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 device or circuit under test and extends to the electrometer input via a triax cable. The generic connection for the noise shield is shown in Figure 2-11 which also summarizes the measurements that may benefit from it.
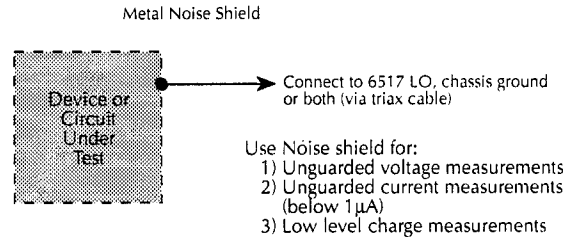
Figure 2-11
Noise shield

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 6517 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 chas-

sis 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. The
generic connection for the guard shield is shown in Figure 2-
12, which also summarizes the measurements that guard is
used for. Notice that a safety shield is also used since guard-
ed measurements can place hazardous voltages on the guard
shield (see Safety Shield).
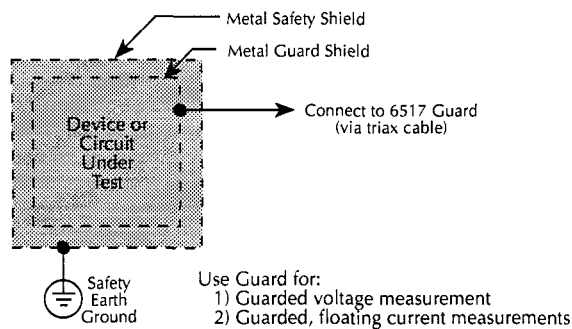
Figure 2-12
Guard shield

For voltage measurements, guarding should be used when
the test circuit impedance is ≥1GΩ or when long input cables
are used. Guard is enabled from the Configure Voltage menu
structure (see paragraph 2.5.2). When enabled, the guard po-
tential is placed on the inner shield of the triax input cable.
Figure 2-21 in paragraph 2.5.1 shows detailed connections
for guarded voltage measurements. See paragraph 2.5.3
(Guarding) for more information on guard.

For current measurements, guarding should be used when
the test circuit impedance ≥1GΩ. Significant leakage could
occur across a DUT through insulators and corrupt the mea-
surement. Input LO (inner shield of the input triax cable) is
used as the guard. Paragraph 2.6.3 (Guarding) explains how
guarding affects high impedance current measurements and
is shown in Figure 2-30.

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. This unique guard technique for float-
ing current measurements is explained in paragraph 2.6.3
(Guarding) and is shown in Figure 2-31.

Safety shield — A safety shield is required whenever a haz-
ardous voltage is present on the noise shield or guard shield,
or when a test circuit is floated above earth ground at a haz-
ardous voltage level (see paragraph 2.4.5). 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.

The generic connections for the safety shield are shown in
Figure 2-13. The metal safety shield must completely sur-
round the noise or guard shield, and must be connected to
safety earth ground using #18 AWG or larger wire.
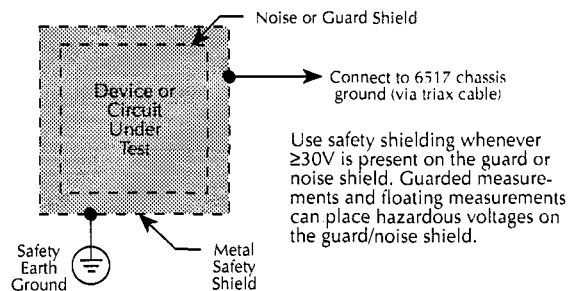
Figure 2-13
Safety shield

2.4.5 Floating circuits

Many measurements are performed above earth ground and,
in some test situations, can result in safety concerns. Figure
2-14 shows two examples where the Model 6517 floats at a
hazardous voltage level. In Figure 2-14A, 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 2-14B, 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.
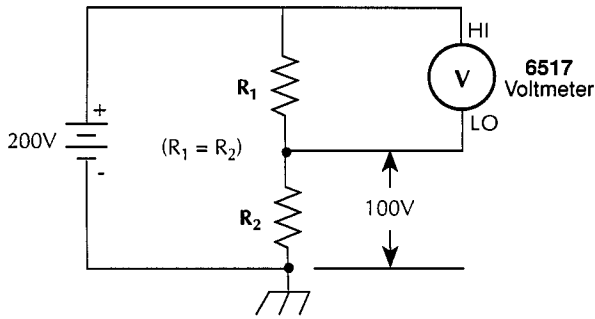
A. Voltage measurement
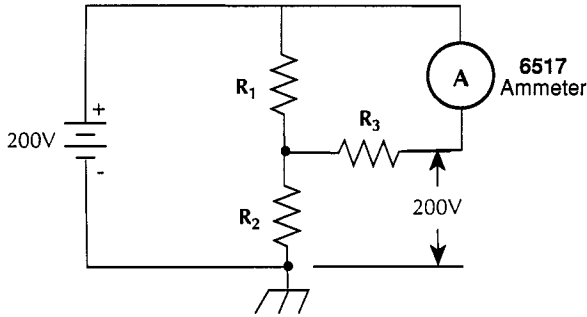
B. Current measurement

Figure 2-14
Floating measurements

The V-Source of the Model 6517 can also be operated above earth ground as shown in Figure 2-15. In this circuit, the V-Source is floating 100V above ground. Thus, 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 as explained in paragraph 2.4.4 (Safety Shield).

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.

WARNING

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 2-15
Floating V-source

2.4.6 Test fixtures

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

Keithley test fixtures

Keithley offers a variety of different test fixtures. The ones that are typically used with the Model 6517 are described as follows.

Model 8002A High Resistance Test Fixture — This test fixtures allows resistance measurements as high as $10^{15}\Omega$. Features include:

- A 3-lug triax connector and dual binding posts make connections to the Model 6517 simple.
- Two in-line DUT connection posts that are mounted on a guard plate.
- Light-free environment for light sensitive DUT.
- Safety Interlock. When connected to the Model 6517, voltage cannot be sourced to the test fixture when the lid is open.
- Screw terminal on test fixture chassis for connection to safety earth ground.

Note: Figure 2-33 in paragraph 2.7.1 shows connections to the Model 6517 and the equivalent circuit.

Model 8009 Resistivity Test Fixture — This test fixture allows volume resistivity in the range from 10^3 to $10^{18}\Omega$-cm, and surface resistivity in the range from 10^3 to $10^{17}\Omega$/sq. Features include:

- A 3-lug triax connector and dual binding posts make connections to the Model 6517 simple.
- Guarded electrodes that can accommodate samples up the ⅛" thick and 4" × 4".
- Safety Interlock. When connected to the Model 6517, 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.

Note: Figure 2-37 in paragraph 2.7.1 shows connections to the Model 6517 and the equivalent circuit.

Custom built test fixtures

Two examples of custom built test fixtures are shown in Figures 2-16 and 2-17. 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 6517 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 2-16 assumes that ammeter input LO is connected to V-Source LO inside the Model 6517. This LO-to-LO connection is controlled from the METER CONNECT selection in the CONFIGURE V-SOURCE menu (see paragraph 2.9.1).

The following requirements, recommendations and guidelines are provided in order to build a quality test fixture that is safe to use.

NOTE

After building a test fixture you should clean it (see Handling and Cleaning Test Fixtures).

Test fixture chassis

1. 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 6517 via the triax cable.
2. 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).

3. 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 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

Figures 2-16 and 2-17 show the types of connectors needed to use the test fixtures with the Model 6517. 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. Thus, DO NOT insulate the outer shell of the triax connector from the metal chassis of the test fixture.

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.

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. See paragraph 2.9.4 for more information on the interlock feature of the Model 6517.

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.

By using an appropriate bulkhead connector on the test fixture, the Keithley Model 6517-ILC-3 Interlock cable can be used to connect the interlock switch to the Model 6517 (see Figure 2-18A). The connector needed is shown in Figure 2-18C. Figure 2-18B shows the dimensions of the hole that must be cut into the test fixture chassis to mount the connector. Figure 2-18D shows how to wire the connector to the test fixture interlock switch.

As an alternative, you can remove one of the plugs from the Model 6517-ILC-3 and hard wire the interlock cable directly to the interlock switch of the test fixture as shown in Figure 2-19.
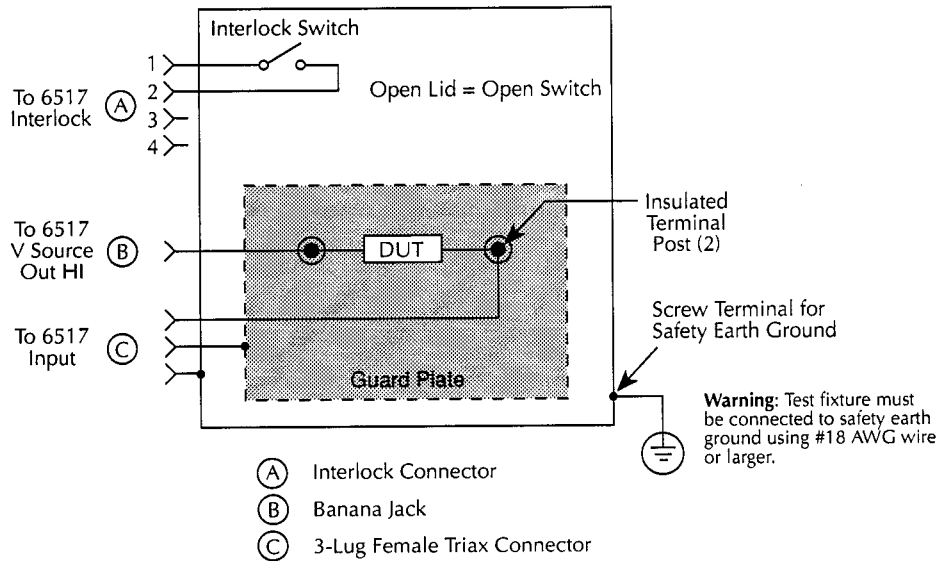
Figure 2-16
Test fixture to source voltage, measure current (resistance measurements)
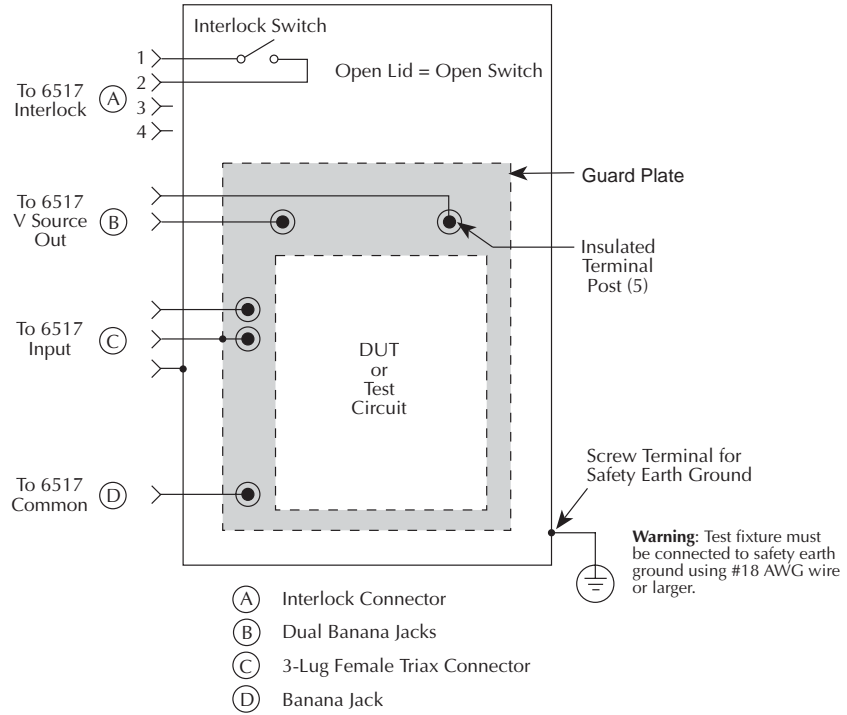
Figure 2-17
Multi-purpose test fixture

* Note: To operate the Model 6517, pin 3 must be connected to pin 1. Pins 1 and 3 are jumpered together in the 6517 ILC-3 cable.
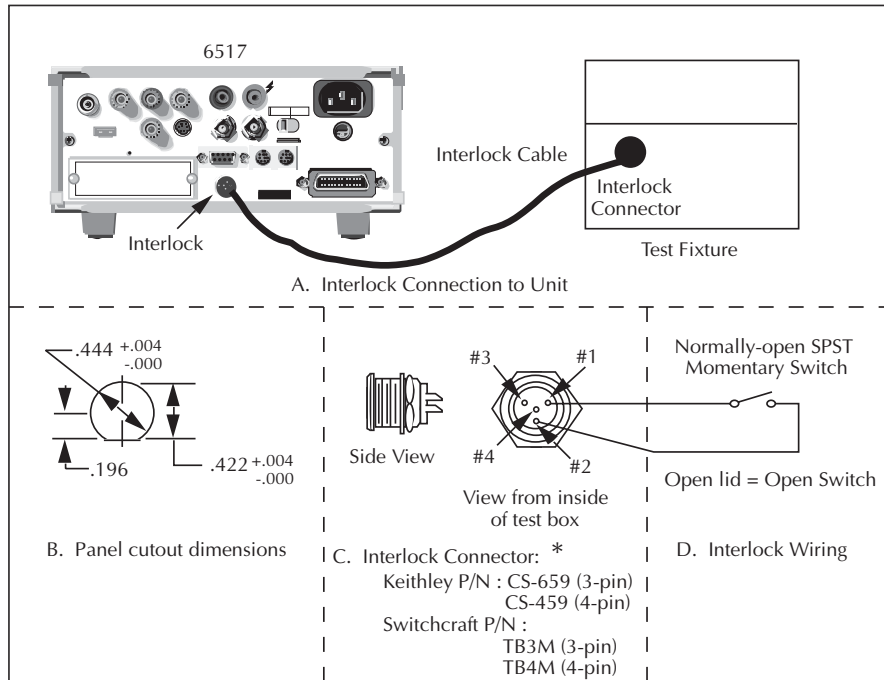
Figure 2-18
Interlock connections
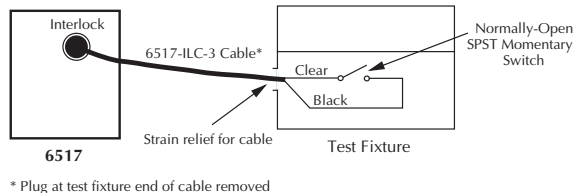
Figure 2-19
Hard-wired interlock

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 avoid handling them 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. Clean the areas as explained in the next tip.

- 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.

2.5   Voltage measurements

The Model 6517 can make unguarded or guarded voltage measurements from 1μV to 210V. Guard should be used if

response time or leakage resistance is a consideration. The concepts of guarding are discussed in paragraphs 2.4.4 and 2.5.3.

2.5.1   Basic measurement procedure

The voltage measurement procedure is summarized as follows:

> **NOTE**
>
> 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**
>
> The input circuit configuration changes with zero check enabled. See paragraph 2.13 for details.

2. Enable or disable guard as needed. Guard is controlled from the GUARD option of the Voltage Configuration menu (see paragraph 2.5.2).

> **NOTE**
>
> 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.

> **NOTE**
>
> 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 (see paragraph 2.12 for detailed range information).

5. Connect the Model 6517 to the voltage to be measured. Figure 2-20 shows typical connections for unguarded measurements, and Figure 2-21 shows typical connections for guarded measurements.

WARNING

Hazardous voltage may be present on the inner shield of the triax cable when GUARD is on. A safety shield connect-ed to safety earth ground (as shown in Figure 2-21) should be used for voltage measurements at or above 30V.

6. Press Z-CHK to disable zero check and take a reading from the display.

NOTE

To disable zero correct, enable zero check and press REL.
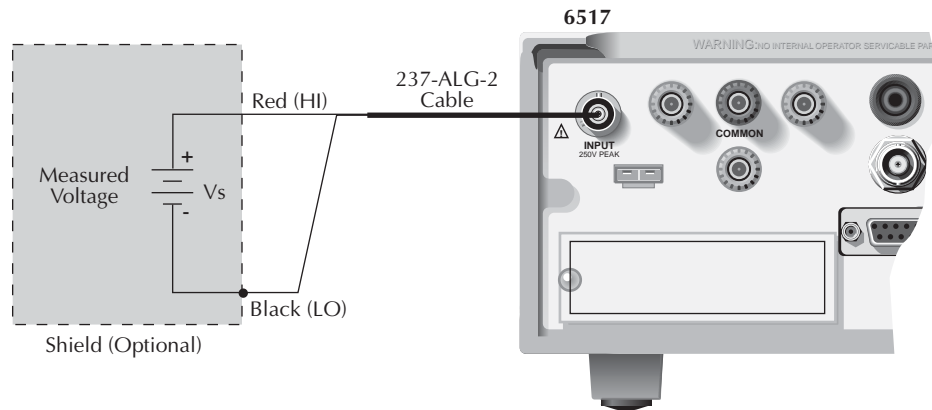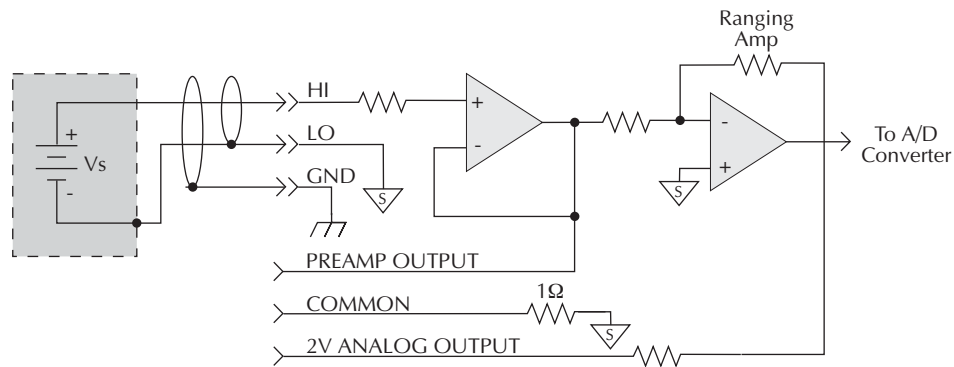
A. Connections

B. Equivalent circuit

Figure 2-20
Typical connections for unguarded voltage measurements
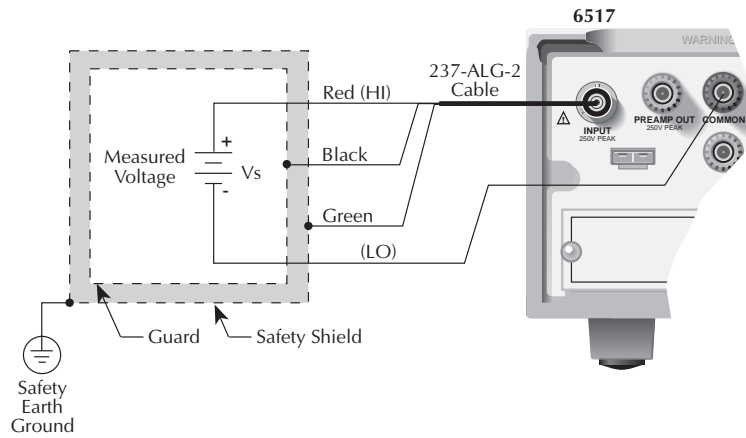
A. Connections
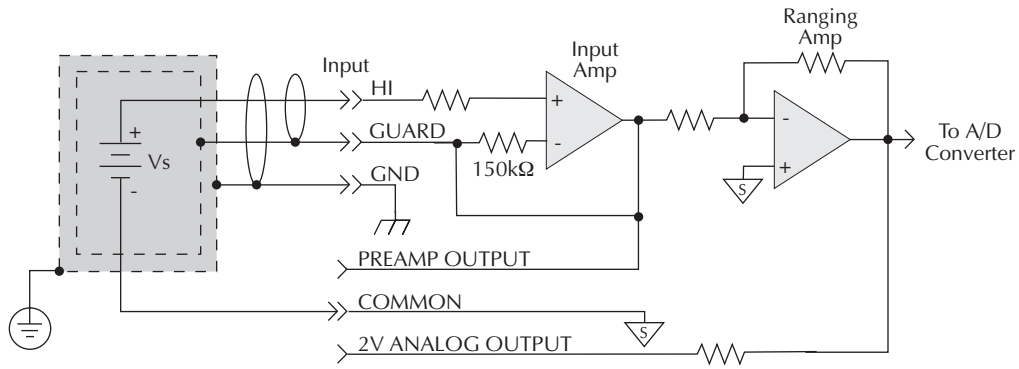
B. Equivalent circuit

Figure 2-21
Typical connections for guarded voltage measurements

2.5.2 Volts configuration

The following information explains the various configuration options for the volts function. The configuration menu is summarized in Table 2-8. This menu is accessed by pressing CONFIG and then V. Paragraph 2.3.5 summarizes the rules for navigating through the menu structure.

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.

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. Guarding is explained in paragraphs 2.4.4 and 2.5.4.

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

Table 2-8
CONFIGURE VOLTS menu structure

Menu item	Description
GUARD	Enable or disable guard.
EXT-FDBK	Enable or disable external feedback mode.
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.
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).
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d	Select a specific resolution.

EXT-FDBK

This option is used to enable or disable the external feedback mode. External feedback is explained in paragraph 2.11. 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 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 20msec.

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 HI-ACCURACY 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 ▲ and ▼ keys, 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. See Table 2-18 for the default integration times for the volts, ohms, amps and coulombs functions.

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 (i.e. press CONFIG V) or by pressing CONFIG FILTER with the desired function already selected. All of the parameters (menu items) for FILTER are explained in paragraph 2.17.

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. See Table 2-19 for the default resolutions of the volts, amps, ohms and coulombs functions.

2.5.3 Voltage measurement considerations

Some considerations for making accurate voltage measurements are summarized in the following paragraphs. Additional measurement considerations are summarized in paragraph 2.21. For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley.

LOADING EFFECTS

Circuit loading can be detrimental to high-impedance voltage measurements. To see how meter loading can affect accuracy, refer to Figure 2-22. 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 6517 is $>2 \times 10E^{14}\Omega$. Thus, to keep the error under 0.1%, the source resistance of the measured voltage must be $<2 \times 10E^{11}\Omega$.

$$\% \text{ Error} = \frac{100R_S}{R_S + R_{IN}}$$
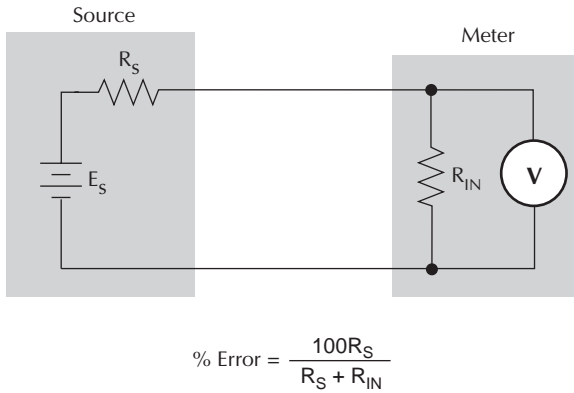
Figure 2-22
Meter loading

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 for more information. 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 100GΩ, 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.

Basically, 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).

GUARDING

Guarding should be used for high-impedance voltage measurements and for voltage measurements that use long input cables. The basic procedure to make guarded voltage measurements is provided in paragraph 2.5.1.

To understand the concept of guarding, let us first review the unguarded circuit shown in Figure 2-23. 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 6517 (see CABLE LEAKAGE RESISTANCE). 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).

Equivalent Circuit
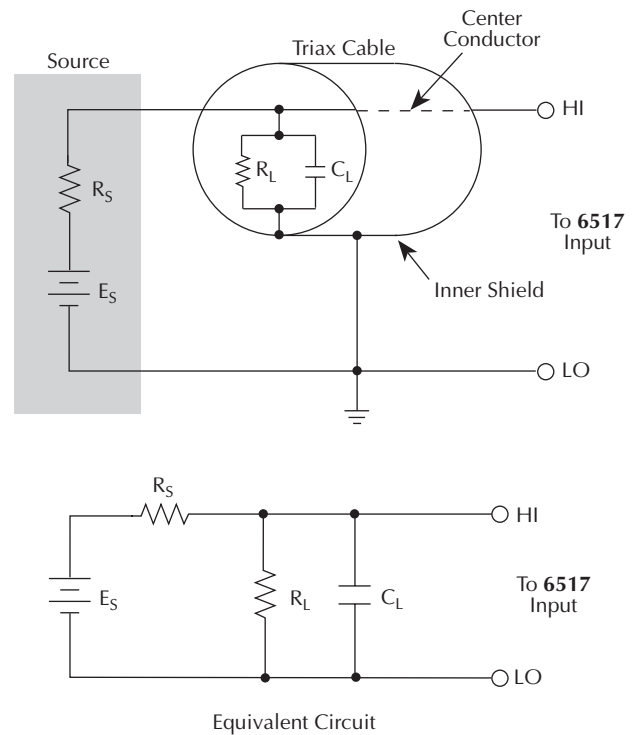
Figure 2-23
Unguarded voltage measurements

Guarding the circuit minimizes these effects by driving the inner shield of the triax cable at signal potential, as shown in Figure 2-24. 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 2-24 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.
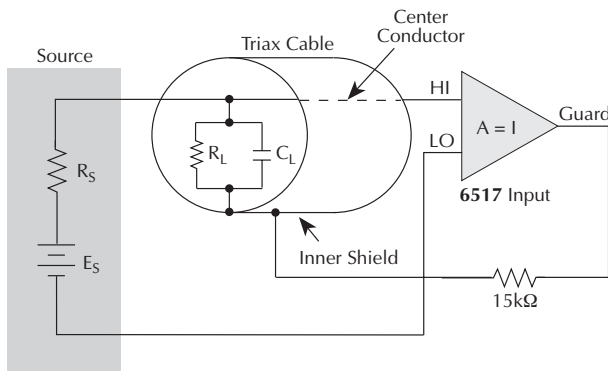
Figure 2-24
Guarded voltage measurements

2.6   Current measurements

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

2.6.1   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 procedures in paragraph 2.19.3 (OFFSET-ADJ).

> **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:

> **NOTE**
>
> 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**
>
> The input circuit configuration changes with zero check enabled. See paragraph 2.13 for details.

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 (see paragraph 2.12 for detailed range information).

4. Connect the Model 6517 to the current to be measured. Figure 2-25 shows typical connections for current measurements.

> **NOTE**
>
> If measuring current in a floating circuit where significant leakage may exist between the ammeter input and circuit low, connect the Model 6517 to the circuit as shown in Figure 2-26. Notice that ammeter input LO is connected to circuit high. Paragraph 2.6.3 (Guarding; Floating Current Measurements) explains how this guarding technique affects the measurement. Also note that a safety shield should be used if the input of the ammeter is floating at a hazardous voltage level ($V_F \leq 30V$).

5. Press Z-CHK to disable zero check and take a reading from the display.

> **NOTE**
>
> To disable zero correct, enable zero check and press REL.
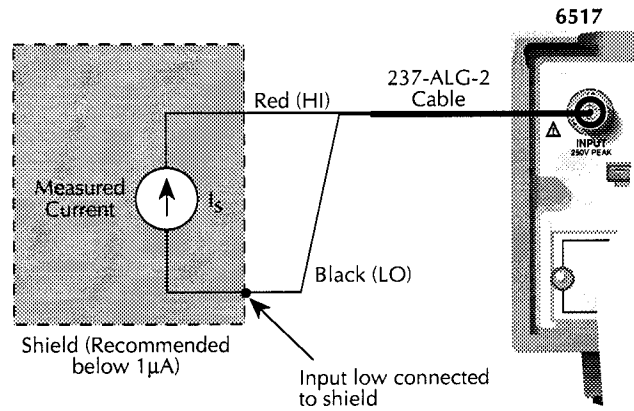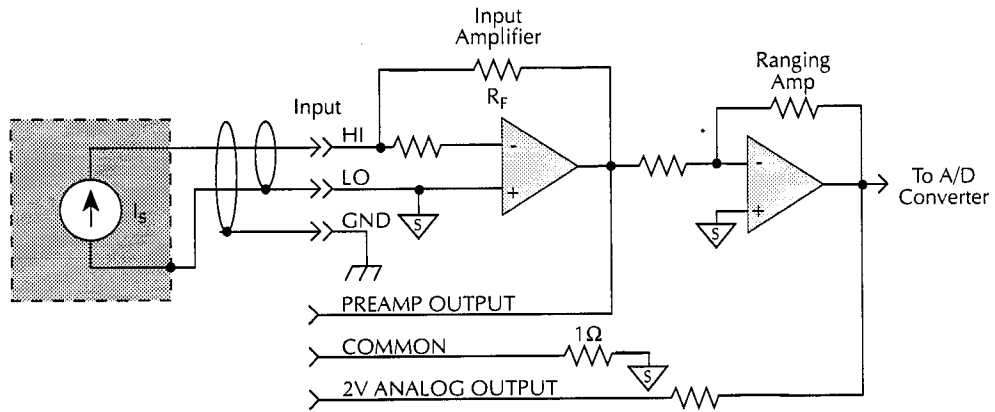
A. Connections

B. Equivalent circuit

Figure 2-25
Typical connections for current measurements
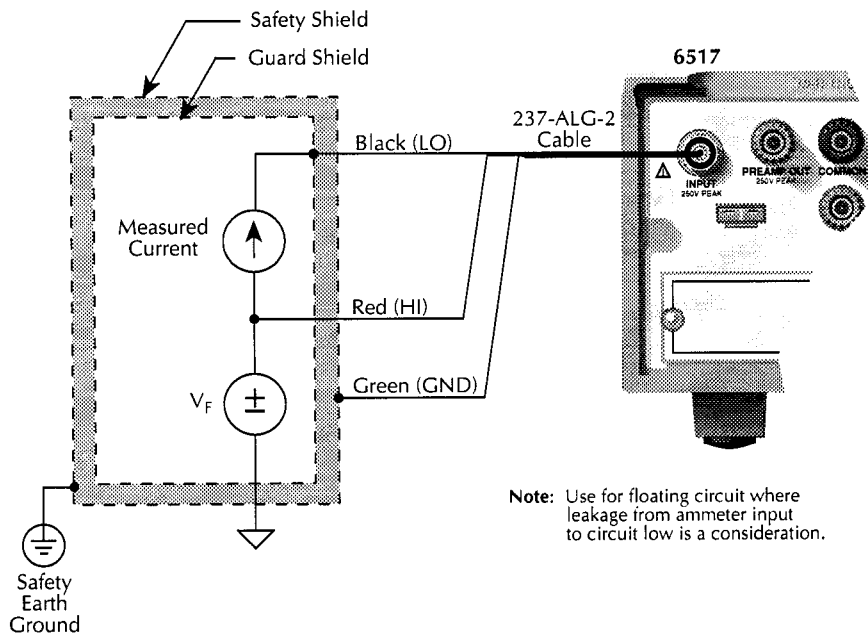
Figure 2-26
Connections for guarded, floating current measurements

2.6.2 Amps configuration

The following information explains the various configuration options for the amps function. The configuration menu is summarized in Table 2-9. This menu is accessed by pressing CONFIG and then I. Paragraph 2.3.5 summarizes the rules for navigating through the menu structure.

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.

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). It is discussed in paragraph 2.5.2.

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 (i.e. press CONFIG V) or by pressing CONFIG FILTER with the desired function already selected. All of the parameters (menu items) for FILTER are explained in paragraph 2.17.

RESOLUTION

The RESOLUTION parameter sets the display resolution. It is discussed in paragraph 2.5.2 and 2.12.

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/or lower measurement ranges. For example, if you know that readings will not exceed $1\mu A$, you can specify the $2\mu A$ range to be the maximum range. When the instrument autoranges (assuming AUTO RANGE is enabled), it will not search into the current ranges above $2\mu A$.

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 that you want the instrument to autorange to.
- MAX-AUTO — Use to select the highest range that you want the instrument to autorange to.

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.

Don't 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

Table 2-9
CONFIGURE AMPS menu structure

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.
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 rank (1-5).
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d	Select a specific resolution.
AUTO-RANGE	Autorange menu:
USE-ALL-RANGES	Use all ranges when autoranging.
SET-LIMITS	Limit the ranges used in the autorange search:
MIN-AUTO	Specify the minimum range in the search.
MAX-AUTO	Specify the maximum range in the search.
DAMPING	Enable or disable damping.

2.6.3 Current measurement considerations

Some considerations for making accurate current measurements are summarized in the following paragraphs. Additional measurement considerations are summarized in paragraph 2.21. For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley.

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 6517 is listed in the specifications. Input bias current may be reduced by performing the offset adjustment procedure explained in paragraph 2.19.3 (OFFSET-ADJ).

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 2-27 to see how voltage burden affects current measurements. Assume V_S is 5mV and R_S is 5kΩ to configure a 1μA current source (5mV/5kΩ = 1μA). An ideal ammeter with zero voltage burden would measure the current source as follows:

$$I_M = \frac{E_S}{R_S} = \frac{5mV}{5k\Omega} = 1mA$$

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

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

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:

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

The voltage burden of the Model 6517 depends on the selected range (see specifications). Voltage burden may be reduced by performing the offset adjustment procedure explained in paragraph 2.19.3 (OFFSET-ADJ).

$$I_M = \frac{V_S - V_B}{R_S}$$
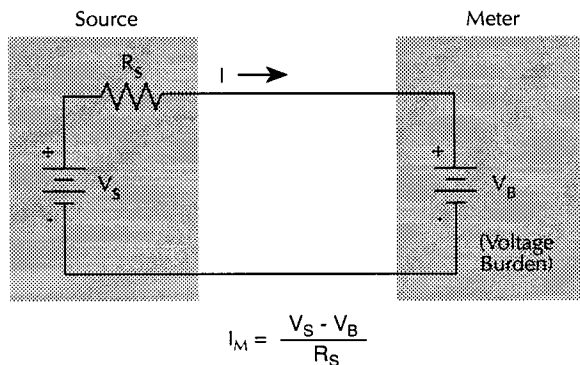
Figure 2-27
Voltage burden considerations

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, as we will now discuss.

Figure 2-28 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:

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

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 2-10 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 2-10
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 6517 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 2-28. 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:

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

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 6517 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 2-10 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.

Current Source   Model 6517 Ammeter
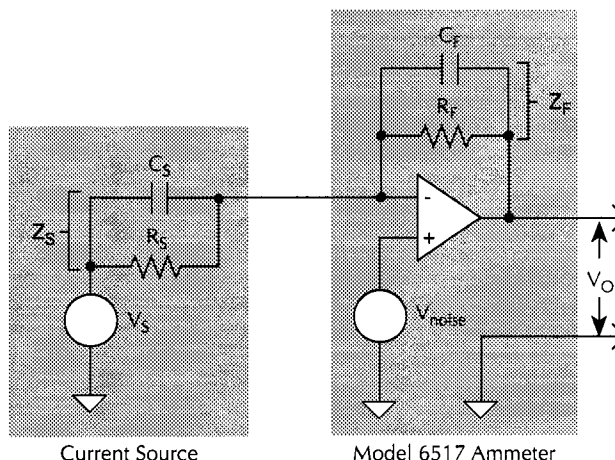
Figure 2-28
Source resistance and capacitance

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 ($\leq 1G\Omega$) DUT through the insulators as shown in Figure 2-29A 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 2-29B, 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.

A. Unguarded

*R = ≥1GΩ
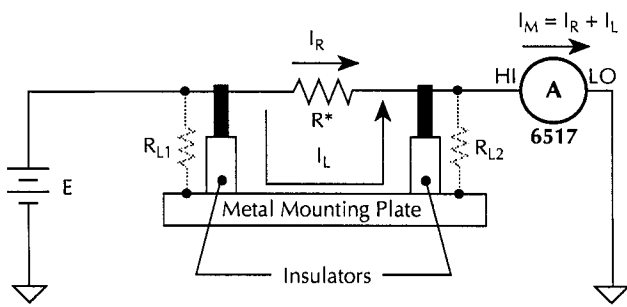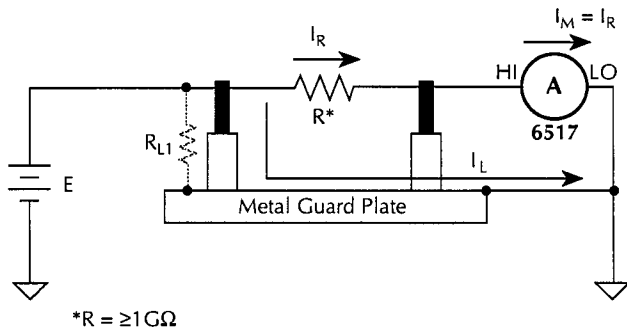
B. Guarded

Figure 2-29
High impedance current measurements

Floating current measurements — As discussed in paragraph 2.5.4 for voltage measurements, 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 (via the input triax cable), and it is at nearly the same potential as input high. In reality, the ammeter drops <1mV and is known as the voltage burden.

Figure 2-30A 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 <1mV, approximately 10V is dropped by R_L. The current through R_L will be approximately 10nA (10V/1GΩ = 10nA). Thus, the current that is measured by the Model 6517 is the sum of the two currents ($I = I_R + 10nA$). Obviously, if I_R is a low level current, then the 10nA leakage current will corrupt the measurement.

Figure 2-30B 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 <1mV. It then follows that there is a <1mV drop across R_L. Thus, the current through R_L is <1pA (<1mV/1GΩ = <1pA). The current that is measured by the Model 6517 is the sum of the two currents ($I = I_R + <1pA$). The use of guarding reduced the leakage current from 10nA to <1pA. 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 6517.
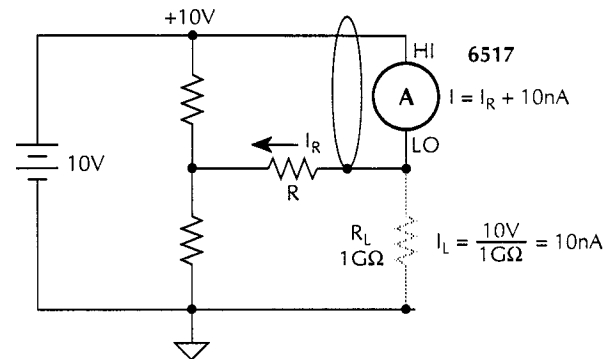
A) Unguarded

A. Unguarded
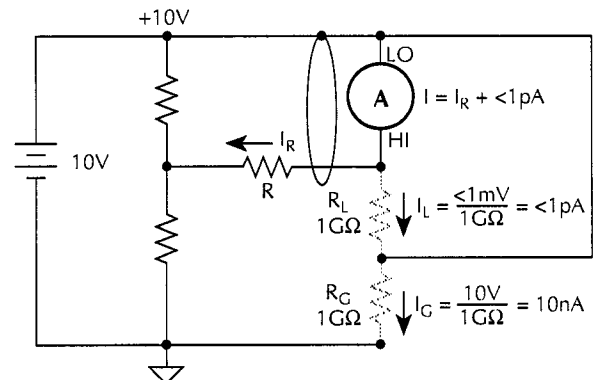
B) Guarded

B. Guarded

Figure 2-30
Floating current measurements

2.7 Resistance and resistivity measurements

The Model 6517 can make resistance measurements and resistivity measurements (surface and volume).

Auto V-Source

The Model 6517 has an auto V-Source mode for resistance and resistivity measurements. With AUTO V-Source selected, the Model 6517 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 2-11). With AUTO V-Source selected, the Model 6517 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.

NOTE

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 6517 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 2-11 identifies the ohms ranges that use 400V.

The V-Source setting (AUTO or MANUAL) is selected from the VSOURCE item of CONFIGURE OHMS menu (see paragraph 2.7.3 for details).

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 20MΩ range has a lower reading limit of 2MΩ.

The reading ranges for the ohms function are listed in Table 2-11.

Readings below the lower range limit will generate the "Underflow" message, while readings that exceed the upper range limit by more than 5% will generate the "Overflow" message.

Note that with AUTO range selected, the instrument cannot go to the 2TΩ, 20TΩ or 200TΩ 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 additional upper and/or lower range limits. Eliminating ranges in the auto range search speeds up the measurement process. See paragraph 2.7.3 (AUTORNG) for details.

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

Table 2-11
Ohms reading ranges and AUTO V-Source

| Reading range | AUTO V-Source | |
	Test voltage	Amps range
200kΩ – 2MΩ	40V	200μA
2MΩ – 20MΩ	40V	20μA
20MΩ – 200MΩ	40V	2μA
200MΩ – 2GΩ	40V	200nA
2GΩ – 20GΩ	40V	20nA
20GΩ – 200GΩ	40V	2nA
200GΩ – 2TΩ	400V	2nA
2TΩ – 20TΩ	400V	200pA
20TΩ – 200TΩ	400V	20pA

2.7.1 Resistance measurements

The Model 6517 can make resistance measurements up to $10^{17}\Omega$ using the force voltage measure current (FVMI) technique. From the known sourced voltage and measured current, the Model 6517 calculates and displays the resultant resistance ($R = V/I$). The V-Source level can be set automatically by the Model 6517 or it can be manually set by the user.

The following steps summarize the basic steps to measure resistance:

WARNING

Make sure the V-Source is in standby. In standby, the OPERATE indicator is off. The OPER key toggles the V-Source between standby and operate.

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 the R (see paragraph 2.7.3 for details).

NOTE

Step 2 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. See paragraphs 2.7 (Auto V-Source) and 2.7.3 (VSOURCE) for details.
4. Connect the resistance to be measured to the Model 6517. Figure 2-31 shows typical connections while Figure 2-32 shows connections using the Model 8002A High Resistance Test Fixture.

NOTE

The connections in Figure 2-33 assume that V-Source LO is internally connected to ammeter LO. This internal connection is controlled from the METER-CONNECT option of the CONFIGURE V-SOURCE menu (see paragraph 2.9.1). This LO-to-LO connection can instead be made by using an external cable to connect V-Source LO to ammeter LO.

5. Select the ohms function by pressing the R key.
6. If the manual V-Source adjustment mode is selected, use the ◄ , ► , and the VOLTAGE SOURCE ▲ and ▼ keys to set the voltage level. The V-Source range can be changed from the RANGE item of the CONFIGURE V-

SOURCE menu. See paragraph 2.9.2 for details on setting range and level for the V-Source. 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. For example, the maximum input voltage to the Model 8002A High Resistance Test Fixture must not exceed 200V peak.

7. Use the ▲ and ▼ RANGE keys to select the resistance measurement range, or select AUTO range. Note that with AUTO range selected, the instrument will not go to the 2TΩ, 20TΩ and 200TΩ ranges.

NOTE

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 "Cancelling Test Fixture Leakage Current" which follows Step 9 of this procedure.

8. Disable zero check by again pressing Z-CHK and press OPER to source voltage to the DUT.

NOTE

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.

9. Take the reading from the display.

WARNING

Place the V-Source in standby before making or breaking connections to the test fixture or DUT.

6517

Red

237-ALG-2
Cable

Black

LO connected
to shield

Measured
Resistance R_X

Shield (Optional)

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

A) Connections

A. Connections

Input
Amplifier

Triax
Input

R_F

Ranging
Amp

To A/D
Converter

Meter
Connect
Relay

HI

Output

V
Source

LO

PREAMP OUTPUT

COMMON

1Ω

2V ANALOG OUTPUT

R_X
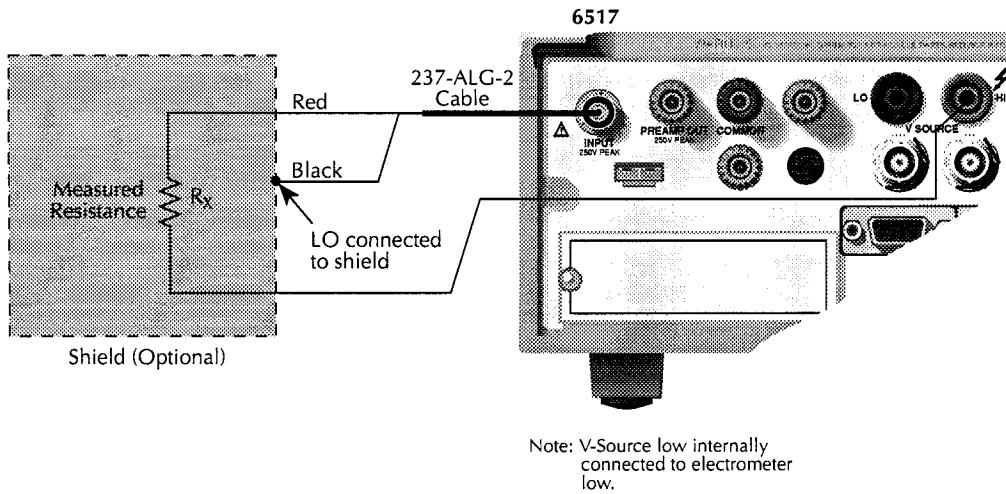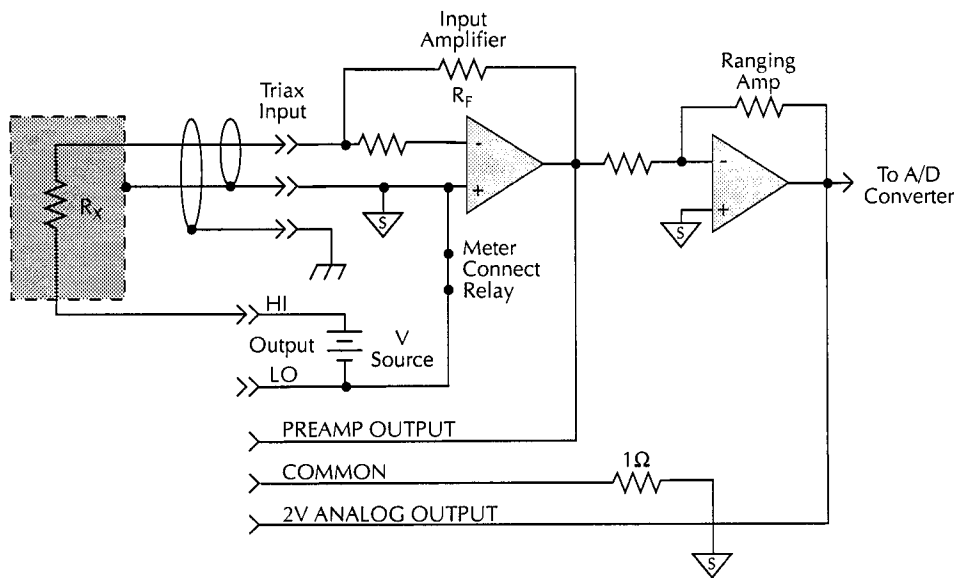
B) Equivalent Circuit

B. Equivalent circuit

Figure 2-31
Typical connections for resistance measurements
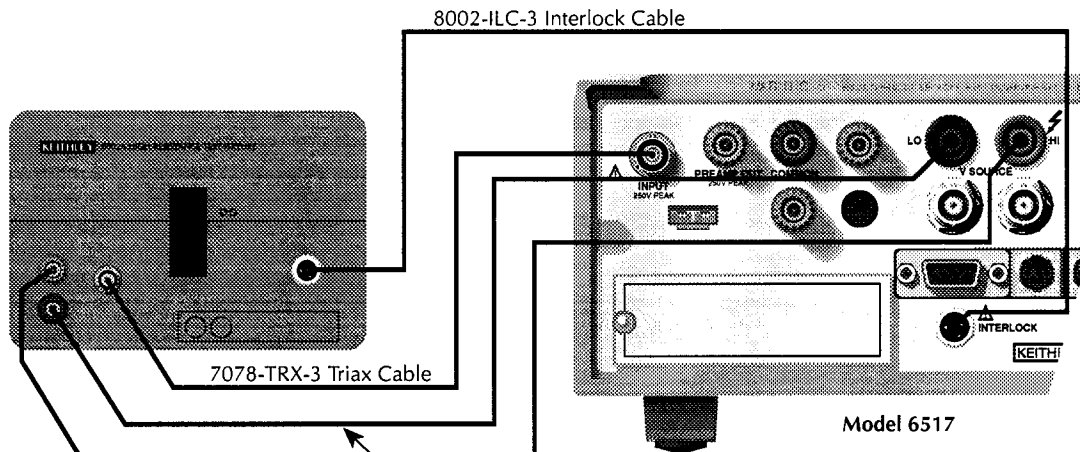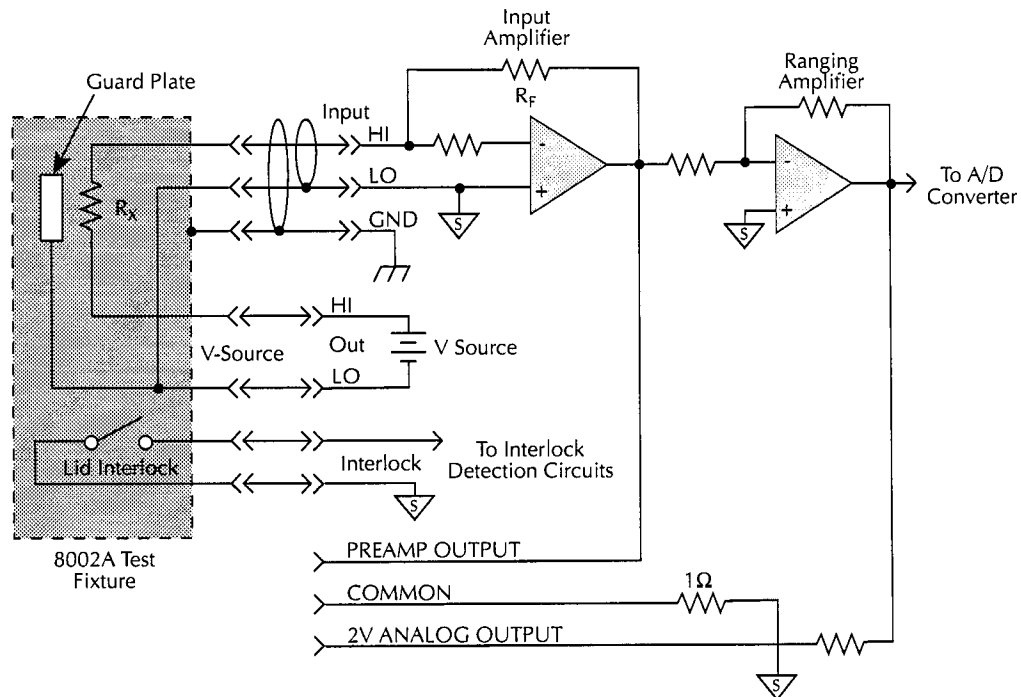
A) Connections

B) Equivalent Circuit

Figure 2-32
Connections for resistance measurements using Model 8002A test fixture

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. Perform the following steps to cancel leakage current:

NOTE

The following procedure assumes that steps 1 through 7 of the preceding resistance measurement procedure has been performed.

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.

2.7.2 Resistivity measurements

The Model 6517 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 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.

NOTE

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 6517 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 (i.e. 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 2-33. The Model 6517 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 2-34 to determine dimension g.
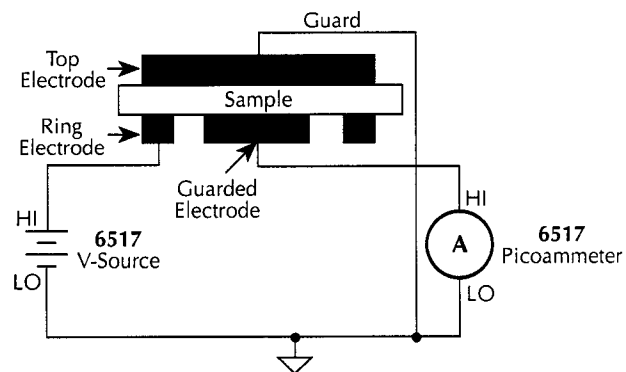
Figure 2-33
Surface resistivity measurement technique

For circular electrodes:

$$P = \pi D_0$$

D0 = D1 + g (refer to Figure 2-34 to determine dimension D0).
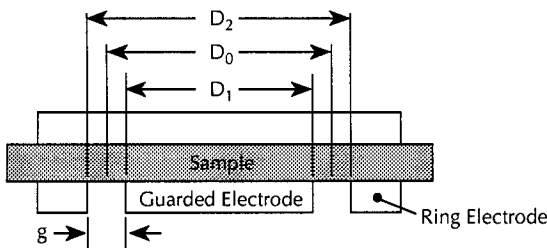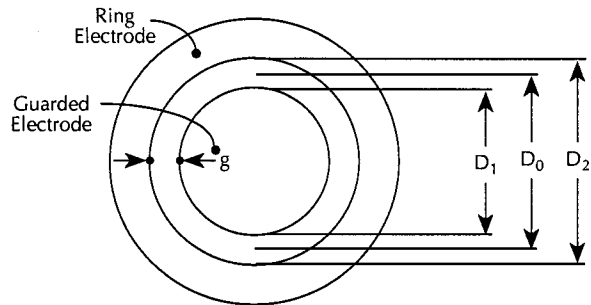
Figure 2-34
Circular electrode dimensions

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 2-35. The Model 6517 automatically performs the following calculation and displays the volume resistivity reading:

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

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.
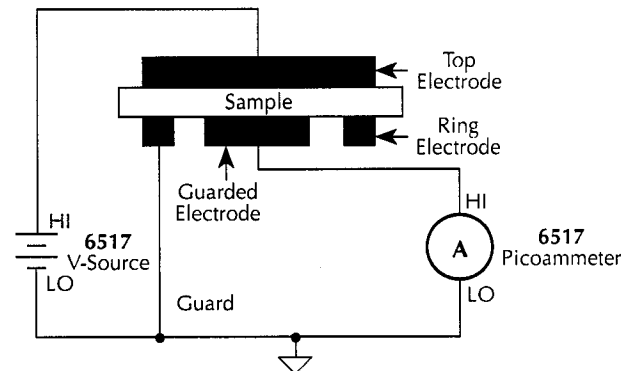
Figure 2-35
Volume resistivity measurement technique

Notes:

1. Refer to Figure 2-34 to determine dimensions D1 and g.
2. 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:

WARNING

Make sure the V-Source is in standby. In standby, the OPERATE indicator is off. The OPER key toggles the V-Source between standby and operate.

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 as explained in paragraph 2.7.3.
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. See paragraphs 2.7 (Auto V-Source) and 2.7.3 (V-SOURCE) for details.
4. Connect the sample to be measured to the Model 6517. Figure 2-36 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 ◀, ▶, and the VOLTAGE SOURCE ▲ and ▼ keys to set the voltage level. The V-Source range can be changed from the RANGE item of the CONFIGURE V-SOURCE menu. See paragraph 2.9.2 for details on setting range and level for the V-Source. Note that you will not be able to adjust the V-Source if AUTO V-Source is selected.

7. Use the ▲ and ▼ RANGE keys to select the ohms measurement range, or select AUTO range. Note that with AUTO range selected, the instrument will not go the 2TΩ, 20TΩ and 200TΩ 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. See paragraph 2.7.5 (Electrification Time) for details.

NOTE

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

Place the V-Source in standby before making or breaking connections to the test fixture or DUT.
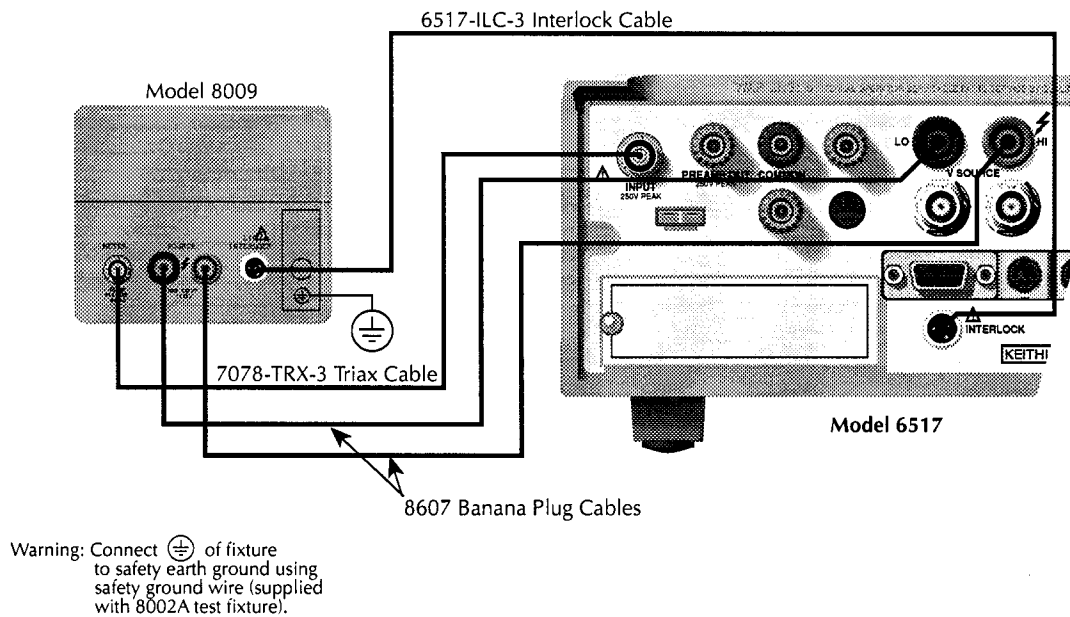
Figure 2-36
Connections for measurements using Model 8009 test fixture

2.7.3 Ohms configuration

The following information explains the various configuration options for the ohms function. The configuration menu is summarized in Table 2-12. This menu is accessed by pressing CONFIG and then R. Paragraph 2.3.5 summarizes the rules for navigating through the menu structure.

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.

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). It is discussed in paragraph 2.5.2.

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 (i.e. press CONFIG V) or by pressing CONFIG FILTER with the desired function already selected. All of the pa-

rameters (menu items) for FILTER are explained in paragraph 2.17.

RESOLUTION

The RESOLUTION parameter sets the display resolution. It is discussed in paragraphs 2.5.2 and 2.12.

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" in paragraph 2.7.1.

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/or lower measurement ranges. For example, if you know that readings will not exceed 1GΩ, you can specify the 2GΩ range to be the maximum range. When the instrument autoranges (assuming AUTO range is enabled), it will not search into the ohms ranges above 2GΩ. Note that the 2TΩ, 20TΩ and 200TΩ ranges are not available for AUTO range.

Table 2-12
CONFIGURE OHMS menu structure

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 time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
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).
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d	Select a specific resolution.
AUTORNG	Autorange menu:
USE-ALL-RANGES	Use all ranges when autoranging.
SET-LIMITS	Limit the ranges used in the autorange search:
MIN-AUTO	Specify the minimum range in the search.
MAX-AUTO	Specify the maximum range in the search.
DAMP	Enable or disable damping.
MEAS-TYPE	Resistance measurement type menu:
RESISTANCE	Select the resistance measurement mode.
RESISTIVITY	Select the resistivity measurement mode:
SURFACE	Configure surface resistivity measurements.
VOLUME	Configure volume resistivity measurements.
VSOURCE	Select AUTO or MANUAL V-Source.

USE-ALL-RANGES: With this selection, all ohms ranges (except the 2TΩ, 20TΩ and 200TΩ 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 that you want the instrument to autorange to.

- MAX-AUTO — Use to select the highest range that you want the instrument to autorange to.

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.

Don't 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:

NOTE

If the Model 6517 is already configured to use the Model 8009 Resistivity Test Fixture (see FIXTURE-MODEL) 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 (see paragraph 2.7.2) 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. Paragraph 2.7.2 explains how to calculate 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 (see paragraph 2.7.2) since the electrode dimensions are known.

  Note that with this selection, an effective area coefficient of one is used (B = 1). If you need to use a different B value, use the USER option instead of MODEL-8009 option.

- 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. Paragraph 2.7.2 explains how to calculate 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 6517 to automatically select the optimum V-Source range and level for the ohms function; 40.000V for the 2MΩ through 200GΩ ranges, and 400.00V for the 2TΩ

through 200TΩ 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 2-11 identifies the ohms ranges that use the high voltage.

2.7.4 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.

2.7.5 Ohms measurement considerations

Some considerations for making accurate resistance and resistivity measurements are summarized in the following paragraphs. Additional measurement considerations are summarized in paragraph 2.21. For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley.

LEAKAGE RESISTANCE

Even though the FVMI method for resistance measurements minimizes the effects of leakage resistance, there 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 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 (see Cancelling Test Fixture Leakage Current in paragraph 2.7.1).

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 6517 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 6517 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. Current measurement considerations are covered in paragraph 2.6.3.

2.8 Charge measurements (Q)

The Model 6517 is equipped with four coulombs ranges to resolve charges as low as 10fC (10^{-14}C) and measure as high as 2.1μC. 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.

2.8.1 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 6517 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. For more details and the procedure to configure auto discharge, see paragraph 2.8.2.

Use the following basic procedure to make charge measurements:

NOTE

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 function and select the desired manual measurement range or auto range.
3. Auto discharge is configured from the Coulombs Configuration menu. Refer to paragraph 2.8.2 to check or change its configuration.
4. Connect the test cable to the Model 6517. With the input open, disable zero check and enable REL to zero the instrument.
5. Connect the circuit to the INPUT of the Model 6517 as shown in Figure 2-37.

NOTE

Do not connect the circuit to the instrument with zero check enabled.

6. Take the charge reading from the display.

2.8.2 Coulombs configuration

The following information explains the various configuration options for the coulombs function. The configuration menu is summarized in Table 2-13. This menu is accessed by pressing CONFIG and then Q. Paragraph 2.3.5 summarizes the rules for navigating through the menu structure.

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.

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). It is discussed in paragraph 2.5.2.

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 (i.e., press CONFIG V) or by pressing CONFIG FILTER with the desired function already selected. All of the parameters (menu items) for FILTER are explained in paragraph 2.17.

RESOLUTION

The RESOLUTION parameter sets the display resolution. It is discussed in paragraph 2.5.2.

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 2μC) measurement ranges. For example, if you know that the readings will not exceed 10nC, you can select LO autorange limits. When the instru-ment 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-2μC): Use this option to limit the autorange search to the high measurement ranges.
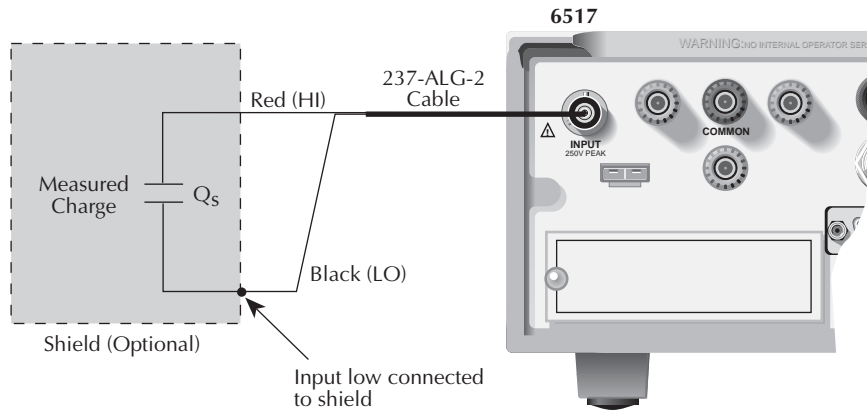
A) Connections

A. Connections
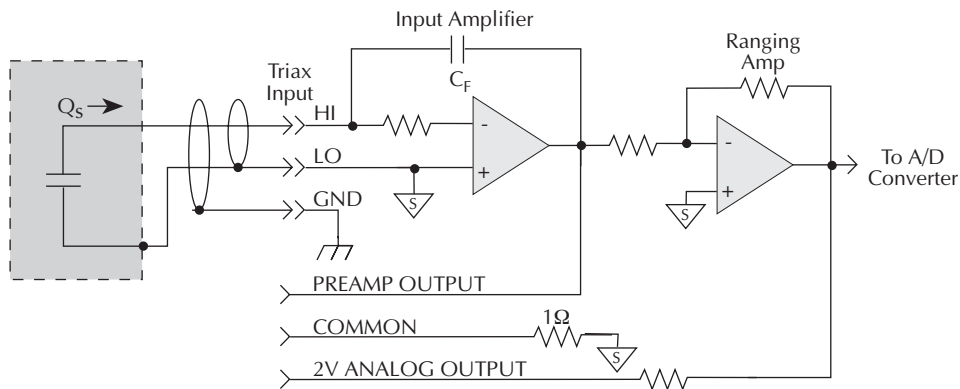
B) Equivalent Circuit

B. Equivalent circuit

Figure 2-37
Typical connections for charge measurements

Table 2-13
CONFIGURE COULOMBS menu structure

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 time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
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 rank (1-5).
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d	Select a specific resolution.
AUTO-DISCHARGE	Enable (specify level) or disable auto discharge.
AUTORANGE	Select autorange limits (high or low).

2.8.3 Charge measurement considerations

Some considerations for making accurate charge measurements are summarized in the following paragraphs. Additional measurement considerations are summarized in paragraph 2.21. For comprehensive information on precision measurements, refer to the Low Level Measurements handbook, which is available from Keithley.

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 6517 has a maximum input bias of 4fA (4×10^{-15}A) for change 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 explained in paragraph 2.19.3 (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.

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.

2.9   Voltage source

The built-in, bipolar, 1W voltage source of the Model 6517 can source up to ±1010V. The two voltage ranges of the voltage source are summarized in Table 2-14.

Table 2-14
V-Source ranges

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

CAUTION

The voltage source may float. However, no output terminal may ever be more than 750V peak above chassis ground. See paragraph 2.4.5 for more information on floating circuits.

WARNING

With the voltage source in operate, the programmed voltage value (possibly hazardous) will be applied to the output terminals of the voltage source. Keep the voltage source in standby until ready to safely source voltage. NEVER make or break any connections with the instrument in operate. The voltage source is in operate when the VOLTAGE SOURCE OPERATE indicator light is on. To place the voltage source in standby, press the OPER key. This key toggles
the V-Source between operate and standby.

V-Source configuration

Operations to configure the V-Source are performed from the V-Source configuration menu which is summarized in Table 2-15. The CONFigure V-SOURCE menu is displayed by pressing CONFIG and then OPER (or ▲ or ▼). Paragraph 2.3.5 summarizes the rules for navigating through the menu structure. The various items of this configuration menu are explained in the following paragraphs.

Table 2-15
CONFIGURE V-Source menu structure

Menu item	Description
RANGE	Select V-Source range (100V or 1000V).
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.

2.9.1   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 2-38). In this configuration, the V-Source functions as a stand-alone voltage source. The V-Source is isolated (>1GΩ) from the measurement circuits of the Model 6517 when V-Source LO is not internally connected to ammeter LO (see Ammeter LO to V-Source LO Connection).

FVMI source — When used to force voltage measure current (FVMI), V-Source LO is connected to ammeter LO as shown in Figure 2-39. 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).
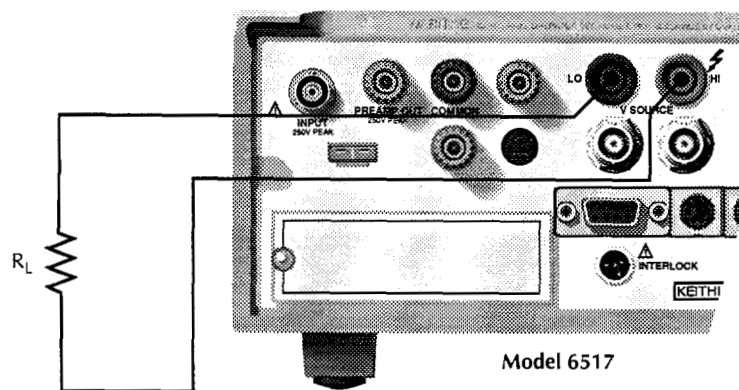
Connections
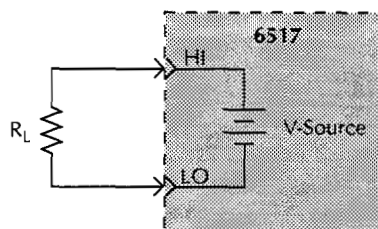
Equivalent Circuit

Figure 2-38
V-source (independent configuration)
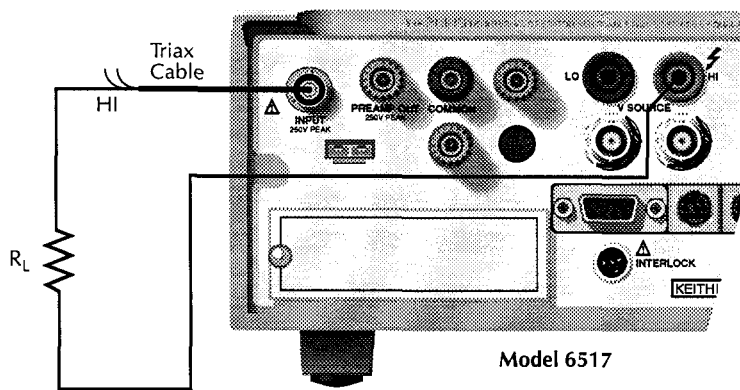
Connections
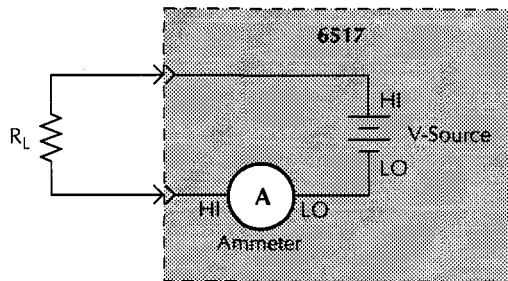
Equivalent Circuit

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

Figure 2-39
V-source (FVMI configuration)

Ammeter LO to V-Source LO connection

The METER CONNECT option of the CONFIG V-SOURCE menu (see Table 2-15) 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.

2.9.2 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 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 A or V key. The voltage source value will appear on the secondary display for three seconds, unless an editing operation is performed (see Adjusting Voltage Source Value).

Selecting voltage source range

With the voltage source value displayed, the position of the decimal point denotes the currently selected range. For example, a reading of 000.000V is 0V on the 100V range, while a reading of 0000.00V is 0V on the 1000V range. The RANGE option of the CONFIG V-SOURCE menu is used to change the V-Source range and is summarized in Table 2-15.

1. From the CONFIG V-SOURCE menu, select RANGE to display the range options (±100V or ±1000V). Note that the 100V range provides better resolution; 5mV vs. 50mV for the 1000V 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

NOTE

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 ▲, ▼, ◄ or ► 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 ▲ or ▼ key to increment or decrement the value.
3. Polarity changes can be made in two ways:

 • Increment or decrement the reading past 0V to change polarity.
 • Place the cursor on the polarity sign (+ or -) and press ▲ or ▼ to toggle polarity.

4. When finished, the voltage source edit mode will cancel (EDIT annunciator off) after three seconds.

2.9.3 Voltage and current limit

The V-Source has a 1mA current limit for the 1000V range, a 10mA limit for the 100V 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 100kΩ load. In this situation, current limit occurs at approximately 100V (100kΩ × 1mA = 100V). Thus, the voltage source will only output 100V.

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

Setting a voltage limit

The V-Source can be set to a maximum absolute value of voltage that can be sourced. For example, setting a value of 30V limits the voltage output from -30V to +30V. The V-LIMIT option of the CONFigure V-SOURCE menu is used to set the V-Source voltage limit and is summarized in Table 2-15.

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).

 LIMIT VALUE — Use this selection to set the voltage limit using the ▲, ▼, ◄ and ► 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 1MΩ 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 2-15.

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.

2.9.4　Interlock and test fixtures

The voltage source should be used with a test fixture that incorporates a safety interlock switch, such as the Keithley Model 8002A High Resistance Test Fixture or the Keithley Model 8009 Resistivity Test Fixture. By using the interlock feature, the Model 6517 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 6517. When used with the Model 8002A or 8009, the V-Source will go into standby whenever the lid of the test fixture is open or ajar.

When using the V-Source with the Model 8009 Resistivity Test Fixture, use the Model 6517-ILC-3 Interlock Cable as shown in Figure 2-36. This cable uses an extra line to detect which resistivity measurement type is selected at the test fixture (surface or volume).

When using the V-Source with the Model 8002A High Resistance Test Fixture, use the Model 8002-ILC-3 Interlock Cable as shown in Figure 2-32. This cable provides the 4-pin to 3-pin conversion required for the Model 8002A. More information on the Model 8002A and 8009 test fixtures is provided in paragraph 2.4.6.

WARNING

Do not connect the interlock of the Model 6517 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 6517s 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.

2.9.5　Operate

WARNING

With the instrument in operate (OPERATE indicator on), the displayed voltage level (possibly hazardous) will be applied to the output terminals of the V-Source. The V-Source should be kept in standby until ready to safely source voltage to a load.

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 as explained in paragraph 2.9.3.

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.

2.10　Analog outputs

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

WARNING

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

CAUTION

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

2.10.1 2V analog output

The 2V ANALOG OUTPUT provides a scaled 0-2V output that is inverting in the volts mode. Connections for using this output are shown in Figure 2-40. For a full-range input, the output will be 2V; typical examples are listed in Table 2-16. 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 10kΩ; to minimize the effects of loading, the input impedance of the device connected to the 2V ANALOG OUTPUT should be as high as possible. For example, with a device with an input impedance of 10MΩ, the error due to loading will be approximately 0.1%

Table 2-16
Typical 2V analog output values

Range	Applied signal	Nominal 2V analog output value*
20pA	10.4pA	1.04V
2μA	1.65μA	1.65V
200mV	140mV	1.4V
200V	35V	0.35V
200kΩ	175kΩ	1.75V
20GΩ	9.5GΩ	0.95V
200pC	125pC	1.25V
20nC	19nC	1.9V

*Output values within ±3% of nominal value.
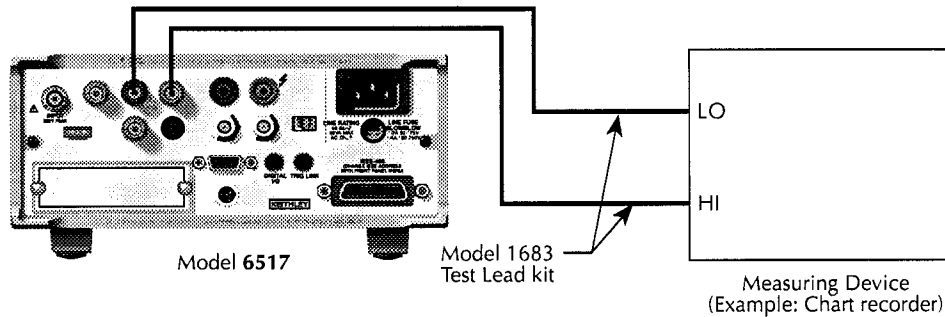
A. Connections
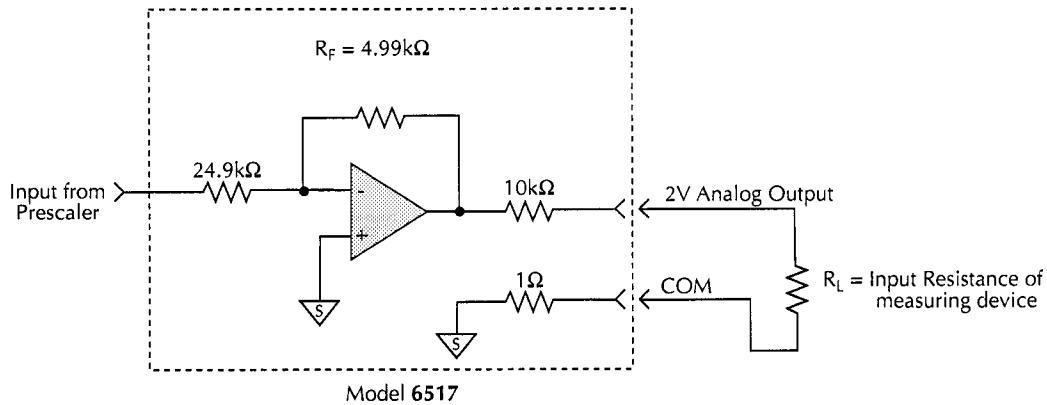
B. Equivalent Circuit

Figure 2-40
Typical 2V analog output connections

2.10.2 Preamp out

The PREAMP OUT of the Model 6517 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 2-41. Full-range outputs for various functions and ranges are listed in Table 2-17. 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 range, PREAMP OUTPUT accuracy is typically 10ppm.

WARNING

High voltage may be present between the PREAMP OUT and COMMON terminals depending on the input signal (see Table 2-17).

CAUTION

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

Note that the PREAMP OUT output resistance is 1Ω. 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 100kΩ.

Table 2-17
Full-range PREAMP OUT values

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

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

A. Connections

Volts

Amps and Ohms

Coulombs
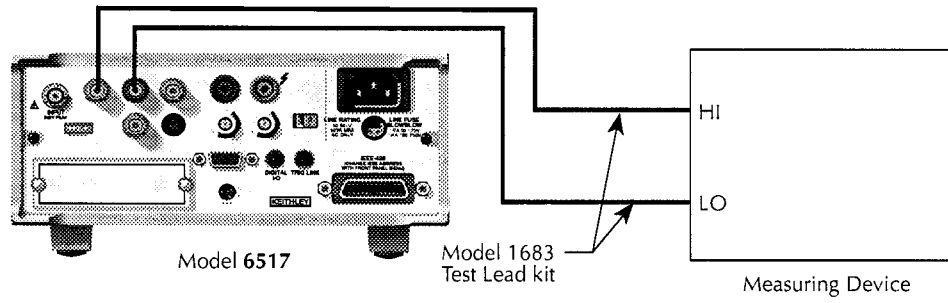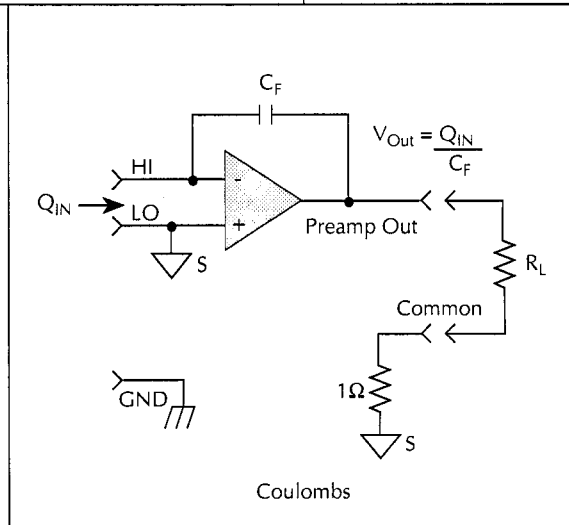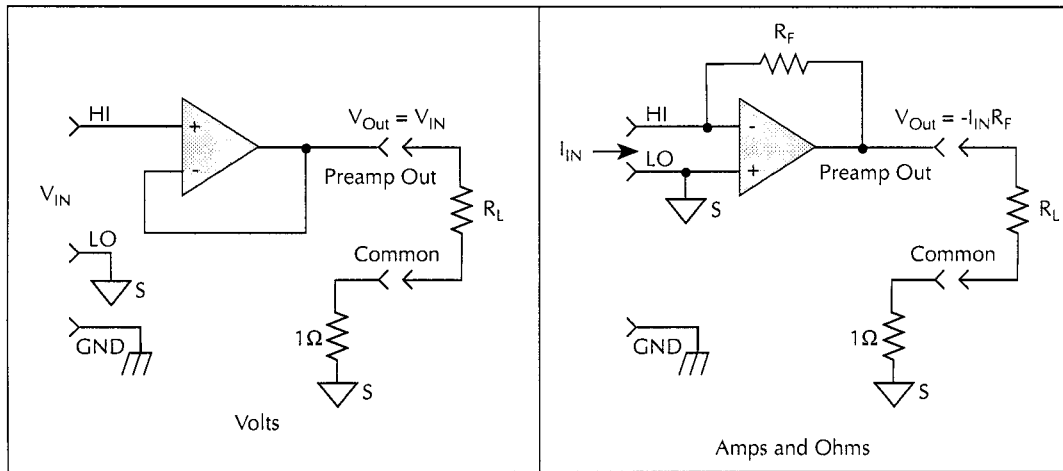
B. Equivalent Circuits

Figure 2-41
Typical preamp out connections

2.11 Using external feedback

The external feedback function provides a means to extend the capabilities of the Model 6517 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.

2.11.1 Electrometer input circuitry

A simplified diagram of the electrometer input in the external feedback mode is shown in Figure 2-42. An input current applied to the inverting (-) input of the 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. 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 20mA in amps and ohms (1mA in volts). The maximum voltage span in external feedback is ±20V.

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, and A_V is the open-loop gain of the electrometer (typically greater than 55×10^6). Note that the input impedance is $Z_{IN} = 10M\Omega \parallel Z_{FB}$ 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 (see paragraph 2.11.2 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 6517. If these insulators become contaminated, they can be cleaned with methanol and then with clean, pressurized air.

2.11.2 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 2-43 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 2-42
Electrometer input circuitry (external feedback mode)

A. Construction

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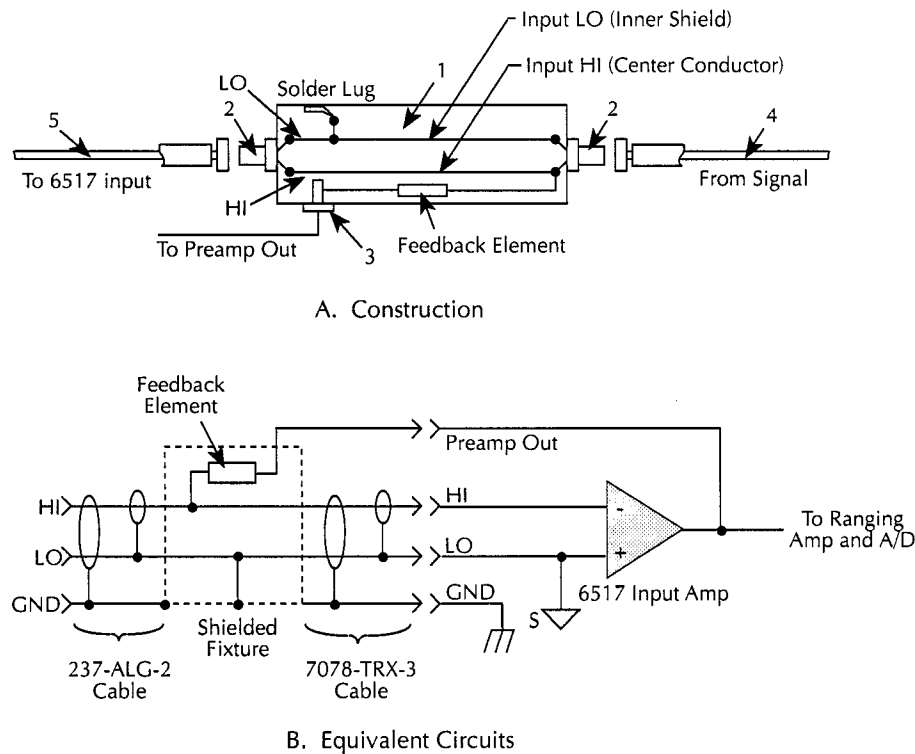
Parts List		
Item	Description	MFR Part Number
1	Shielded Fixture	Pomona #2390
2	Female Triaxial	Keithley 7078-TRX-TBC
3	Banana Jack	Keithley BI-9-2
4	Triaxial Cable	Keithley 237-ALG-2
5	Triaxial Cable	Keithley 7078-TRX-3

Figure 2-43
Shielded fixture construction

2.11.3 External feedback procedure

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

1. Connect the feedback element between the PREAMP OUT terminal and the Input High terminal.
2. 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.

NOTE

There is no front panel message or LED to indicate the status (on or off) of external feedback.

3. The display will shown the voltage measured at the output of the input preamplifier (PREAMP OUT).

2.11.4 Non-standard coulombs ranges

In its standard form, the Model 6517 has four coulombs ranges allowing it to measure charge between 10fC and 2.1μC. 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, and V is the voltage in volts. The Model 6517 display will read charge directly in units determined by the value of C. For example, a 10μF capacitor will result in a displayed reading of 10μC/V.

In practice, the feedback capacitor should be greater than 100pF for feedback stability and of suitable dielectric material to ensure low leakage and low dielectric absorption. Polystyrene, polypropylene, and Teflon dielectric capacitors are examples of capacitor types with these desirable characteristics. The capacitor should be mounted in a shielded fixture like the one in Figure 2-43.

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

2.11.5 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:

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

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_O, m, and RB. I_O is the extrapolated current for V_O. 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, RB constitutes the ohmic bulk resistance of the diode junction material. I_O and RB limit the usefulness of the junction diode at low and high currents respectively. The factor m introduces non-linearities 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 2-44. Analyzing the transistor in this configuration leads to the relationship:

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

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 2-43 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 minimum 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:

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

Using the above transistors, a minimum RC time constant of 100μsec at maximum input current would be used. At I_{IN} (max) of 100μA, this value would correspond to 0.4μF. Note that at 100nA, this value would increase the RC response time constant to 100msec. A minimum capacitance of 100pF 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 1mV 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:

$$V_{DISP} = V_{REL} kT/q (\ln (I_{READ}/I_O) - \ln (I_{REL}/I_O))$$
$$= kT/q (\ln (I_{READ}/I_{REL}))$$
$$= 0.26/I (\ln (I_{READ}/I_{REL})) @ 25°C$$

NOTE

The circuit topology of Figure 2-44 works for positive input currents only. For bipolar input signals, an external offset bias must be applied, or use a PNP transistor for Q1.

2.11.6 Non-decade current gains

The Model 6517 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 2-45, 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 $10^2\Omega$.

2.12 Range and resolution

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

2.12.1 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 is 105% of the measurement range. For example, the maximum signal level on the 2V range is 2.1V (2V × 1.05 = 2.1V). When the A/D reading calculation for the input signal exceeds the selected range, the message "Overflow" will be displayed. However, if a stray out of range reading (such as a noise spike) occurs, the message "Out of limit" will occur if the A/D reading calculation is within the select range.

Each measurement range for the ohms function has a lower reading limit that is one decade below the selected range. For example, the 20MΩ range has a lower reading limit of 2MΩ. See paragraph 2.7 for more information on ohms measurement ranges.

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 2TΩ, 20TΩ or 200TΩ ranges since a hazardous voltage level (400V) 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/or 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.
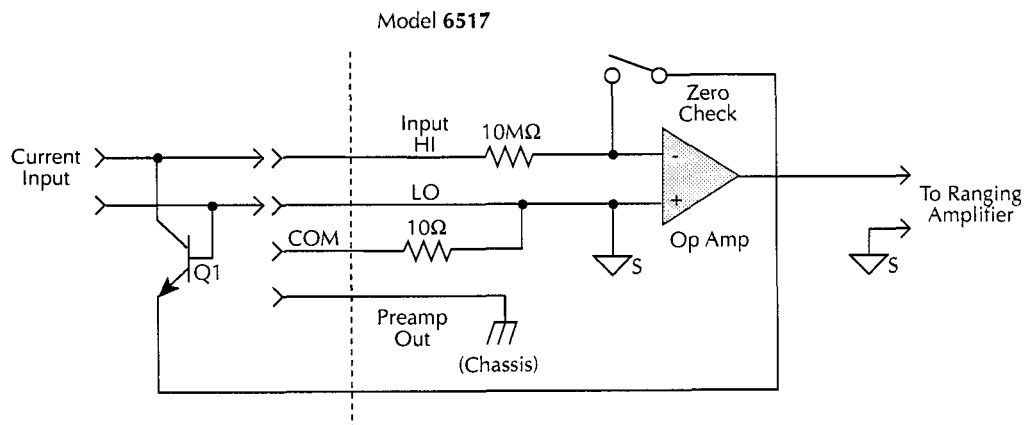
Figure 2-44
"Transdiode" logarithmic current configuration
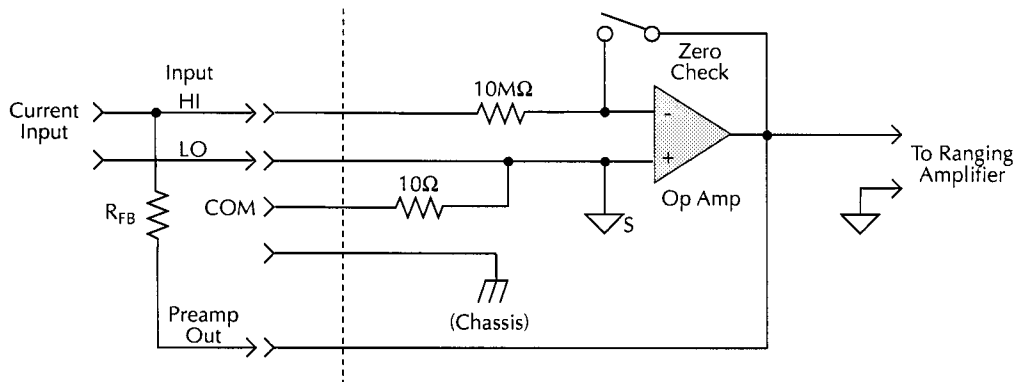
Figure 2-45
Non-decade current gains

2.12.2 Display resolution

The Model 6517 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 2-18 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 2-19. See paragraphs 2.5.2 (volts), 2.6.2 (amps), 2.7.2 (ohms) and 2.8.2 (coulombs) to set display resolution and speed.

Table 2-18
Integration times set-by-resolution (all functions)

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

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

Table 2-19
Auto resolution (all functions)

Resolution	Integration time
3.5d	0.01 to <0.02 PLC
4.5d	0.02 to <0.20 PLC
5.5	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.

2.13 Zero check and relative

2.13.1 Zero check

When zero check is enabled (on), the input amplifier is reconfigured to shunt the input signal to low as shown in Figure 2-46. 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.
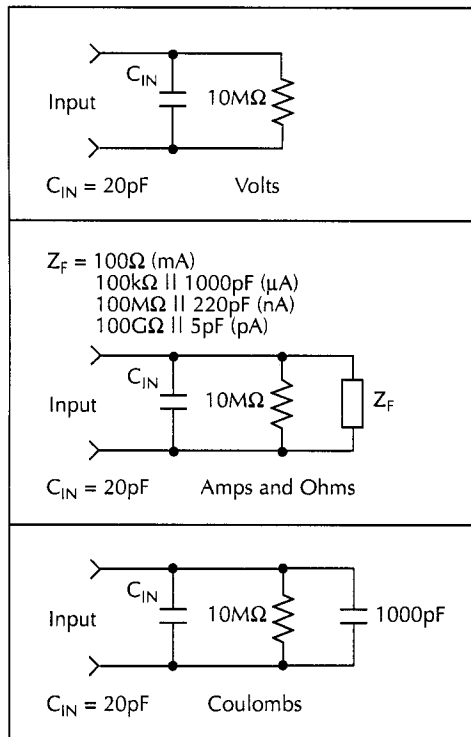
Figure 2-46
Equivalent input impedance with zero check enabled

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.

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. REL is explained in paragraph 2.13.2.

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 2-46).

2.13.2 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 (see configuring rel).

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 15V is set as a rel value on the 20V range, the rel is also 15V on the 200V and 2V 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 2mA range, the Model 6517 still overflows for a 2.1mA 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 RANGE ▲ and ▼ keys. 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:

rel'd reading = actual value - relative value

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

displayed reading = 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 150V rel value is stored, an applied voltage of +175V will result in a displayed value of only +25V.

Multiple display of rel

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 NEXT or PREVious 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)

2.14 Test sequences

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

- Device Characterization Tests:
  Diode Leakage Current
  Capacitor Leakage
  Cable Insulation Resistance
  Resistor Voltage Coefficient

- Resistivity Tests:
  Surface
  Volume

- Surface Insulation Resistance (SIR) Test
- Sweep Tests:
  Square-wave
  Staircase

2.14.1 Test descriptions

The following information describes each test, shows the connections to the Model 6517, and explains how to set up the Model 6517 for the measurements. For tests that perform more than one measurement, the readings are automatically stored in the buffer. If, for example, the test performs 10 measurements, those 10 readings will be stored in the buffer at locations 0 through 9.

Diode leakage current test

This test is used to measure the leakage current for a diode. Figure 2-47 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 2-48 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). See paragraph 2.14.2 for details.

Capacitor leakage 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 2-49 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 a specified time (BIAS-TIME) to allow the capacitor to fully charge (current decays exponentially with time). The leakage current is then measured and stored in the buffer. After the measurement, the V-Source is set to output 0V for a specified time (DISCHARGE time) to allow the capacitor to discharge. This test is selected and configured from the CONFigure SEQUENCE menu (DEV-CHAR; CAPACITOR). See paragraph 2.14.2 for details.

Note: Ammeter LO internally
connected to V-Source
LO (See Paragraph 2.9.1).
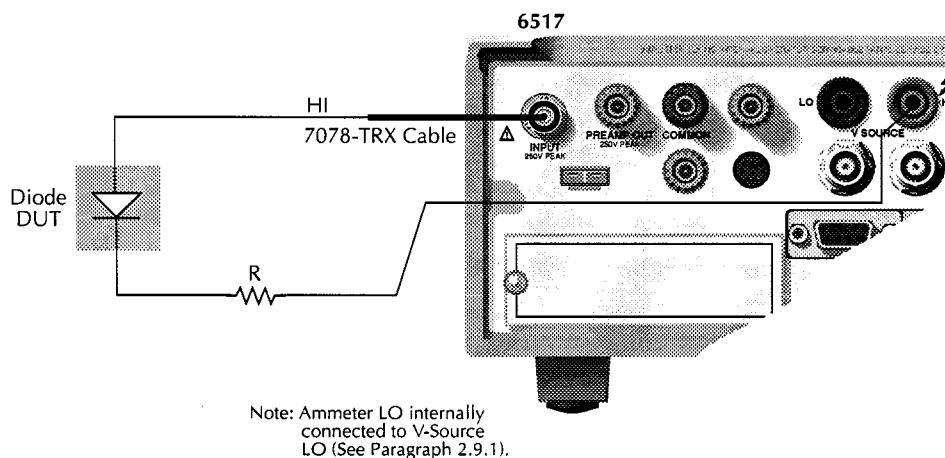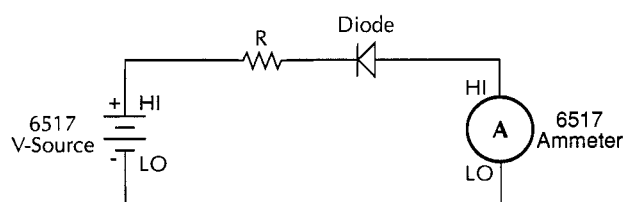
A) Connections

B) Equivalent Circuit

Figure 2-47
Connections; diode leakage current test

Test Parameters:

Start V = +1V
Stop V = +10V
Step V = +1V
Delay = 1 sec
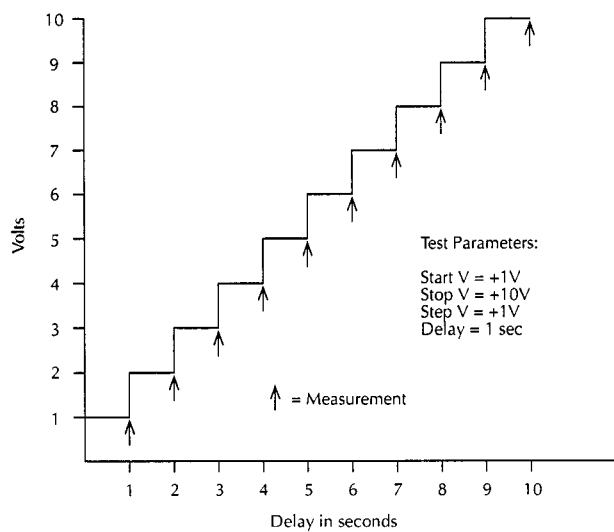
↑ = Measurement

Figure 2-48
Default measurement points; diode leakage current test
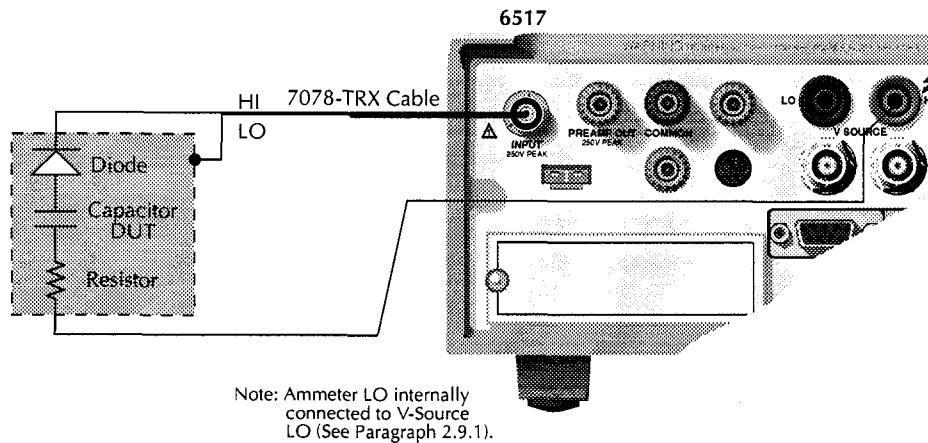
A) Connections
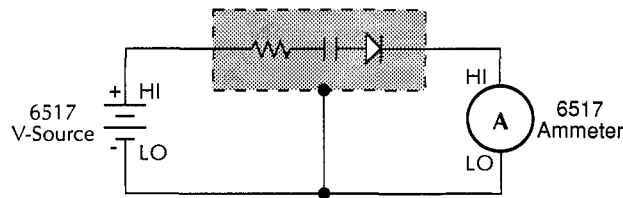
B) Equivalent Circuit

Figure 2-49
Connections; capacitor leakage test

Cable insulation resistance test

This test is used to measure the insulation resistance of a cable. Figure 2-50 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 (BIAS-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 CONFIGURE SEQUENCE menu (DEV-CHAR; CABLE). See paragraph 2.14.2 for details.

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 2-51. The resistor should be placed in a shielded test fixture that is designed to minimize leakage resistance, such as the Model 8002A test fixture. If using the Model 8002A, refer to Figure 2-32 for connection information. If using a different test fixture, refer to Figure 2-31 for basic connection information.

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 6517 then automatically calculates the voltage coefficient and stores it in the buffer. This test is selected and configured from the CONFigure SEQUENCE menu (DEV-CHAR; RESISTOR). See paragraph 2.14.2 for details.

A) Connections

Note: Ammeter LO internally connected to V-Source LO (See Paragraph 2.9.1).
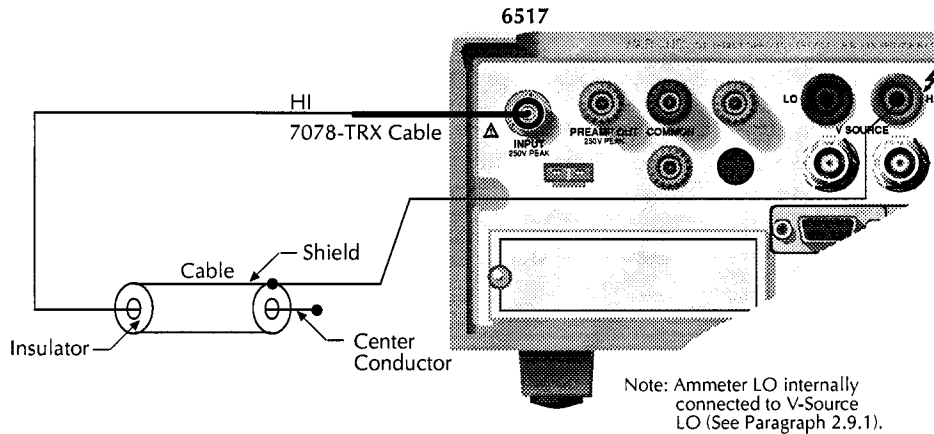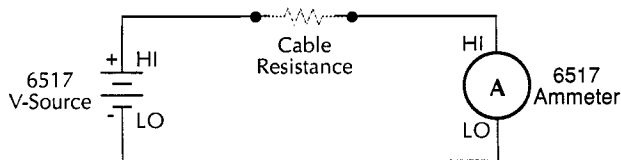
B) Equivalent Circuit

Figure 2-50
Connections; cable insulation resistance test
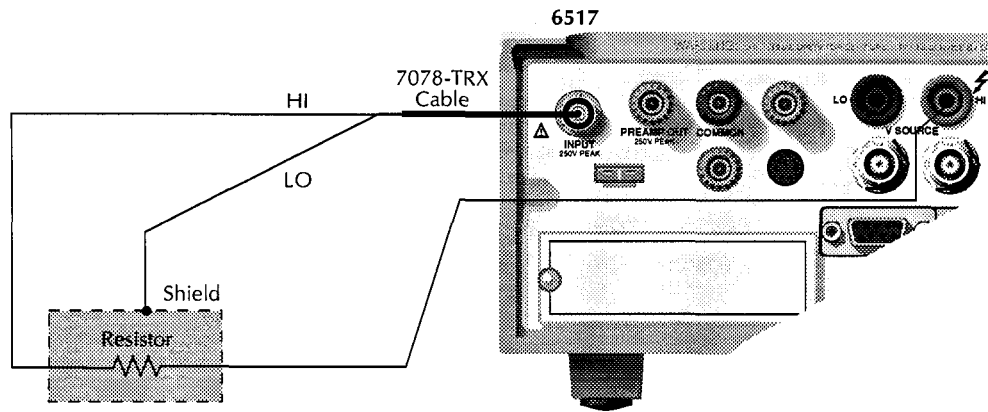
Note: Ammeter LO internally
connected to V-source LO
(see paragraph 2.9.1).

A) Connections
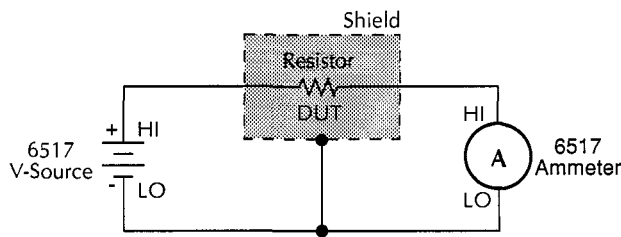
B) Equivalent Circuit

Figure 2-51
Test circuit; resistor voltage coefficient test

Resistivity tests (Surface and Volume)

This test is used to measure the resistivity (surface or volume) of an insulator sample. When used with the Model 8009 Resistivity Test Fixture, the test conforms to the ASTM D-257 standard. For detailed information on resistivity measurements, refer to paragraph 2.7.2. Figures 2-34 and 2-26 show the test circuits for the respective measurement, and Figure 2-36 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 6517 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 (RESISTIVITY; SURFACE and VOLUME). See paragraph 2.14.2 for details.

Surface Insulation Resistance (SIR) test

This test is used to measure the insulation resistance between PC-board traces. Figure 2-52 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 6517 measures the resistance and stores the reading in the buffer.

This test is selected and configured from the CONFIGURE SEQUENCE menu (SIR). See paragraph 2.14.2 for details.

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 2-53 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). See paragraph 2.14.2 for details.

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 2-54 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). See paragraph 2.14.2 for details.

6517

PC-Board
Test Pattern

HI
7078-TRX Cable

Note: Ammeter LO internally
connected to V-Source
LO (See Paragraph 2.9.1).

A) Connections

PC-Board
Test Pattern

6517
V-Source

HI
LO

HI

A   6517
Picommeter

LO
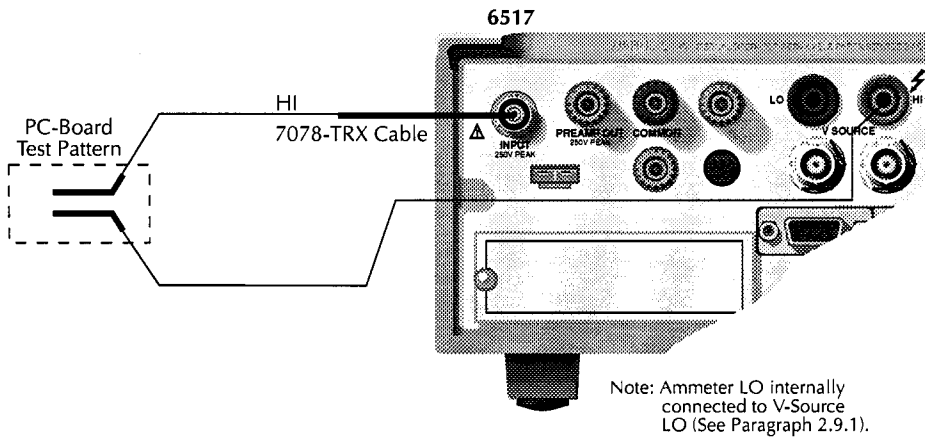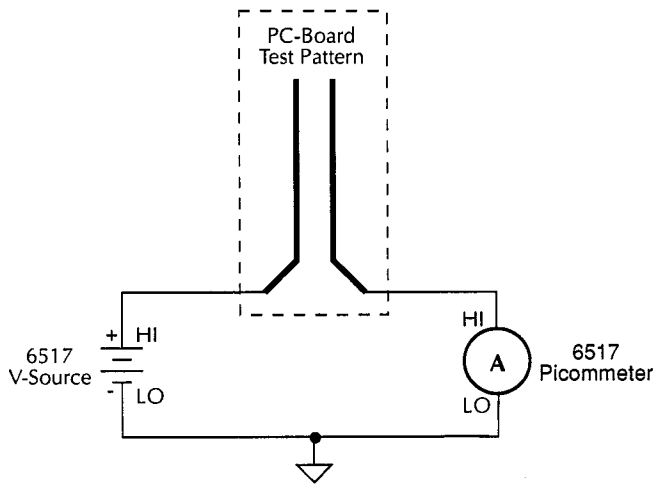
B) Equivalent Circuit

Figure 2-52
Connections; surface insulation resistance test

Cycle: 1   2   3   • • •   10

+1V

0V

-1V

|← 1sec

↑ ↓ = Measurements

Test Parameters:
HI-Level = +1V
HI-Time = 1sec
LO Level = -1V
LO-Time = 1sec
Cycle Count = 10
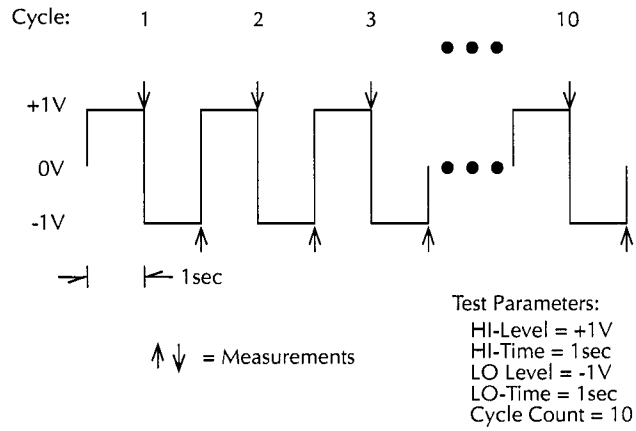
Figure 2-53
Default measurement points; square wave sweep test

Volts

Delay in seconds

Test Parameters:

Start = +1V
Stop = +10V
Step = +1V
Step Time = 1 sec
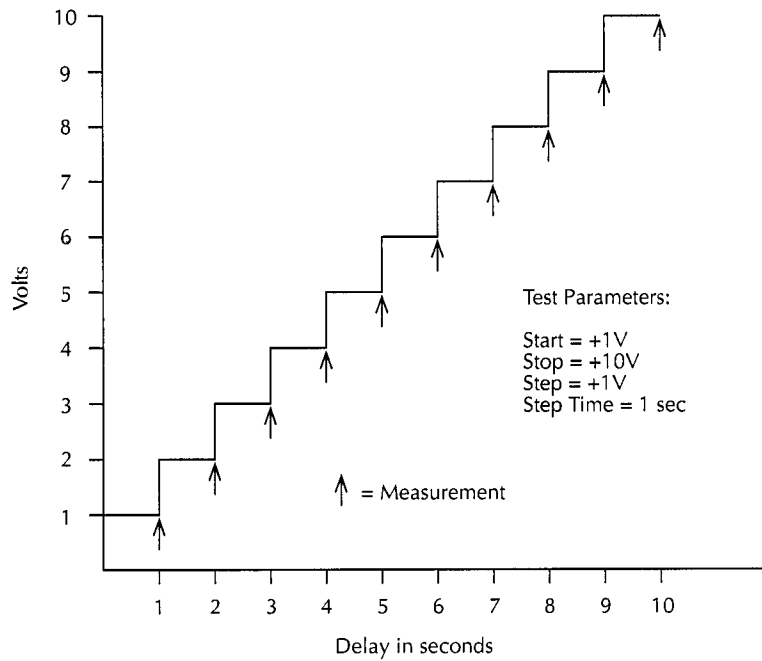
↑ = Measurement

Figure 2-54
Default measurement points; staircase sweep test

2.14.2 Configure Test Sequence

The CONFIGURE SEQUENCE menu is used to select and configure a test sequences and is summarized in Table 2-20. The top level of the menu is displayed by pressing CONFIG and then SEQ.

General rules to navigate the menu levels are provided in paragraph 2.3.5.

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-CUR-RENT, 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 Test. After selecting LEAKAGE, you will be prompted to enter the bias voltage, bias time (in minutes), and the discharge time. 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 and the bias time. 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 VOLT-AGE-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 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.

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 (see paragraph 2.14.3).

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 of the Model 8009 or 8002A 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 6517 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 6517 receives an external trigger via the EXT TRIG IN con-

nector. 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 6517 receives a trigger via the selected trigger link line. Note that the TRIG key can instead be used to start the test.

Table 2-20
CONFIGURE SEQUENCE menu structure

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.	+1V
STOP V	Specify stop voltage.	+10V
STEP V	Specify step voltage.	+1V
DELAY	Specify delay.	1sec
CAPACITOR		
LEAKAGE	Capacitor Leakage Test:	
BIAS V	Specify bias voltage.	+1V
BIAS-TIME	Specify bias time.	1 sec
DISCHARGE	Specify discharge time.	2 sec
CABLE		
INSULATION-RESISTANCE	Cable Insulation Resistance Test:	
BIAS V	Specify bias voltage.	+1V
BIAS-TIME	Specify bias time.	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.	2 sec
RESISTIVITY	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 2-20 (cont.)
CONFIGURE SEQUENCE menu structure

Menu item	Description	Default parameter
SIR		
SUR-INSUL-RES-TEST	Surface Insulation Resistance Test:	
BIAS V	Specify bias voltage.	+50V
BIAS-TIME	Specify bias time.	1 sec
MEAS-V	Specify measurement voltage	+100V
MEAS-TIME	Specify measurement time.	1sec
SWEEP	Sweep Tests:	
SQUARE-WAVE	Square Wave Sweep Test:	
HI-LEVEL	Specify high level voltage.	+1V
HI-TIME	Specify time at high level.	1sec
LO-LEVEL	Specify low level voltage.	-1V
LO-TIME	Specify time at low level.	1sec
CYCLE COUNT	Specify number of cycles.	10
STAIRCASE	Staircase Sweep Test:	
START	Specify start voltage.	+1V
STOP	Specify stop voltage.	+10V
STEP	Specify step voltage.	+1V
STEP TIME	Specify step time.	1sec
CONTROL	Select trigger source to start test:	Manual
MANUAL	Start when TRIG key pressed.	
IMMEDIATE	Start immediately.	
LID-CLOSURE	Start when test fixture lid closed.	
GPIB	Start on GPIB trigger (GET or *TRG).	
EXTERNAL	Start when external trigger received.	
TRIGLINK	Start when trigger is received via the specified Trigger Link line.	Line #1

2.14.3 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 6517 for the desired test as explained in paragraph 2.14.1.
3. Select and configure the desired test as explained in paragraph 2.14.2.
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 automatically enable 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.

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 6517.
3. Readings are automatically stored in the buffer starting at memory location (reading #) zero.

2.15 Triggers

The following paragraphs discuss front panel triggering, trigger configuration and external triggering, including example setups.

Model 6517 triggers are set up from the CONFIGURE TRIGGER menu. The menu structure is shown and summarized in Table 2-21.

Notice from Table 2-21 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 in the next paragraph.

Table 2-21
CONFIGURE TRIGGER menu structure

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

Table 2-21 (cont.)
CONFIGURE TRIGGER menu structure

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

2.15.1 Trigger model

The following information describes triggering of the Model 6517 from the front panel. The flowchart of Figure 2-55, which is the simplified trigger model, summarizes basic front panel triggering. The flowchart of Figure 2-56, which is the complete trigger model, summarizes advanced front panel triggering.
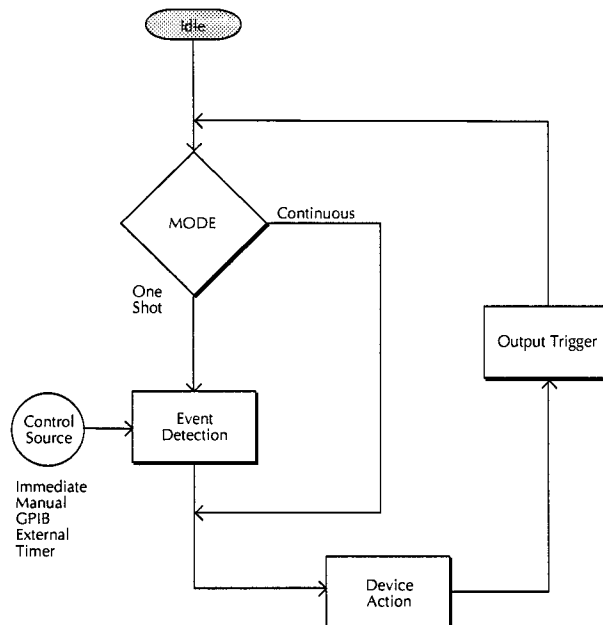
Figure 2-55
Basic trigger model

BASIC TRIGGER MODEL

As shown in Figure 2-55, 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 2-55 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 measure-

ments (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).

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 6517 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 6517.
- External — Event detection is satisfied when an input trigger via the EXTERNAL TRIGGER connector is received by the Model 6517.
- 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 METER COMPLETE connector on the rear panel of the instrument. This out-going trigger pulse can be used to trigger another instrument to perform an operation (see paragraph 2.15.4 External Triggering).

ADVANCED TRIGGER MODEL

As shown in Figure 2-56, 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 2-56 for the following explanation of the advanced trigger model.
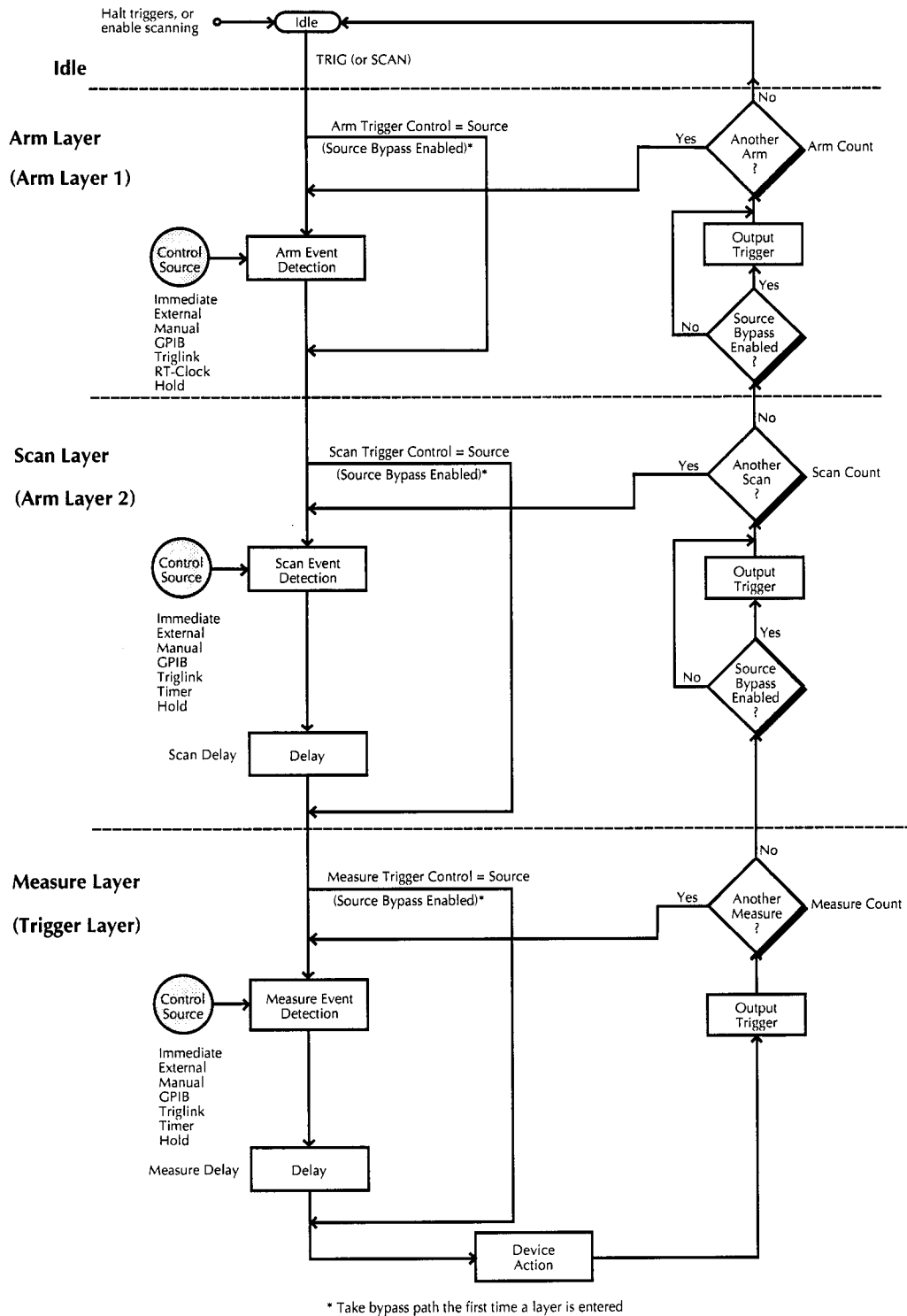
Figure 2-56
Advanced trigger model

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 6517 in the scan mode. Triggering will resume when the scan is started or if the scan is aborted by pressing EXIT.

Trigger Model Layers

As can be seen in Figure 2-56, 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 6517 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 6517 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 6517.
- 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 via the EXTERNAL TRIGGER connector is received by the Model 6517.
- Triglink — Event detection is satisfied when an input trigger via the TRIGGER LINK is received by the Model 6517.
- 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, 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 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. For all other control

source selections, the trigger pulse is available at the METER COMPLETE connector.

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 METER COMPLETE 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).

2.15.2 Basic trigger configuration

The following information explains how to configure the Model 6517 for basic triggering. If you instead wish to use advance triggering, refer to paragraph 2.15.3. Basic triggering is configured from the BASIC item of the CONFIGURE TRIGGER menu (see Table 2-21), which is displayed by pressing the CONFIG key and then the TRIG key. General rules for navigating the menu structure is provided in paragraph 2.3.5.

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 instru-

ment waits for the selected control source event to occur before making a measurement (see SOURCE).

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 6517 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.

NOTE
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 6517 receives a bus trigger (GET or *TRG), it performs a measurement. See Section 3 for detailed information on bus triggers.

NOTE
The front panel TRIG key (see MANUAL) 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 6517 results in a measurement.

The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 2.15.4 for detailed information on external triggering.

NOTE
The front panel TRIG key (see MANUAL) 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 (1msec) to 999999.999 seconds with 1msec 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.

NOTE

The front panel TRIG key (see MANUAL) is active with the time selected. Pressing the TRIG key after the completion of a measurement starts the next measurement.

2.15.3 Advanced trigger configuration

The following information explains how to configure the Model 6517 for advanced triggering. If you instead wish to use basic triggering, refer to paragraph 2.15.2. Advanced triggering is configured from the ADVANCED item of the CONFIGURE TRIGGER menu (see Table 2-21), which is displayed by pressing the CONFIG key and then the TRIG key. General rules for navigating the menu structure are provided in paragraph 2.3.5.

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 6517 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 6517 performs a device action, as defined by the trigger model. In addition to a measurement, this may in-

clude range changing, filtering, calculations, data storing, scanning, and other operations.

The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 2.15.4 for detailed information on external triggering.

NOTE

The front panel TRIG key (see MANUAL) 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.

NOTE

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 6517 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 3 for detailed information on bus triggers.

NOTE

The front panel TRIG key (see MANUAL) 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 6517. 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 6517 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.

See paragraph 2.15.5 for details on using the Trigger Link.

NOTE

The front panel TRIG key (see MANU-AL) 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 6517 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 1msec 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.

NOTE

The front panel TRIG key (see MANU-AL) is active with the time selected. Pressing the TRIG key after the completion of a measurement starts the next measurement (assuming the Model 6517 is programmed for another measurement; see COUNT).

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 sec.) 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 6517 to measure up to 99999 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 6517 passes operation into the measure layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 2.15.4 for detailed information on external triggering.

> **NOTE**
>
> The front panel TRIG key (see MANUAL) 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.

> **NOTE**
>
> 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 6517. See Section 3 for detailed information on bus triggers.

> **NOTE**
>
> The front panel TRIG key (see MANUAL) 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 6517. 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 6517 receives a trigger over the Trigger Link. See paragraph 2.15.5 for details on using the Trigger Link.

> **NOTE**
>
> The front panel TRIG key (see MANUAL) 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 (1msec) to 999999.999 seconds with 1msec 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.

> **NOTE**
>
> The front panel TRIG key (see MANUAL) 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 6517 is programmed for another scan sequence; see COUNT).

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 sec.) 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 6517 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 6517 passes operation into the scan layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 2.15.4 for detailed information on external triggering.

> NOTE
> The front panel TRIG key (see MANUAL) 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.

> NOTE
> 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 6517. See Section 3 for detailed information on bus triggers.

> NOTE
> The front panel TRIG key (see MANUAL) 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 6517. 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 6517 receives a trigger over the Trigger Link. See paragraph 2.15.5 for details on using the Trigger Link.

> NOTE
> The front panel TRIG key (see MANUAL) 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 6517 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 (see CLOCK in paragraph 2.19.7). 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 6517 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.

2.15.4 External triggering

The Model 6517 has BNC connections on the rear panel for external triggering (see Figure 2-57). The EXT TRIG IN jack allows the Model 6517 to be triggered by other instruments. The MTR COMP OUT jack allows the Model 6517 to trigger other instruments.

EXT TRIG IN   MTR COMP OUT
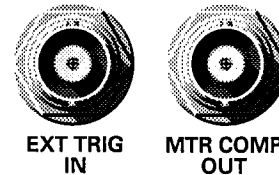
Figure 2-57
External triggering connectors

External trigger

The EXT TRIG IN jack requires a falling-edge, TTL-compatible pulse with the specifications shown in Figure 2-58.

In general, external triggers can be used as events to control measure operations. For the Model 6517 to respond to external triggers, the appropriate layers of the trigger model must be configured for it. Paragraphs 2.15.2 and 2.15.3 explain how to program the three layers of the measurement.
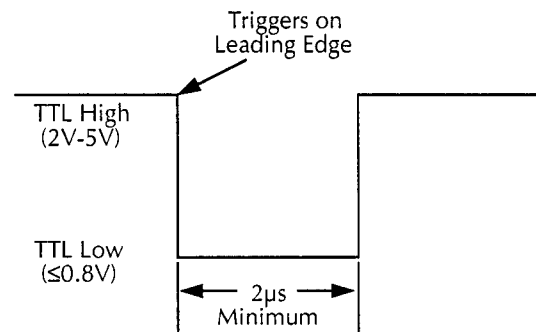
Figure 2-58
External triggering and asynchronous trigger link input pulse specifications

Meter complete

The MTR COMP OUT jack provides a TTL-compatible output pulse that can be used to trigger other instruments. The specifications for this trigger pulse are shown in Figure 2-59.
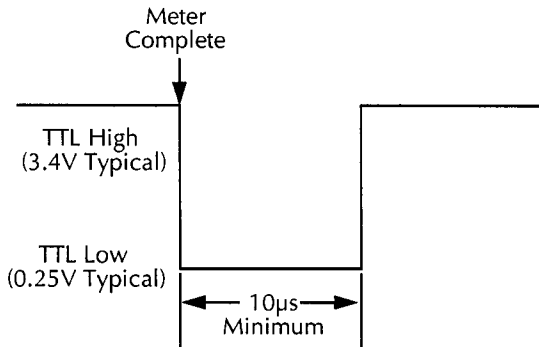
Figure 2-59
Meter complete and asynchronous trigger link output pulse specifications

Typically, you would want the Model 6517 to output a trigger after the settling time of each measurement. (Settling time includes the internally set measurement settling time and the user programmed DELAY period.) An output completion pulse occurs after each measurement as long as the measure source is set to external, timer, manual, or immediate. See paragraphs 2.15.2 and 2.15.3 for details.

The Model 6517 can also output a completion pulse while in the scan and/or arm layers of operation. Figure 2-56 shows where these triggers occur in the trigger model. If the scan layer Source Bypass is enabled (Control = Source) and the Scan Source is programmed for External, an output trigger occurs on each return path through the scan layer. If the arm layer Source Bypass is enabled (Control = Source) and the Arm Source is programmed for External, an output trigger occurs on each return path through the arm layer. See paragraph 2.15.3 for programming the scan and arm layers.

External triggering example #1

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a multimeter. Such a test system is shown in Figure 2-60, which uses a Model 6517 Electrometer to measure ten DUTs switched by a Model 7158 multiplexer card in a Model 7001 or 7002 Switch System.

The external trigger connections for this test are shown in Figure 2-61. Channel Ready (output) of the Model 7001 or 7002 is connected to External Trigger Input of the Model 6517. Meter Complete Output of the Model 6517 is connected to External Trigger (input) of the Model 7001 or 7002. For this example, the Models 6517 and 7001/7002 are configured as follows:

Figure 2-60
DUT test system
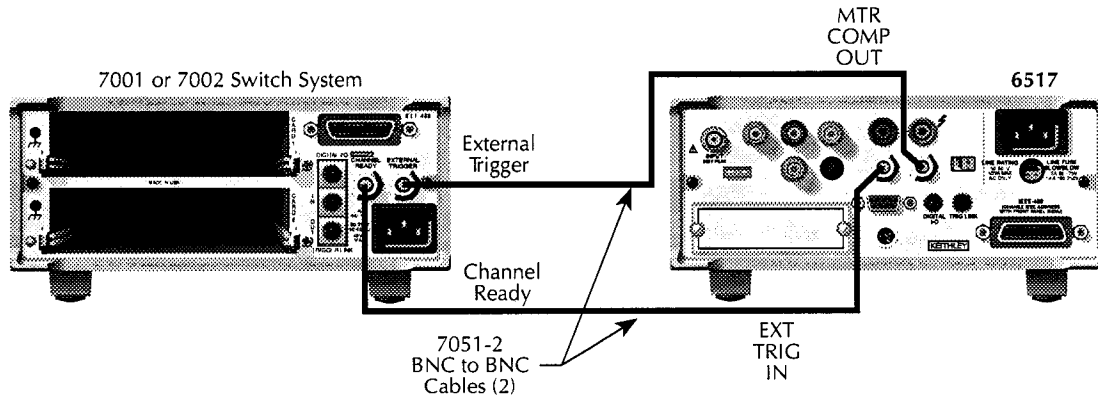
Figure 2-61
External trigger connections

Model 6517:

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 = External
Measure count = Infinite*
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 = External
Number of channels = Use Scanlist length*
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 6517 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 6517 waits in the measure layer for a trigger.

With the Channel Trigger Control of the switch system set for Source, scan operation initially bypasses the need for an external 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. When the front panel STEP key is pressed:

- The scanner arms and closes the first channel.
- After Channel 1!1 settles, a trigger is sent from Channel Ready of the Model 7001/7002 to External Trigger Input of the Model 6517 to trigger a measurement of DUT #1.
- After the Model 6517 completes the measurement, it outputs a trigger from Meter Complete Output to External Trigger of the Model 7001/7002, which closes the next channel.
- After Channel 1!2 settles, a trigger is sent to the Model 6517 to trigger a measurement of DUT #2.

This process continues until all ten channels are scanned and measured.

The data store capability of the Model 6517 could be used to store the measurements as they occur. Just press the STORE key to set the number of readings to store, then press ENTER. The Model 6517 waits (with the asterisk annunciator lit) for an external trigger from the Model 7001/7002 before taking a reading, storing it, and sending a trigger pulse.

External triggering example #2

External triggering can also be used in a test system consisting of a Model 6517 Electrometer and a Model 706 Scanner with an appropriate scanner card.

The external trigger connections are the same as those shown in Figure 2-61 for the Models 6517 and 7001/7002. Channel Ready Output of the Model 706 is connected to External Trigger Input of the Model 6517. External Trigger Input of the Model 706 is connected to Meter Complete Output of the Model 6517.

The trigger configuration of the Model 6517 does not change from the previous example. The Model 706 is configured for external triggering.

2.15.5 Trigger Link

The Model 6517 has enhanced external triggering capabilities using the Trigger Link. 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 2-62.

In general, Trigger Link input triggers to the Model 6517 are used to control the measure operation. For the Model 6517 to respond to Trigger Link compatible triggers, the appropri-

ate 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 6517 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.

Pin	Trigger Link Line
1	Line #1
2	Line #2
3	Line #3
4	Line #4
5	Line #5
6	Line #6
7	Digital Common
8	Digital Common
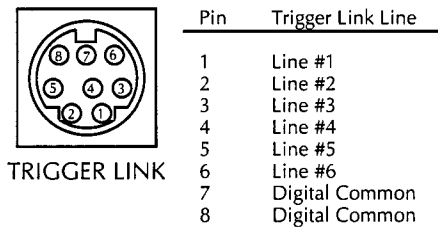
TRIGGER LINK

Figure 2-62
Trigger link connector

Asynchronous operation

In the asynchronous operating mode, Trigger Link functions fundamentally in the same manner as External Triggering (see paragraph 2.15.4). Like External Triggering, the asynchronous mode uses separate lines for input and output triggers. Also, the asynchronous mode uses the same TTL-compatible pulses as External Triggering. The specifications for the input and output trigger signals of asynchronous mode are shown in Figures 2-58 and 2-59, respectively.

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 6517 outputs a Trigger Link completion pulse (typically to a scanner to close the next channel). The measure layer is configured using he CONFIGURE TRIGGER menu (see paragraph 2.15.3).

The scan layer and/or 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 #1

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 2-63, which uses a Model 6517 Electrometer to measure ten DUTs switched by a Model 7158 multiplexer card in a Model 7001/7002 Switch System.

The Trigger Link connections for this test system are shown in Figure 2-64, Trigger Link of the Model 6517 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 6517 and 7001/7002 are configured as follows:
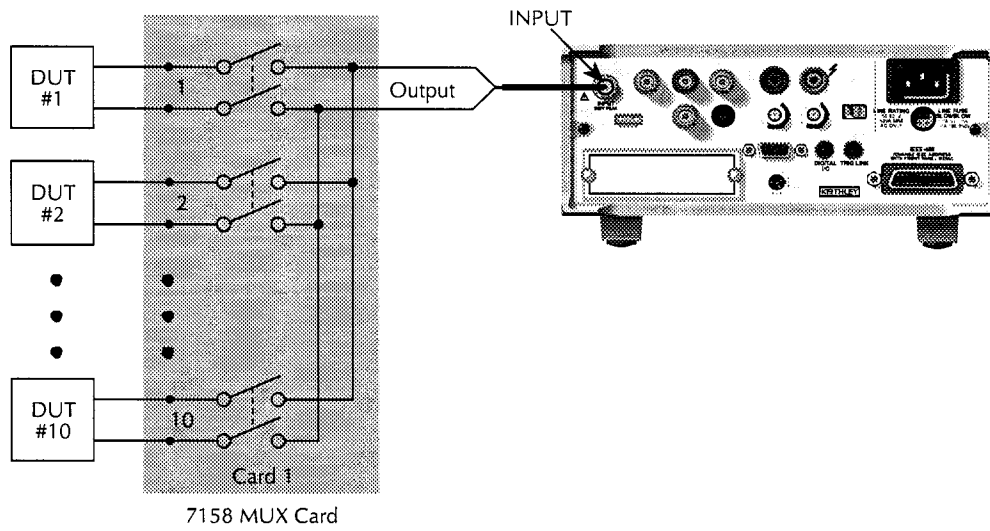
Figure 2-63
DUT test system
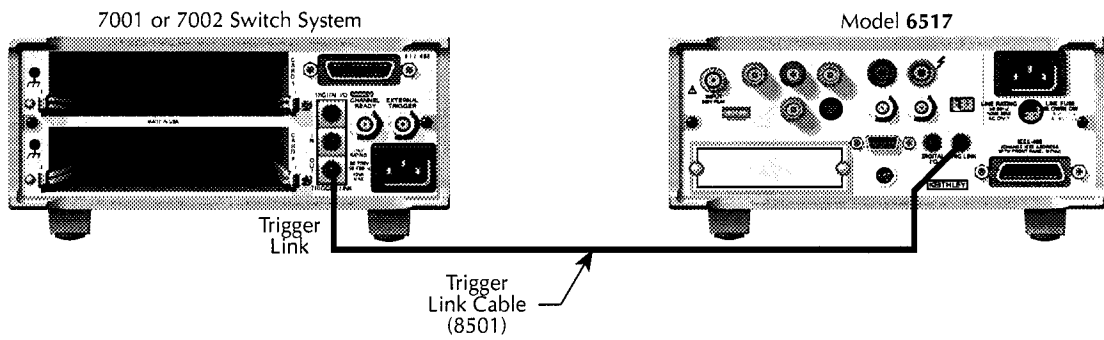
Figure 2-64
Trigger Link connections (asynchronous example #1)

Model 6517:

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 = External
Measure count = Infinite*
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 = External
Number of channels = Use Scanlist length*
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 6517 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 6517 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 6517, press STORE on the electrometer, enter the desired number of readings (ten), and press ENTER. The Model 6517 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 6517 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 2-65.

(A) The BENCH RESET condition arms the Model 6517 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 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.

(E) and (F) Remember that the Model 6517 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 6517 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 6517 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.
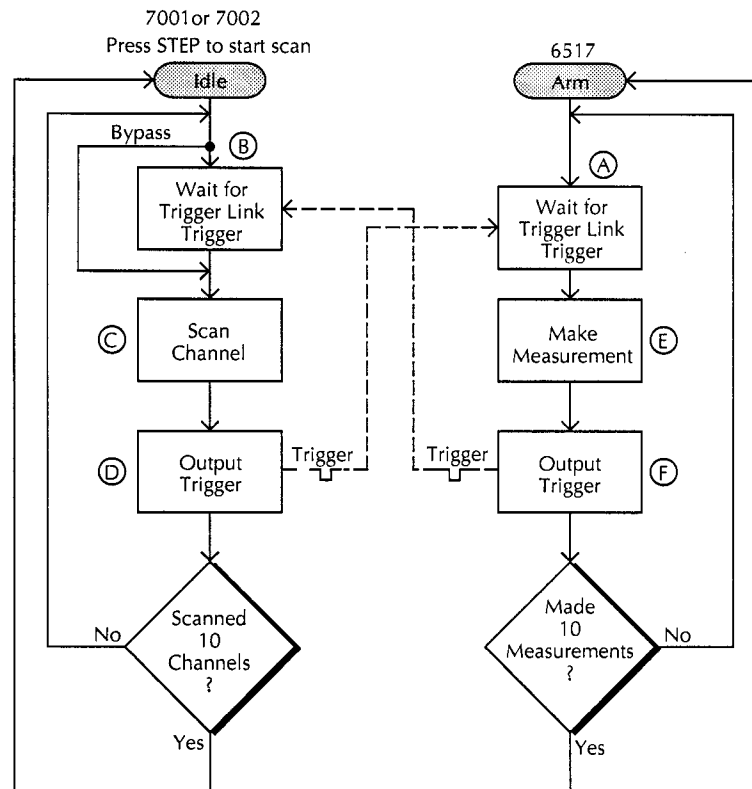
Figure 2-65
Operation model for asynchronous trigger link example #1

External Triggering and Trigger Link

As previously mentioned, the trigger pulses for the asynchronous Trigger Link are identical to the trigger pulses used for External Triggering. The only thing that prevents them from being used together in a test system is connection incompatibility. Trigger Link uses an 8-pin micro-DIN connector while External Triggering uses two BNC connectors.

This connection problem can be solved by using the Model 8502 Trigger Link Adapter. The adapter has two 8-pin micro-DIN connectors and six BNC connectors. The micro-DIN connectors mate directly to the Trigger Link connector on the Model 6517 using a trigger link cable. The BNC connectors mate directly to the External Triggering BNC connectors on other instruments using standard male BNC to BNC cables.

Figure 2-66 shows how a Keithley Model 706 Scanner can be connected to the Trigger Link of the Model 6517 using the adapter. With this adapter, a Model 706 could be substituted

for the Model 7001/7002 in the previous example (Asynchronous Trigger Link example #1). With the Model 706 set for External Triggering, the test would start when the single scan mode is selected and initiated.

Asynchronous Trigger Link example #2

In this example, the test system (Figure 2-67) includes a Model 6517 to measure each DUT at two different current levels that are provided by a Model 220 current source. With the source set to the first current level, the ten channels are scanned and measured. The source is then set to the second current level and the ten channels are again scanned and measured.

Since this example uses an instrument that does not have Trigger Link (Model 220), the Model 8502 Trigger Link Adapter is required. Connections are shown in Figure 2-68. For this example, the Model 220 is programmed for External Triggering and is set to source the first current level. The Models 6517 and 7001/7002 are configured as follows:
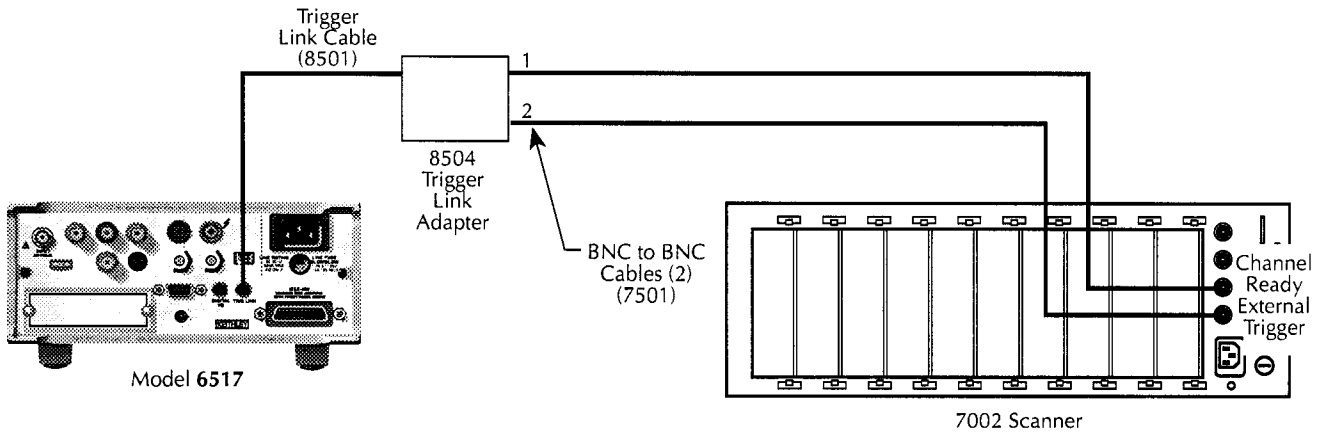
Figure 2-66
Connections using Trigger Link adapter
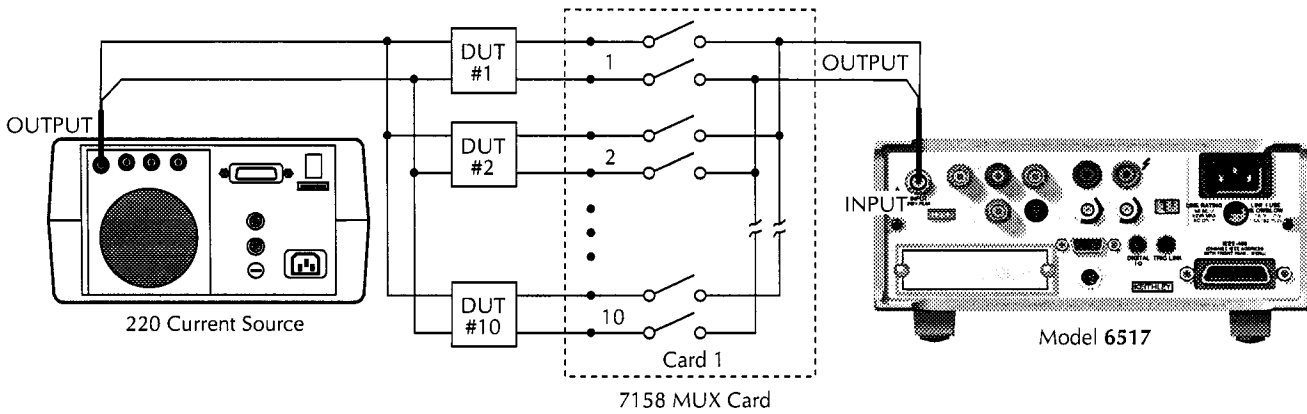
Figure 2-67
DUT test system (asynchronous example #2)
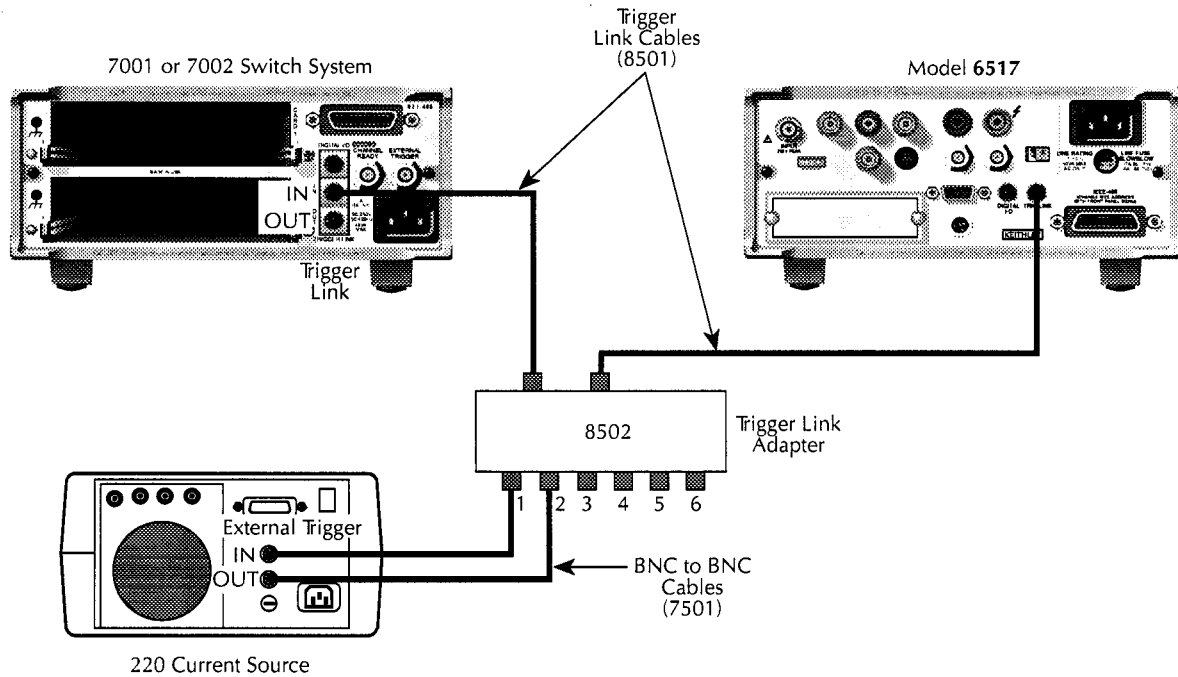
Figure 2-68
Trigger Link connections (asynchronous example #2)

Model 6517:

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 con-
dition.

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 = TrigLink
Trigger link mode = Asynchronous
Input line = #2
Output line = #1
Number of scans = 2
Scan trigger control = Source

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 6517 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 6517 waits in the measure layer for a trigger.

To run the test and store the readings in the Model 6517, press STORE on the electrometer, enter the desired number of readings (20), and press ENTER. The Model 6517 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 2-69.
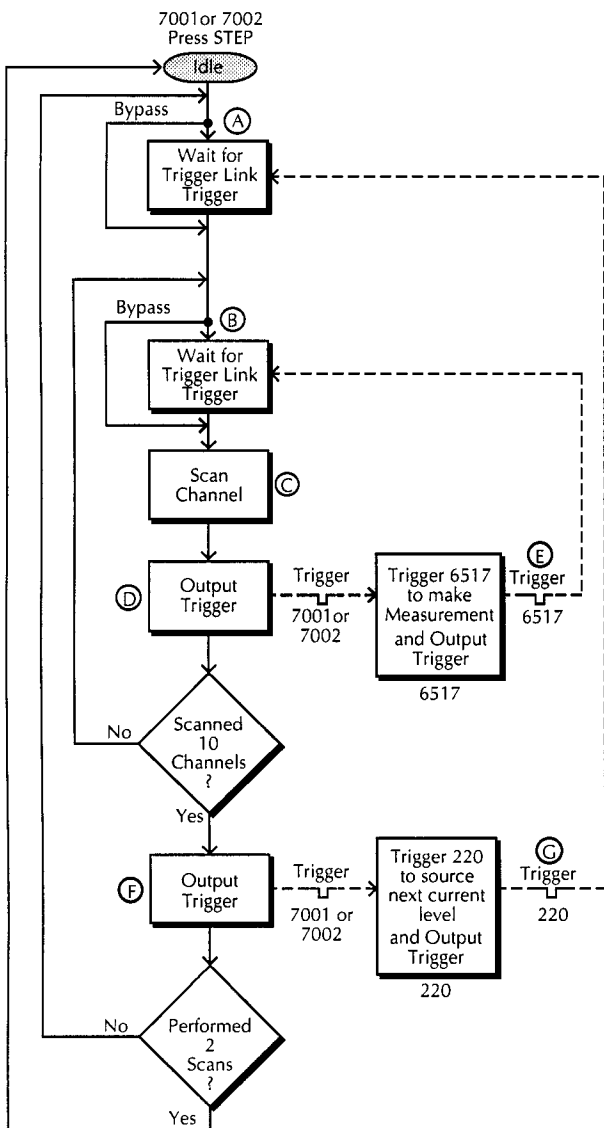
Figure 2-69
Operation model for asynchronous Trigger Link example #2

(A) Pressing STEP on the Model 7001/7002 takes it out of the idle state and places operation at point A in the flowchart. Since the arm layer is programmed for Immediate Spacing, operation drops down to the scan layer at point A.

(B) Since Scan Trigger Control of the Model 7001/7002 is set for Source, the scan does not wait at point A for a trigger. Instead, it bypasses "Wait for Trigger Link Trigger" and proceeds to point B. Note that this Bypass is in effect only on the first pass through the model.

(C) Since Channel Trigger Source of the Model 7001/7002 is also 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 outputs a Trigger Link trigger 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.

(E) The trigger pulse from the Model 7001/7002 triggers the Model 6517 to make a measurement of DUT #1. After the measurement is complete, the electrometer outputs a Trigger Link trigger pulse (point E). The trigger applied to the Model 7001/7002 from the Model 6517 closes the next channel in the scan, which in turn triggers the electrometer to measure the next DUT. This process continues until all ten channels are scanned and measured.

(F) After the last channel is scanned and measured, operation proceeds to point F, where the Model 7001/7002 outputs a trigger pulse. Since the Model 7001/7002 is programmed to perform two scans, its operation loops back up to point A, where it waits for an input trigger. Note that Bypass is no longer in effect.

(G) The trigger pulse from the Model 7001/7002 triggers the Model 220 to output the next programmed current level. After the current level is set, the Model 220 outputs a trigger pulse (point G).

The trigger pulse applied to the Model 7001/7002 from the Model 230 places operation at point B. The Bypass is again in effect because this is the beginning of a new scan. This allows operation to drop down to point C, where the first channel is again closed and eventually measured. As previously explained, all ten channels are scanned and measured.

After the last channel of the second scan is closed and measured, the Model 7001/7002 returns to the idle state.

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 2-70). 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.
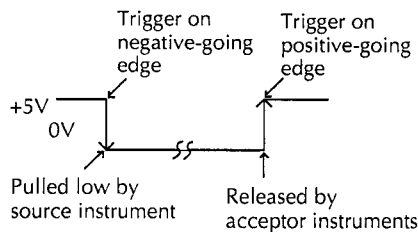
Figure 2-70
Semi-synchronous Trigger Link specifications

For example, assume that a Model 6517 is connected to two Model 7001 or 7002 Switch Systems for semi-synchronous operation, as shown in Figure 2-71. All three instruments are programmed to use trigger line #1. The two Model 7001s/

7002s have relay settling times of 10msec and 50msec, respectively. The Model 6517 is designated as the trigger control source and the two Model 7001/7002 units as trigger control acceptors.

Assume that the Model 6517 initially performs a measurement. After the reading is done, the Model 6517 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 6517 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 2-63) 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 2-72. The two instruments are configured as follows:
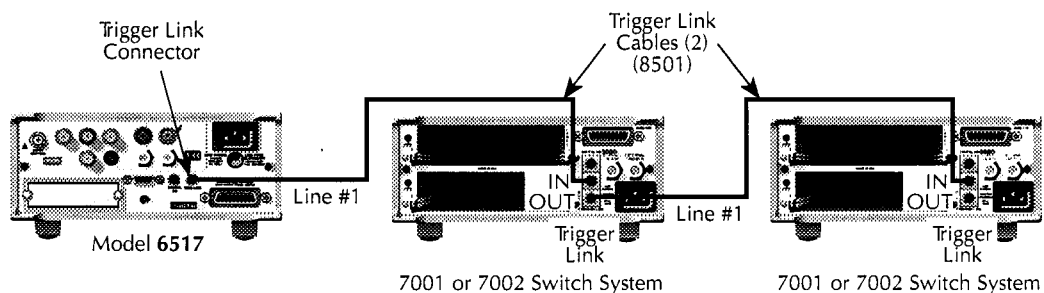
Figure 2-71
Typical semi-synchronous mode connections
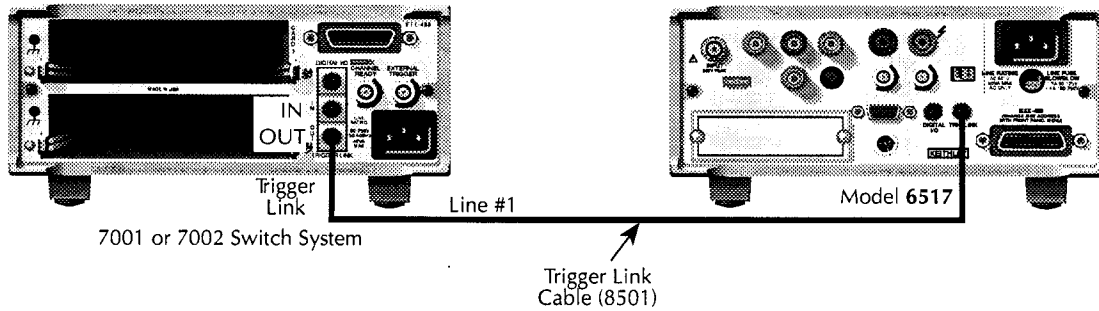
Figure 2-72
Trigger Link connections (semi-synchronous example)

Model 6517:

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 6517, press STORE on the electrometer, enter the desired number of readings (ten), and press ENTER. The Model 6517 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 2-73.
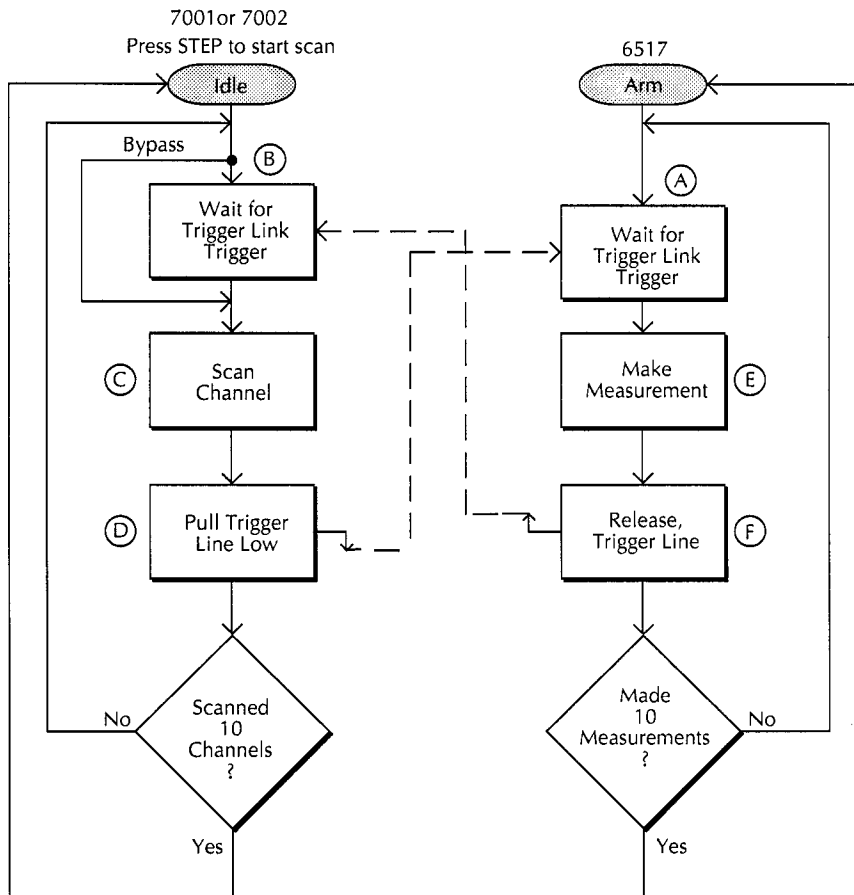
Figure 2-73
Operation model for semi-synchronous Trigger Link example

Ⓐ The BENCH RESET condition arms the Model 6517 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 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.

Ⓔ and Ⓕ Remember that the Model 6517 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 6517 to measure DUT #1 (point E). Note that the electrometer holds the trigger line low. After the measurement is complete, The Model 6517 releases the trigger line (point F) and then loops back to point A where it waits for another input trigger.

When the Model 6517 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 6517 to measure the next DUT. The process continues until all ten channels are scanned and measured.

2.16   Buffer

The Model 6517 has a buffer to store reading data. The maximum possible number of stored readings depends on how many optional data elements are selected (see Table 2-22).

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 (see paragraph 2.16.3).

Optional data elements include timestamp, humidity, external temperature and channel number (for scanning). When selected, the timestamp 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 (see paragraph 2.16.3).

The following paragraphs discuss configuration of the buffer as well as recalling buffered data. The CONFIG DATA STORE menu structure is shown and summarized in Table 2-23.

Table 2-22
Maximum buffer readings

Buffer elements					
CHANNEL	TIMESTAMP	ETEMperature	HUMIDITY	VSOURCE	Max Buffer Size =
0	0	0	0	0	15706
0	0	0	1	0	11779
0	0	1	0	0	11779
0	0	1	1	0	9423
0	1	0	0	0	10470
0	1	0	1	0	8566
0	1	1	0	0	8566
0	1	1	1	0	7248
1	0	0	0	0	13462
1	0	0	1	0	10470
1	0	1	0	0	10470
1	0	1	1	0	8566
1	1	0	0	0	9423
1	1	0	1	0	7852
1	1	1	0	0	7852
1	1	1	1	0	6730
0	0	0	0	1	11779
0	0	0	1	1	9423
0	0	1	0	1	9423
0	0	1	1	1	7852
0	1	0	0	1	8566
0	1	0	1	1	7248
0	1	1	0	1	7248
0	1	1	1	1	6282
1	0	0	0	1	10470
1	0	0	1	1	8566
1	0	1	0	1	8566
1	0	1	1	1	7248
1	1	0	0	1	7852
1	1	0	1	1	6730
1	1	1	0	1	6730
1	1	1	1	1	5889

0 = N (not included)
1 = Y (included)

2.16.1 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.

The buffer is configured from the CONFIG DATA STORE menu (see Table 2-23). This menu is displayed by pressing CONFIG and then STORE. Rules for navigating menu structures are provided in paragraph 2.3.5.

Table 2-23
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 timestamp:
Type	Check or change type:
Relative-Time	Reference timestamp to relative time.
Real-Time	Reference timestamp to real-time.
Format	Select timestamp format:
Absolute	Reference each timestamp to the first buffer reading (relative), or to the time and date (real).
Delta	Reference each timestamp to the previous buffer reading.
Elements	Enable/disable optional data elements; timestamp, humidity, external temperature, channel and V-Source.
Display	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 in number of readings. The maximum buffer size is summarized in Table 2-22.

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 with the requested number of readings and stops. You can then recall the readings.

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 PRETRIG-GER, 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 timestamp is included with each buffer reading if it is selected as a data element (see ELEMENTS). This menu selection is used to check and/or change the timestamp type and format.

TYPE: This menu item is used to check and/or change the timestamp type. Note that changing the timestamp type clears the buffer.

- RELATIVE-TIME — With this selection, timestamps are oriented to a timer with the first buffer reading timestamped at 0.000000 seconds. Each following timestamp is then based on the currently selected format (see FORMAT). With the ABSOLUTE format selected, the timestamp for each reading is referenced (in seconds) to the first buffer reading. With the DELTA format selected, each timestamp is referenced (in seconds) to the previous timestamp.
- REAL-TIME — With this selection, timestamps are oriented to the real-time clock and are based on the currently selected format (see FORMAT). With the ABSO-LUTE format selected, each reading is simply timestamped with the actual time and date. Time can be expressed in the 12-hour (AM, PM) format or the 24-hour format (see CLOCK in paragraph 2.19.8).

With the DELTA format selected, the first buffer reading is timestamped at 00000d 00h 00m 00.00s (zero days, hours, minutes and seconds). Each subsequent timestamp is referenced (in days, hours, minutes and seconds) to the previous timestamp.

Timestamp type for buffer readings is coupled to timestamp type for bus readings. Thus, if you change timestamp type from this menu structure, it also changes in the MAIN MENU structure (see TIMESTAMP in paragraph 2.19.8).

FORMAT: This menu item is used to check and/or change the timestamp format. Note that if format is changed after readings are stored in the buffer, the timestamps will change to reflect the alternate format.

- ABSOLUTE — With this selection, each timestamp provides the time and date that the reading was taken (see REAL-TIME timestamp type), or the number of seconds from the first buffer reading that the reading was taken (see RELATIVE-TIME timestamp type).

DELTA: With this selection, each timestamp is referenced to the timestamp for the previous reading. This provides the time between buffer readings. Timestamps are provided in days, hours, minutes and seconds (see REAL-TIME times-

tamp type) or in seconds (see RELATIVE- TIME timestamp 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 in 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 the RANGE ▲ or ▼ key.

The optional data elements are described as follows:

Timestamp — When selected, the timestamp will be displayed on the primary display for each stored reading. The form that timestamp 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 (see paragraph 2.16.3). Note that the appropriate sensor has to be connected to the instrument, and it has to be enabled via the DATA-STAMP item of GENERAL menu (see paragraph 2.19.7).

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 (see paragraph 2.16.3).

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.

2.16.2 Storing and recalling readings

Tables 2-24 through 2-26 detail the sequence of steps for the various modes of buffer control. The tables assume the buffer is configured as explained in paragraph 2.16.1. 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 in paragraph 2.16.3.

Table 2-24
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 ... Rdg#+00099 @Time=+002.700473 sec	
EXIT	(normal reading display)	

Table 2-25
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 2-26
Pretrigger sequence

Action	Result	Annunciator
STORE ENTER TRIG	STORE 00100 READINGS Waiting for pretrigger event Storing reading #xx of 50 Storage complete; press RECALL	(* on) (* off)
RECALL	Rdg#-00050 @Time=-004.999990 sec ... Rdg#+00000 @Time=+000.000000 sec ... Rdg#+00049 @Time=+004.899996 sec	
EXIT	(normal reading display)	

Note: A manual trigger is used as an example. Other pretrigger events include GPIB, trigger link, and external.

2.16.3 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 6517 and it has to be enabled (see A/D-CONTROLS in paragraph 2.19.7).

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 (i.e., 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:

   $$y = \frac{\sum\limits_{i=1}^{n} x_i}{n}$$

   where: x_i is a stored reading, and
   n is the number of stored readings.

   Note: 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:

$$y = \sqrt{\frac{\sum\limits_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum\limits_{i=1}^{n} x_i\right)^2}{n-1}}$$

where: x_i is a stored reading, and
n is the number of stored readings.

Note: If n ≤1, the result is NAN (not a number).

NOTE

These statistics are invalid if the measurement function changed during data store (e.g., when scanning different functions).

The Model 6517 uses IEEE-754 floating point format for math calculations.

The last display in this series allows you to dump the buffered readings to a printer. See paragraph 2.19.2 for details on configuring printers.

2.17 Filters

Filtering stabilizes noisy measurements caused by noisy input signals.

The Model 6517 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.

2.17.1 Digital Filters

Digital Filter Types

The Model 6517 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 (e.g., 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 2-74.

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 2-75.

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 both types, but thereafter moving mode yields a faster reading than repeating mode. Also, advanced has a faster response to changes in the input signal than averaging.
- Number of reading conversions: Speed and accuracy are tradeoffs.
- Noise window: For the advanced type, a tradeoff of speed, accuracy, and response to input signal changes.

2.17.2 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.
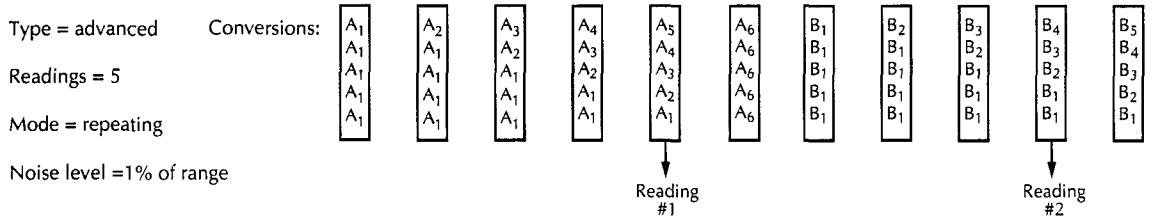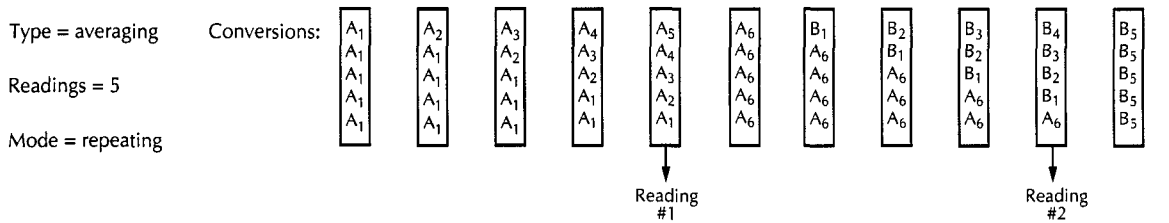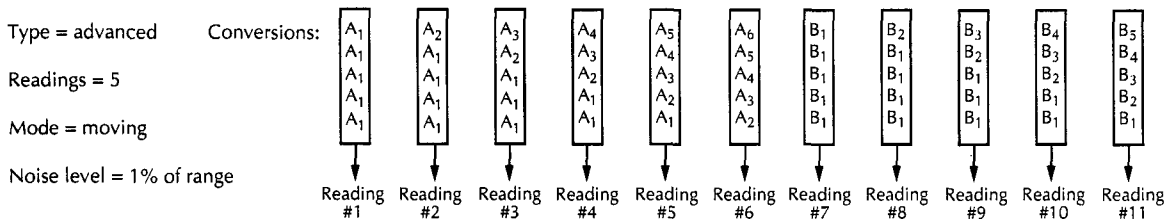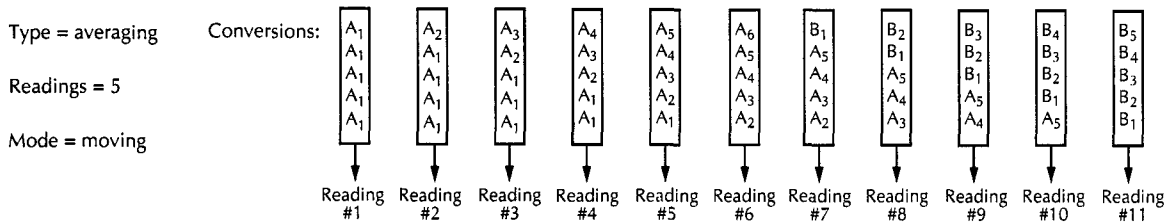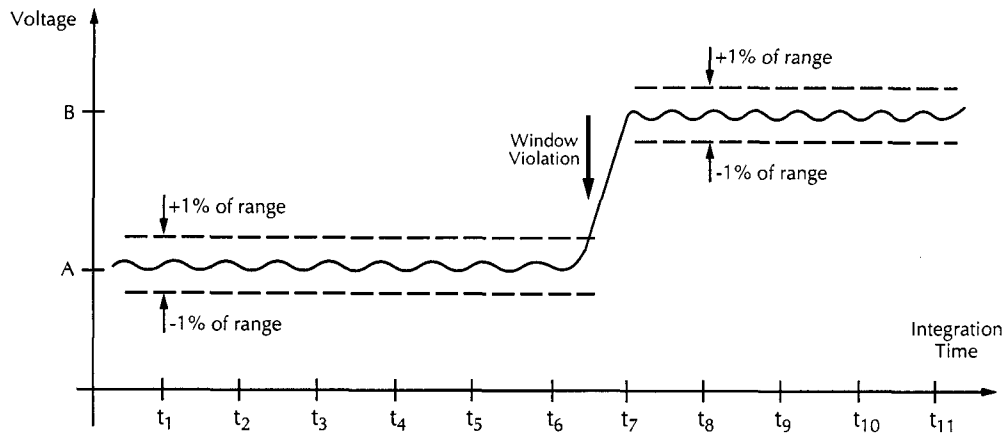
Figure 2-74
Digital filter; averaging and advanced filter types
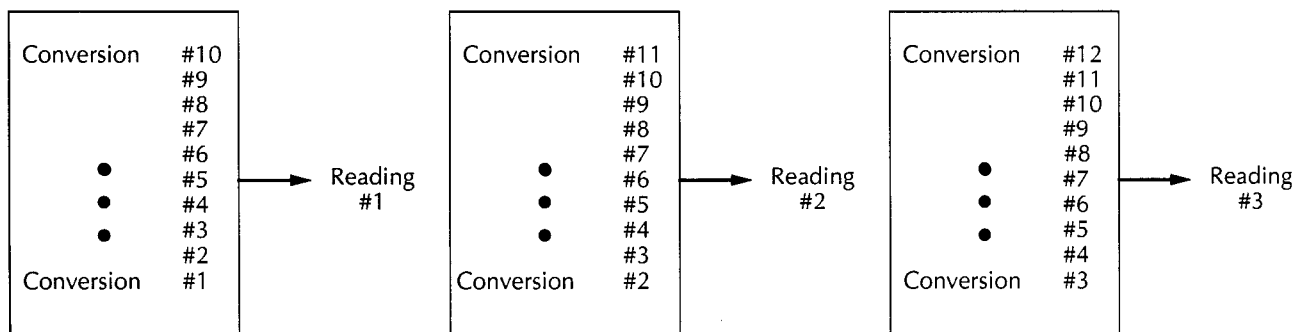
A. Type - Average, Readings = 10, Mode - Moving
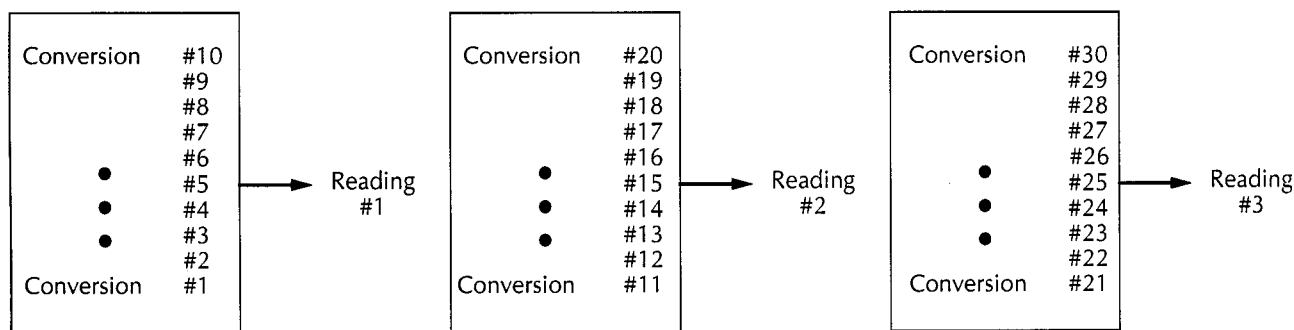
B. Type - Average, Readings = 10, Mode - Repeating

Figure 2-75
Digital filter; moving and repeating filter modes

2.17.3 Configuring the filters

Each measurement function has its own filter configuration and is summarized in Table 2-27.

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, just press CONFIG, then FILTER.

• To configure the filter of another function and remain in the present function, press CONFIG, and the appropriate function key, then select FILTER from its menu.

• To configure the filter of another function and change to that function, press the appropriate function key, and CONFIG, 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.

Table 2-27
CONFIGURE FILTER menu structure

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).

2.18 Math

Model 6517 math operations are divided into four 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 and are discussed in paragraph 2.16.3. Limit tests are described in paragraph 2.19.5, under main menu operations.

Note that once enabled for a function, the CONFIGURE MATH calculations are in effect across function changes.

NOTE

The Model 6517 uses IEEE-754 floating point format for math calculations.

2.18.1 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 (see paragraph 2.18). The before and after calculation can be viewed with one of the multiple displays, as described in paragraph 2.18.8. When necessary, the resulting Y value is displayed in scientific notation.

2.18.2 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:

$$Percent = \frac{Input\ Reading}{Target\ Value} \times 100$$

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, as described in paragraph 3.18.8, the display would be:

+100.000 V%
Reading = +1.00000

where the bottom line shows the reading (in the units and multiplier prefix of the top line) before the percentage calculation is performed.

2.18.3 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 (see paragraph 2.18.7).

2.18.4 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 (see paragraph 2.18.7).

2.18.5 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 (see paragraph 2.18.7).

2.18.6 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 6517.

$$\log_{10} 1.000000mA = -3$$

Note that this calculation uses the absolute value of the normal input reading since you cannot compute the log of a negative number.

2.18.7 Selecting and configuring math

The polynomial, percent ratio, percent deviation or logarithmic calculation is selected and configured from the CONFIGURE MATH menu (see Table 2-28). The selected calculation is enabled by pressing the MATH key (MATH annunciator turns on). The Model 6517 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 2-28
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 again press ENTER.

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.

2.18.8 Calculate 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 PREVious 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 uA, then the units on the bottom line are uA.)

2.19 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 2-29.

The top level of the main menu is displayed by placing the instrument in the reading display state, and then pressing the MENU key.

General rules to navigate the menu levels are provided in paragraph 2.3.5.

Table 2-29
MAIN MENU STRUCTURE

Menu item	Description
SAVESETUP	Setup menu:
SAVE	Save setup at a memory location (0-9).
RESTORE	Return 6517 to setup stored at a memory location (0-9).
POWERON	Power-on Menu:
BENCH	Power on to bench default setup conditions.
GPIB	Power on to GPIB default setup conditions.
USER-SETUP-NUMBER	Power on to setup stored at a memory location (0-9).
RESET	Reset Menu:
BENCH	Return 6517 to bench default setup.
GPIB	Return 6517 to GPIB default setup.
COMMUNICATION	Communications Menu:
GPIB	Select and configure GPIB:
ADDRESSABLE	Addressable menu:
ADDRESS	Check/change IEEE-488 bus address (0-30).
LANGUAGE	Select SCPI or DDC language.
TALK-ONLY	GPIB/Printer Talk-only mode menu:
INTERFACE	Select printer interface:
IEEE-488	Specify IEEE-488 printer.
CENTRONICS	Specify Centronics parallel printer.
INTERVAL	Specify printing interval (every reading to 1 out of 9999).
FORMFEED	Formfeeds menu:
CONTROL	Enable/disable page breaks.
SET-PAGE-SIZE	Set number line between form feeds (1-255).
ELEMENTS	Select GPIB data elements (reading, units, reading number, relative humidity, channel number, timestamp, internal temperature, external temperature, status).
STATUS	Display IEEE-488 bus status byte.
RS-232	Select and configure RS-232:
CONTROL	Select operating mode:
SEND-RECEIVE	Send receive mode.
TALK-ONLY	Talk-only mode; set up printer interval and formfeeds.
BAUD	Select baud rate (19,200, 9600, 4800, 2400, 1200, 600 or 300).
BITS	Select number of data bits (7 or 8).
PARITY	Select parity (none, odd or even).
STOP	Select stop bits (1 or 2).
ELEMENTS	Select data elements (reading, units, reading number, relative humidity, channel number, timestamp, internal temperature, external temperature, status).
TEST	Self-test menu:
BUILT-IN-TEST	Test analog and digital boards.
AUTOMATIC	Run all test automatically.
MANUAL	Select tests to run.
DIAGNOSTICS	Factory diagnostic tests.
FRONT-PANEL-TESTS	Test display board.
KEYS	Verify operation of front panel keys.
DISPLAY-PATTERNS	Verify operation of display.
CHAR-SET	Display the entire character set.

Table 2-29 (cont.)
MAIN MENU STRUCTURE

Menu item	Description
LIMITS	Limits menu:
LIMIT-SET-1	Limit-Set-1 menu:
CONTROL	Enable/disable limit set #1.
LOLIM1	Set value of low limit #1.
HILIM1	Set value of high limit #1.
LIMIT-SET-2	Limit-Set-2 menu:
CONTROL	Enable/disable limit set #2.
LOLIM2	Set value of low limit #2.
HILIM2	Set value of high limit #2.
STROBE-CONTROL	Enable/disable limit strobe signal of digital output #4 when trigger occurs.
PASS-PATTERN	Specify patterns on digital outputs to signify limit pass.
STATUS-MSG	Enable/disable status message mode.
GENERAL	General menu:
DIGOUT	Digital output menu:
STATE	Check/change states of digital output lines.
LOGIC-SENSE	Check/change sense of digital output lines.
SERIAL #	Display serial number, memory option SCPI version, and firmware revisions.
A/D-CONTROLS	A/D menu:
LINE-SYNC	Enable/disable line synchronization. Also displays power line frequency.
DATA-STAMP	Configure A/D to measure additional inputs (humidity and external temperature).
LIMIT-CTRL	Enable/disable A/D hardware limit.
TIMESTAMP	Configure timestamp:
TYPE	Check or change type.
RELATIVE-TIME	Reference timestamp to relative time.
REAL-TIME	Reference timestamp to real time.
RESET-TIME	Reset relative timestamp to zero.
RESET-RDG#	Reset reading number to zero.
DISPLAY	Display menu:
NUMERIC-FORMAT	Select measurement units (engineering or scientific).
DECIMAL-CHAR	Select period or comma as decimal point.
CLOCK	Clock menu:
TIME	Check or set time of day.
DATE	Check or set date.
FORMAT	Select clock format: (12-hour or 24-hour format).

2.19.1 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-on 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 A and V 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) 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 keys (▲ and ▼) to key in 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 on power-on.

The instrument can be set to power on to the factory bench defaults, the factory GPIB defaults, or to a user setup stored (see SAVE) 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 (see Table 2-30) the next time it is turned on.

GPIB: With this option, the unit returns to the GPIB default conditions (see Table 2-30) the next time it is turned on.

USER-SETUP-NUMBER: Using this option, the instrument powers on to as user setup saved at a specific memory location (see SAVE).

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 keys (A and V) to key in 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 2-30). The RESET options are explained as follows:

BENCH: With this option, the instrument returns to the bench default conditions (see Table 2-30). 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 2-30). 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 2-30
Factory default conditions

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

Table 2-30 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
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	Off
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	Off
Function	Percent	Percent
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 (2µC)	Manual (2µC)
Autorange	Off	Off
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 2-30 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
R (Ohms):		
Auto V-Source Ohms		
Range	Manual (2MΩ)	Manual (2MΩ)
Autorange	Off	Off
Limits	Use all ranges	Use all ranges
Auto V-Source Ohms		
Range	Manual (200kΩ)	Manual (200kΩ)
Autorange	Off	Off
Limits	None	None
V-Source	Manual	Manual
Relative	Off	Off
Value Auto	0.0	0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Scanning:		
Scan Type	Internal	Internal
Internal Scan:		
Channels	All	All
Count	10	10
Memory	Yes	Yes
Scan Mode	Voltage	Voltage
Settling Time	0.0 sec	0.0 sec
Timer	No	No
Interval	2.5 sec	2.5 sec
V-Source Limit	Yes	Yes
External Scan:		
External Inputs	10	10
Trigger Source	Triglink	Triglink
Scan Count	10	10
Timer	No	No
Interval	2.5 sec	2.5 sec
Memory	Yes	Yes
Speed	Normal (1 PLC)	Normal (1 PLC)
Status Messages	Off	Off
Timestamp	No effect	No effect

Table 2-30 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
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
Bias Time	1 sec	1 sec
Discharge Time	2 sec	2 sec
Cable:		
Bias Voltage	1V	1V
Bias Time	1 sec	1 sec
Resistor:		
Source V1	1V	1V
Delay 1	1 sec	1 sec
Source V2	2V	2V
Delay 2	2 sec	2 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	0 sec	0 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	0 sec	0 sec
Discharge Time	2 sec	2 sec
SIR:		
Bias Voltage	50V	50V
Bias Time	1 sec	1 sec
Measure Voltage	100V	100V
Measure Time	1 sec	1 sec
Square Wave Sweep:		
High Level	1V	1V
High Time	1 sec	1 sec
Low Level	-1V	-1V
Low Time	1 sec	1 sec
Cycle Count	10	10

Table 2-30 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
Test Sequence		
Staircase Sweep:		
Start	1V	1V
Stop	10V	10V
Step	1V	1V
Step Time	1 sec	1 sec
Start Source	Manual	Manual
Triglink Line	Line #1	Line #1
Triggers	Advanced (armed)	Advanced (idled)
Advanced:		
Measure Layer:		
Source	Immediate	Immediate
Triglink Mode	Asynchronous	Asynchronous
Triglink Input	Line #2	Line #2
Triglink Output	Line #1	Line #1
Delay	0.0 sec	0.0 sec
Count	Infinite	1
Control	Acceptor	Acceptor
Scan Layer:		
Source	Immediate	Immediate
Triglink Input	Line #2	Line #2
Triglink Output	Line #1	Line #1
Delay	0.0 sec	0.0 sec
Count	Infinite	1
Control	Acceptor	Acceptor
Arm Layer:		
Source	Immediate	Immediate
Triglink Input	Line #2	Line #2
Triglink Output	Line #1	Line #1
Count	1	1
Control	Acceptor	Acceptor
Basic:		
Trigger Mode	Continuous	Continuous
Trigger Source	Immediate	Immediate
Timer Interval	0.1 sec	0.1 sec
V (Volts):		
External Feedback	Off	Off
Guard	Off	Off
Range	Manual (200V)	Manual (200V)
Autorange	Off	Off
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.

2.19.2 COMMUNICATION

The COMMUNICATION menu option allows you to select and configure the GPIB or RS-232 bus.

> **NOTE**
>
> 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 GPIB language (SCPI or DDC).
- To select the talk-only mode and its parameters.
- To select the data elements to send.
- To view the status byte of the instrument.

Changing between "Addressable" and "Talk-only" causes triggers to be halted.

ADDRESSABLE: With the instrument set for "Addressable", it can listen and talk to a bus controller:

- ADDRESS — This menu item lets you check and/or 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 ▲ and ▼ keys to display the desired number and press ENTER.

- LANGUAGE — This menu item is used to select the language for the GPIB:

> **NOTE**
>
> Selecting the alternate language (SCPI or DDC) resets the instrument to the power-on defaults. This reset action causes the instrument to exit from the MAIN MENU.

SCPI — Select this option to use the SCPI programming language to control the instrument.

DDC — Select this option to use Device-Dependent Command programming. This mode allows you control both a Model 6517 and a 617 electrometer over the GPIB using the same DDC commands. See Section 3 of this manual for details.

TALK-ONLY: In the talk-only mode, the Model 6517 ignores commands from the bus and merely outputs data, as requested by the printer. When the instrument is in the talk-only mode, the TALK annunciator turns on.

The options for TALK-ONLY are explained as follows:

- INTERFACE — With the IEEE-488 option of this item, data elements are sent to an IEEE-488 bus printer set for listen always. With the CENTRONICS option, data elements are sent to a printer with a Centronics (parallel) interface. The printer must be connected with a Model 8530 IEEE-488 to Centronics Printer Adapter Cable.
- INTERVAL — The INTERVAL option controls how often readings are printed (expressed as 1 out of nnnn readings).
- FORMFEED — Use the FORMFEED option of the menu to enable or disable the sending of a formfeed character to the printer after printing a user-selectable number of lines per page (1-255 lines).

ELEMENTS: This menu item lets you select the data elements sent. Use one of the range keys 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 (see paragraph 2.19.7).
- 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 (see paragraph 2.19.7).
- 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 (see paragraph 2.19.7).
- TIME — The real-time or relative timestamp for each reading. Timestamp type is selected from the TIMESTAMP item of the GENERAL MENU (see paragraph 2.19.7).
- STATUS — The reading status information (normal reading, measurement overflow or 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 select the control mode; send/receive or talk-only.
- To set the parameters for talk-only.
- To set the parameters for the RS-232 interface (baud rate, number of data bits and stop bits, and parity.
- To select the data elements to send.

See Section 3 of this manual for details on using the instrument over the RS-232 serial interface.

CONTROL: Use this menu item to select one of the operating modes for the RS-232 Interface:

- SEND-RECEIVE — This is the normal operating mode for sending commands to the instrument and for sending data from the instrument to the computer.
- TALK-ONLY — In the talk-only mode, the instrument ignores commands and simply outputs data, as requested by the printer. When the instrument is in the talk-only mode, the TALK annunciator turns on. The options for talk-only are explained as follows:

INTERVAL: This option controls how often readings are sent (printed). The interval is expressed as 1 out of nnnn readings.

FORMFEEDS: This option is used to control (enable or disable) page breaks and specify the number of lines per page. When enabled, a form feed occurs after the specified number of lines are printed.

BAUD: Use this option to set the baud rate for the RS-232 serial interface. Selections include 19200, 9600, 4800, 2400, 1200, 600 and 300 bits per second.

BITS: Use this option to select the number of data bits (7 or 8) to send over the RS-232 serial interface.

PARITY: Use this option to select parity for the RS-232 serial interface. Selections include none, odd or even parity.

STOP: Use this menu item to select the number of stop bits to use (1 or 2).

ELEMENTS: This menu item lets you select the data elements sent. Use one of the range keys 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 (see paragraph 2.19.7).
- 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 (see paragraph 2.19.7).
- 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 (see paragraph 2.19.7).
- TIME — The real-time or relative timestamp for each reading. Timestamp type is selected from the TIMESTAMP item of the GENERAL MENU (see paragraph 2.19.7).
- STATUS — The reading status information (normal reading, measurement overflow or underflow, relative reading).
- VSRC — The actual output level of the V-Source.

2.19.3 CAL

The CALIBRATION menu is used to calibrate the Model 6517.

COMPREHENSIVE, POINT-CALS and CAL-OPT

These procedures for calibration are locked. These procedures require accurate calibration equipment and should only be performed by qualified personnel. Refer to the Model 6517 Service Manual for details.

CAL-DATES

Use this menu item to view or change the calibration dates. Use the VIEW option of the menu to display the last calibration date and the next calibration date. The DISPLAY-AT-POWERUP option controls whether the next calibration date is displayed during the power-up sequence.

The CHANGE option is locked, to enable it requires the CAL switch to be pressed. The option allows you to change the calibration date and next calibration date. Refer to the Model 6517 Service Manual for instructions.

OFFSET-ADJ

Use this menu item to calibrate voltage burden and input offset current. After selecting OFFSET-ADJ, you will be prompted to connect a short to the input triax connector and then press ENTER. The message "Performing V offset calibration" will be displayed while calibration is in process. When finished, you will be prompted to remove the short, cap the triax input connector and then press ENTER. The message "Performing I Bias calibration" will be displayed while calibration is in process.

2.19.4 TEST

The SELF-TEST MENU is used as a diagnostic tool to isolate problems with the Model 6517. Information on using these test procedures is included in the optional Model 6517 Repair Manual.

2.19.5 LIMITS

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.

NOTE

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 0.6MΩ 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. (Also see DIGOUT in paragraph 2.19.8).

LIMIT-SET-1 and LIMIT-SET-2

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 item 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 the range keys 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.

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 2-76.

Note that the Model 6517 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.

LLIM1 | | | | | HLIM1

Low Limit #1

High Limit #1

Average of midpoint
and Low Limit #1

Average of midpoint
and High Limit #1

Midpoint of Low Limit #1
and High Limit #1
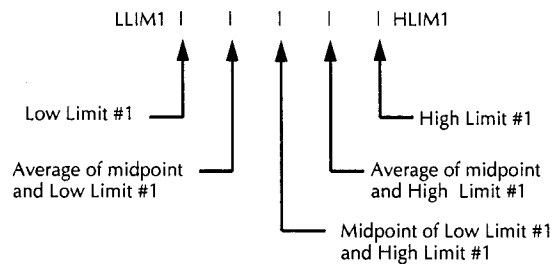
A. Defined points of display

Reading   Pass/Fail indication

-0.2836   V   PASS

LLIM1 | | ===| | | HLIM1

-1V   0V   1V

30% of difference between
midpoint and Low Level #1
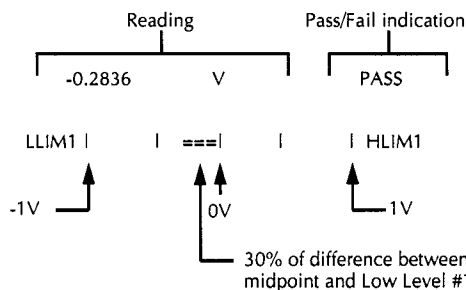
NOTES : 1. Press INFO to view the programmed Low Limit #1 and
            High Limit #1 values.
        2. Multiple display of limit values do not use unit prefixes
            (i.e., volts not millivolts).

B. Example Display with Limits = ±1V

Figure 2-76
Limits bar graph example

STROBE-CONTROL

This menu item 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 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

This 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 the range keys. 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 2-77. Use the following procedure to program the limits:

1. From the LIMITS menu, set the limit values and actions according to the following table:

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.
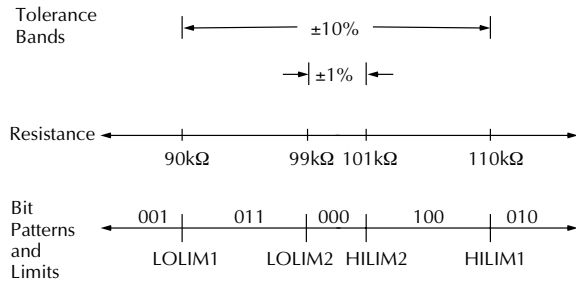
Figure 2-77
Using limit test to sort 100kΩ resistors

2.19.6 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 get out of this mode.

2.19.7 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 6517.
- To set line synchronization of readings, display the frequency of the line power, and configure the A/D to measure humidity and/or external temperature.
- To configure timestamp.
- To choose the character displayed for a decimal and select measurement units.
- To set the real-time clock.

DIGOUT (Digital I/O menu)

Access the DIGOUT menu as follows:

1. From the main menu, select the GENERAL menu.
2. Use the ◄ and ► keys to highlight DIGOUT, and press Enter. The following will be displayed:

   DIGOUT
   STATE   LOGIC-SENSE

Digital I/O port

The Model 6517's Digital I/O port is an 8-pin micro-DIN socket located on the rear panel. The port's location and pin designations are shown in Figure 2-78.
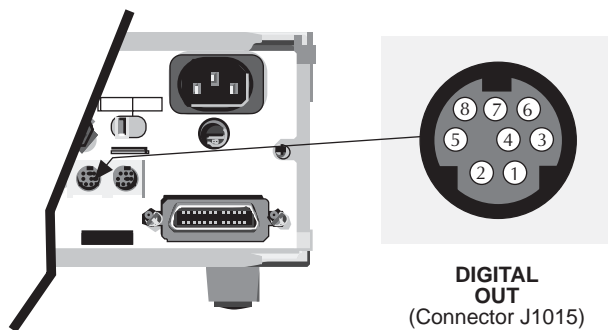
**DIGITAL
OUT**
(Connector J1015)

Pin Designation

1 = +5V
2 = Data In (calibration fixture use*)
3 = V_EXT flyback connection (+5V to +30V)
4 = Digital output #4
5 = Digital output #3
6 = Digital output #1
7 = Digital output #2
8 = Digital ground

*Pin 2 is for use with Model 5156 Calibration Source

Figure 2-78
Digital I/O port

The Model 6517's 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 — refer to the Model 6517 Service Manual). 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.

Controlling digital circuitry

Each of the four digital, open-collector outputs (connector J1015, pins 4 through 7) 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). Paragraph 2.19.5 contains information on controlling digital outputs from the limits menu.

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 2-79 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 J1015 (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 J1015 (the digital I/O port). Applying current or voltage exceeding these limits may damage the instrument.
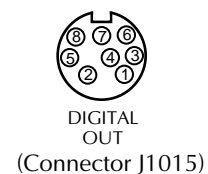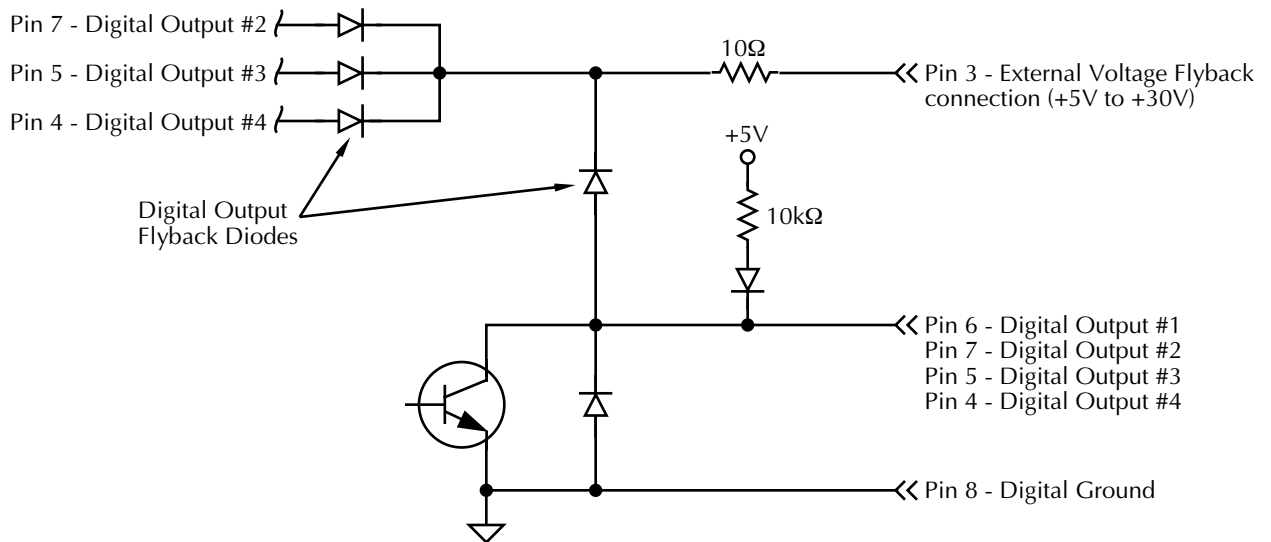
Figure 2-79
Digital I/O port simplified schematic

An externally powered relay connected to the digital output port is shown in Figure 2-80. Other externally powered devices can be similarly connected by replacing the relay with the device. When using the Model 6517's collector outputs to turn on 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 6517 digital outputs to the logic inputs.
2. Connect the digital grounds.
3. Using the STATE menu, check output state setting of the Model 6517 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 6517 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 low (0V), the output sink can drive at least 10 standard TTL inputs. When high (+5V), the 10kΩ pull-up resistor will source >100μA while remaining at a >3.75V output (a reliable logic high).
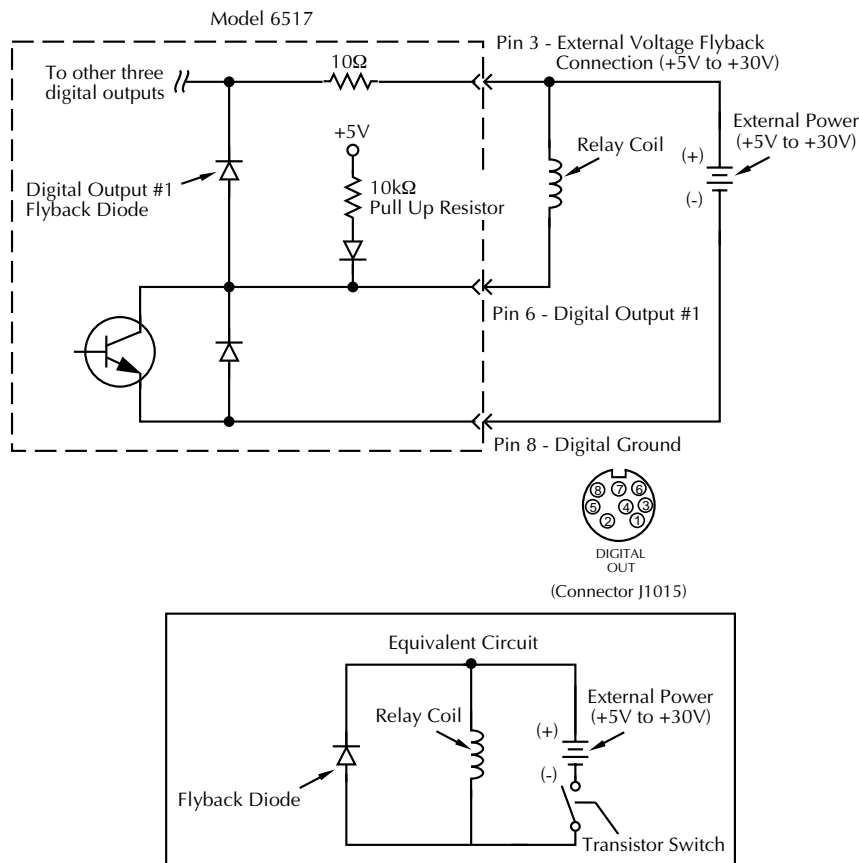
Figure 2-80
Sample externally powered relays

2.20 Scanning

The Model 6517 can be used with an internal scanner card (i.e., Model 6521 or 6522) or with external scanner cards installed in switching mainframes such as the Models 706, 7001 and 7002.

A scanner allows you to switch among a number of input signals to the Model 6517 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.

2.20.1 Internal scanning

By installing one of the optional scanner cards in the rear panel option slot, the Model 6517 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. For example, to use the Model 6521 scanner card, refer to the Model 6521/6522 Instruction Manual for operating information.

2.20.2 External scanning

When using external scanning, you can configure the Model 6517 to measure up to 400 channels. In order to synchronize Model 6517 measurements with external channel closure, connect the Model 6517 external trigger inputs or the trigger link to the external switching mainframe trigger inputs and outputs. Refer to paragraphs 2.15.4 and 2.15.5 for examples on using external triggering and the trigger link.

Use the following information to configure the Model 6517 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. General rules to navigate through the menus are provided in paragraph 2.3.5.

1. Set up the Model 6517 for the desired measurement (i.e., set function, range, etc.).

NOTE

If there is no card installed in the option slot of the Model 6517, 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 ENTERNAL-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.

NOTE

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 6517:

SELECT TRIG SOURCE
TRIGLINK   EXTERNAL   TIMER   GPIB
MANUAL   IMMEDIATE

These trigger sources are explained in paragraph 2.15.

6. The next message will prompt you to set the external scanner to the trigger source that you selected in step 6 for the Model 6517. 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 6517. 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 6517. If you selected TIMER as the trigger source in step 6, select YES. You will then be prompted to enter the interval between triggers (0.001 sec to 999999.999 sec). 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 paragraph 2.16 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.

2.21 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.

2.21.1 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 2-80 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.

To prevent ground loops, instruments should be connected to ground at only a single point, as shown in Figure 2-81. 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 2-80
Multiple ground points create a ground loop
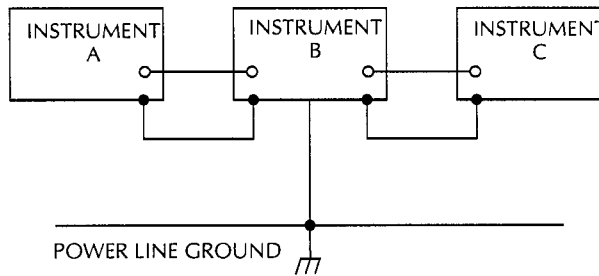
Figure 2-81
Eliminating ground loops

2.21.2 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 Model 7078-TRX triax cables are low noise.

• Use the shortest cables possible, and secure them (i.e., taping or tying) to a non-vibrating surface to keep them from moving.

2.21.3 Piezoelectric and stored charge effects

Piezoelectric currents are generated when mechanical stress is applied to certain insulating materials (i.e., 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.

2.21.4 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 deceases 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. Paragraph 2.4.6 provides general cleaning tips.

2.21.5 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 (see paragraph 2.21.4). To minimize the effects of moisture, keep humidity to a minimum (ideally <50%), and keep components and connectors in the test system clean. Paragraph 2.4.6 provides general cleaning tips.

2.21.6 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 (i.e., Keithley test fixtures) provide adequate light protection, others may allow sufficient 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.

2.21.7 Electrostatic interference

Electrostatic interference occurs when a 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 6517 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.

2.21.8 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.

2.21.9 RFI/EMI

Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI) are general terms frequently used to describe electromagnetic interference over a wide range of frequencies across the spectrum. RFI can be especially troublesome at low signal levels, but it may also affect higher level measurements in extreme cases.

RFI or EMI can be caused by steady-state sources such as TV or radio broadcast signals, or it can result from impulse sources, as in the case of arcing in high-voltage environments. In either case, the effect on instrument performance can be considerable if enough of the unwanted signal is present. The effects of RFI/EMI can often be seen as an unusually large offset, or, in the case of impulse sources, sudden, erratic variations in the displayed reading.

RFI/EMI can be minimized by taking one or more of several precautions when operating the Model 6517 in such environments. The most obvious method is to keep the instrument and experiment as far away from the RFI/EMI source as possible. Shielding the instrument, experiment, and test leads will often reduce RFI/EMI to an acceptable level. In extreme cases, a specially constructed screen room may be necessary to sufficiently attenuate the troublesome signal.

If all else fails, 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-pole 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 other detrimental effects (such as increased response time) on the measurement.

2.22 Relative humidity and external temperature readings

With the appropriate options connected, the Model 6517 can measure relative humidity and external temperature. Humid-

ity and external temperature readings are provided as a multiple (NEXT) display for each function (see paragraph 2.3.4). These readings can also be included as data elements for the bus interfaces (GPIB and RS-232), and for the buffer. See paragraphs 2.16 (Buffer) and 2.19.2 (Communication) for details.

Relative humidity

The Keithley 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 6517. Note that an extension cable (Model 8503) is available for the humidity sensor.

Humidity measurements are controlled (enabled or disabled) from the A/D-CONTROLS (DATA-STAMP) item of the GENERAL MENU (see paragraph 2.19.7).

External temperature

The Keithley 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 6517.

External temperature readings are controlled (enabled or disabled) from the A/D CONTROLS (DATA-STAMP) item of the GENERAL MENU. Measurement units (°C, °F or K) are selected from the DISPLAY (TEMP-UNITS) item of the GENERAL MENU. The GENERAL MENU is covered in paragraph 2.19.7.

NOTE

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.

3

IEEE-488 Reference

3.1   Introduction

This section contains information on remote operation for the Model 6517 and is organized as follows:

3.2   Connections: Explains instrument connections to the IEEE-488 bus and RS-232 interface.

3.3   GPIB address selection: Explains how to set the primary address from the front panel.

3.4   GPIB programming language selection: Explains how to select the SCPI or DDC programming language.

3.5   QuickBASIC 4.5 programming: Summarizes programming using QuickBASIC 4.5 with the KPC-488.2 interface and Universal Language Driver (CECHP).

3.6   General bus commands: Covers the general IEEE-488 commands required for basic operations, such as placing the unit in remote.

3.7   Front panel aspects of IEEE-488 operation: Covers status indicators, messages that pertain to bus operation, and the use of the LOCAL key.

3.8   Status structure: Explains the various registers and queues that make up the status structure of the Model 6517.

3.9   Trigger model: Explains the operation process (Trigger Model) over the IEEE-488 bus.

3.10   Program message syntax: Covers the syntax rules for common commands and SCPI commands.

3.11   Common commands: Covers the IEEE-488.2 common commands used by the Model 6517.

3.12   SCPI Signal oriented measurement commands: Covers the signal oriented commands used by the Model 6517.

3.13-3.26   SCPI command subsystems: Covers the SCPI commands used by the Model 6517.

3.27   RS-232 interface: Explains how to use the Model 6517 from the RS-232 interface.

3.28   DDC programming language: Summarizes the use of device-dependent command (DDC) programming using the DDC language.

The IEEE-488 is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) 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 Model 6517 conforms to these standards.

The Model 6517 also conforms to the IEEE-488.2-1987 standard and the SCPI 1991 (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.

A DDC language is also available for IEEE-488 bus operation. In this mode, device-dependent commands (DDCs) are used instead of SCPI and common commands. This mode is used when you want to use the Model 6517 as a "drop-in" replacement for the Model 617. This allows an existing program written for the Model 617 to be used by the Model 6517 without having to make any code modifications.

RS-232 serial port

The Model 6517 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.

3.2   Connections

The following information shows how to make connections using the IEEE-488 bus or the RS-232 serial port.

3.2.1   IEEE-488 bus connections

The Model 6517 can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example is shown in Figure 3-1. 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. Current standards call for metric threads, which are identified with dark colored screws. Earlier versions had different screws, which were silver colored. Do not attempt to use these type of connectors on the instrument, which is designed for metric threads.
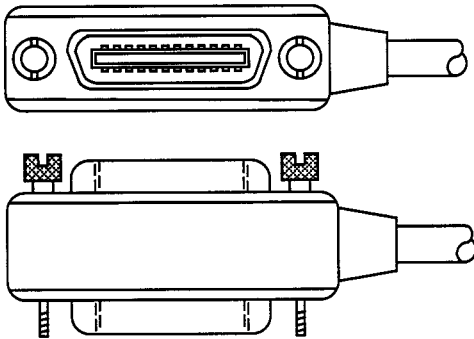
Figure 3-1
IEEE-488 connector

A typical connecting scheme for a multi-unit test system is shown in Figure 3-2. 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.
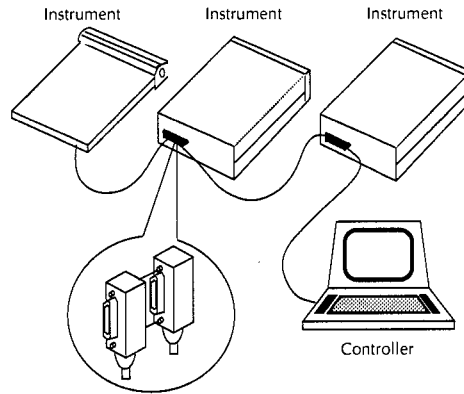
Figure 3-2
IEEE-488 connections

NOTE

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley.

Connect the Model 6517 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 3-3 shows the location of the IEEE-488 connector on the instrument.
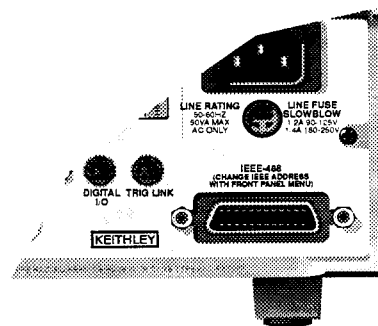
Figure 3-3
IEEE-488 connector location

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

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.

3.2.2 RS-232 serial interface connections

The serial port of the Model 6517 can be connected to the serial port of a computer or listening device (i.e., 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 3-4 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).

Pin Number	Designation
2	Transmitted Data (Tx)
3	Received Data (Rx)
5	Signal Ground (Gnd)

RS232
Rear Panel Connector
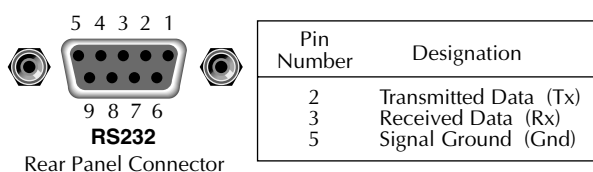
Figure 3-4
RS-232 interface connector

3.3 GPIB primary address selection

The Model 6517 is shipped from the factory with a 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 (◄ and ►) 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.

NOTE

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 SET-UP menu.

4. Place the cursor on ADDRESSABLE and press ENTER. The ADDRESSABLE GPIB menu will be displayed.
5. Place the cursor on ADDRESS and press ENTER.
6. 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)

7. To retain the displayed address, press EXIT four times to return the instrument to the measurement display state.
8. To change the primary address, use the ◄ and ► keys and the RANGE ▲ and ▼ keys to display the new address value (0 to 30). The ◄ and ► keys control cursor position and the ▲ and ▼ keys increment and decrement the selected digit.
9. 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.
10. Press EXIT three times to return to the measurement display state.

NOTE

Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.

3.4 GPIB programming language selection

When using the Model 6517 over the GPIB interface, you can use either SCPI commands and common commands, or DDCs. Most of the information in this manual documents the SCPI programming language. See paragraph 3.28 for information on using the DDC progrmming language.

Perform the following steps to check or change the GPIB programming language:

1. Display the MAIN MENU by pressing the MENU key.
2. Use the cursor keys (◄ and ►) to place the cursor on COMMUNICATION and press ENTER. The COM-MUNICATIONS SETUP menu will be displayed.
3. Place the cursor on GPIB and press ENTER. The GPIB/ PRINTER SETUP menu will then be displayed.
4. Place the cursor on ADDRESSABLE and press EN-TER. The ADDRESSABLE GPIB menu will be displayed.
5. Place the cursor on LANGUAGE and press ENTER to display the GPIB LANGUAGE selections (SCPI and DDC).
6. The cursor position (flashing menu item) indicates the present GPIB progrmming language.

7. To retain the present selection, press ENTER or EXIT. Press EXIT three more times to return the instrument to the measurement state.

8. To change the programming language, place the cursor on the alternate selection and press ENTER. The instrument will then reset to the power-on default conditions.

3.5 QuickBASIC 4.5 programming

Programming examples are written in Microsoft QuickBA-SIC 4.5 using the Keithley KPC-488.2 (or Capital Equipment Corporation) IEEE interface and the HP-style Universal Language Driver (CECHP).

Before any programming example can be run, the Universal Language Driver must first be installed. From DOS, execute the following command to install the driver:

cechp

If you include the CECHP command in your AUTOEX-EC.BAT file, the driver will automatically be installed every time you turn on your computer.

Program fragments

Program fragments are used to demonstrate proper programming syntax. As the name implies, only a fragment of the whole program is used in order to avoid redundancy.

At the beginning of each program, driver files have to be opened and the input terminator should be set for CRLF as follows:

```
OPEN "ieee" FOR OUTPUT AS #1
OPEN "ieee" FOR INPUT AS #2
PRINT #1, "interm crlf"
```

A typical program fragment includes an OUTPUT command and an ENTER command. The OUTPUT command sends a program message (command string) to the Model 6517. If the program message includes a query command, then the ENTER command is required to get the response message from the Model 6517. The ENTER command addresses the Model 6517 to talk. The following example program fragment demonstrates how OUTPUT and ENTER are used. Note that the commands assume address 27 which is the factory set address of the Model 6517.

```
PRINT #1, "output 27; :func 'volt:ac'; func?"
PRINT #1, "enter 27"
```

If you wish to display the response message on the CRT, the computer will have to read the message and then printed it to the CRT display as follows:

```
LINE INPUT #2, A$
PRINT A$
```

The following programming example shows how all the above statements are used together. The program fragment is shown in bold typeface.

```
OPEN "ieee" FOR OUTPUT AS #1         ' Open driver
OPEN "ieee" FOR INPUT AS #2          ' Open driver
PRINT #1, "interm crlf"              ' CRLF terminator
  ' Select volts and query
PRINT #1, "output 27; :func 'volt:dc'; func?"
PRINT #1, "enter 27"         ' Get response message
LINE INPUT #2, A$            ' Read response message
PRINT A$                     ' Display message
```

3.6   General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. Table 3-1 lists the general bus commands. Also included is the programming statement for each command using the Keithley KPC-488.2 IEEE interface and the HP-style Universal Language Driver (CECHP). Note that the commands requiring that a primary address be specified assume that the address is set to 27. This is the address that is set at the factory.

3.6.1   REN (remote enable)

The remote enable command is sent to the Model 6517 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 true does not actually place the instrument in the remote state. Instead the instrument must be addressed to listen after setting REN true before it goes into remote.

Note that the instrument need not be in remote to be a talker.

Program fragment

```
PRINT #1, "remote 27"        ' Place 6517 in re-
                               mote; turn on REM
                               annunciator
```

Note that all front panel controls except for LOCAL (and POWER) are inoperative while the instrument is in remote. You can restore normal front panel operation by pressing the LOCAL key.

3.6.2   IFC (interface clear)

The IFC command is sent by the controller to place the Model 6517 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 100µsec.

Program fragment

```
PRINT #1, "output 27; *idn?" ' Send query com-
                               mand
PRINT #1, "enter 27"         ' Read data; turn
                               on TALK annuncia-
                               tor
SLEEP 3                      ' Wait 3 seconds
PRINT #1, "abort"            ' Talker      idle
                               state;turn   off
                               TALK annunciator
```

Table 3-1
General bus commands and associated statements

Command	Programming statement	Effect on Model 6517
REN	REMOTE 16	Goes into effect when next addressed to listen.
IFC	ABORT	Goes into talker and listener idle states.
LLO	LOCAL LOCKOUT	LOCAL key locked out.
GTL	LOCAL 16	Cancel remote, restore front panel operation for 6517.
	LOCAL	Cancel remote, restore front panel operation for all devices.
DCL	CLEAR	Returns all devices to known conditions.
SDC	CLEAR 16	Returns Model 6517 to known conditions.
GET	TRIGGER 16	Initiates a trigger.
SPE, SPD	SPOLL 16	Serial Polls the Model 6517.

3.6.3 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.

Program fragment

```
PRINT #1, "remote 27"        ' Place 6517 in re-
                               mote
PRINT #1, "local lockout"    ' Lock  out  front
                               panel (including
                               LOCAL key)
SLEEP 6                      ' Wait  6 seconds
PRINT #1, "Local 27"         ' Restore    front
                               panel operation
```

3.6.4 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.

Program fragment

```
PRINT #1, "remote 27"        ' Place 6517 in re-
mote
SLEEP 3                      ' Wait  3 seconds
PRINT #1, "local 27"         ' Take 6517 out of
                               remote
```

3.6.5 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 6517 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.

Program fragment

```
PRINT #1, "clear"            ' Clear all devices
```

3.6.6 SDC (selective device clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. Howev-

er, 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.

Program fragment

```
PRINT #1, "clear 27"         ' Clear 6517
```

3.6.7 GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan and/or measure event to control operation. The Model 6517 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.

With the instrument programmed and waiting for a GPIB trigger, the following program fragment will provide the GET.

Program fragment

```
PRINT #1, "trigger 27"       ' Trigger 6517 from
                               over the bus
```

This sends IEEE-488 commands UNT UNL LISTEN 27 GET. When the command is executed, the trigger event occurs. (The command TRIGGER just sends GET. Any other listeners are triggered when the command is executed.)

3.6.8 SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 6517 serial poll byte. The serial poll byte contains important information about internal functions, as described in paragraph 3.8.6. 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 6517.

Program fragment

```
PRINT #1, "spoll 27"         ' Serial poll the 6517
INPUT #2, S                  ' Read the serial poll
                               byte
PRINT S                      ' Display the decimal
                               value of the serial
                               poll byte
```

3.7 Front panel aspects of IEEE-488 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.

3.7.1 Error and status messages

Table 2-4 summarizes the error and status messages associated with remote programming using SCPI and Common Commands. Additional information on errors associated with RS-232 operation is provided in paragraph 3.25.

3.7.2 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 does not necessarily indicate the state of the REN line, as the instrument must be addressed to listen with REN true before the REM indicator turns on. When the instrument is in remote, 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 6517 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. See paragraph 3.8.6 for details.

3.7.3 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.

3.8 Status structure

The status structure for the Model 6517 is summarized in Figure 3-5. 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 Figures 3-6 through 3-12.
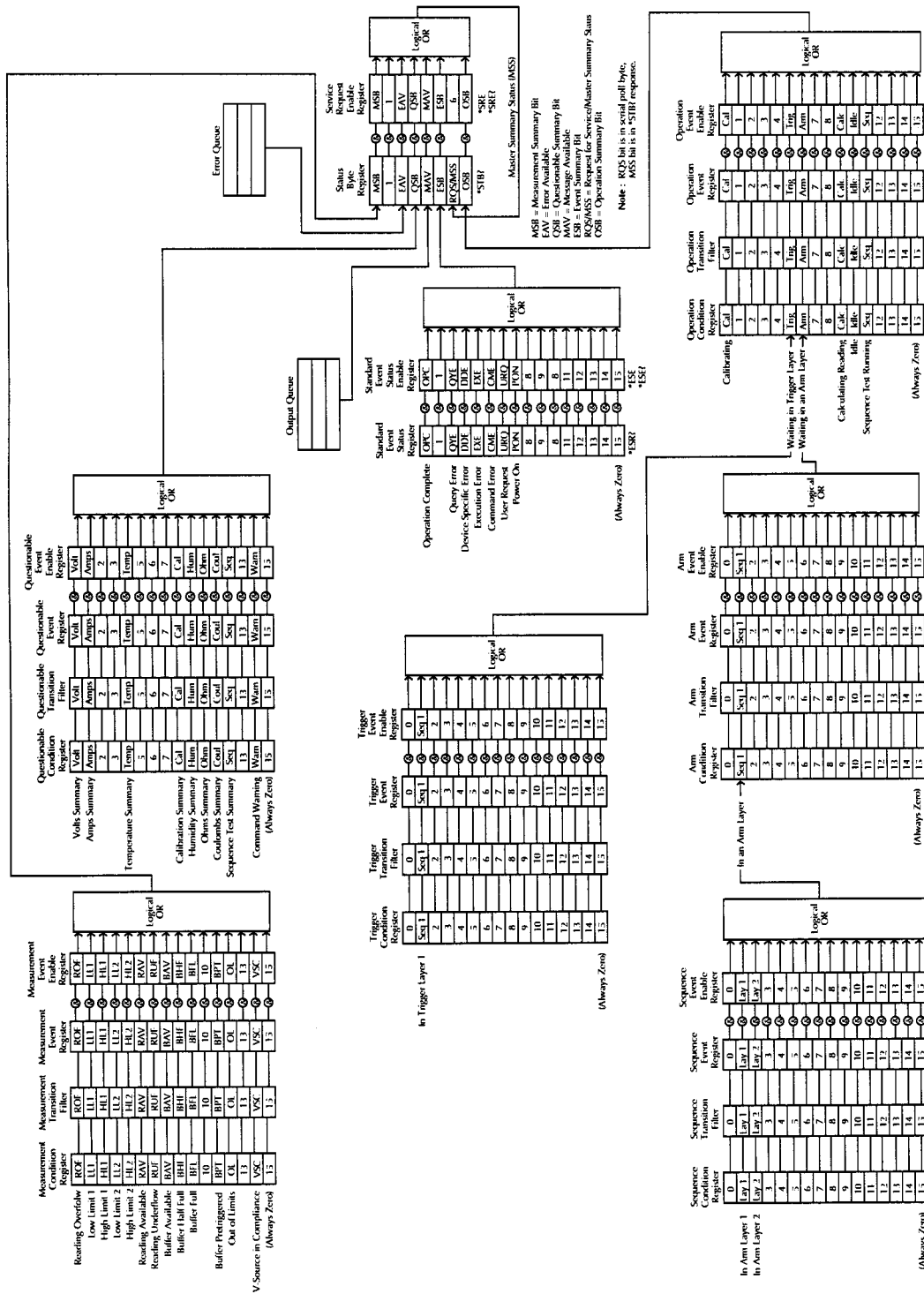
Figure 3-5
Model 6517 status register structure
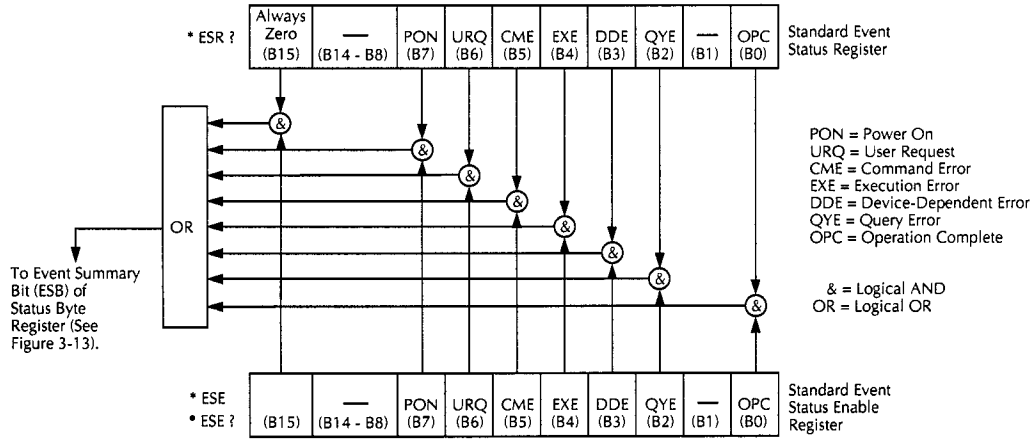
Figure 3-6
Standard event status
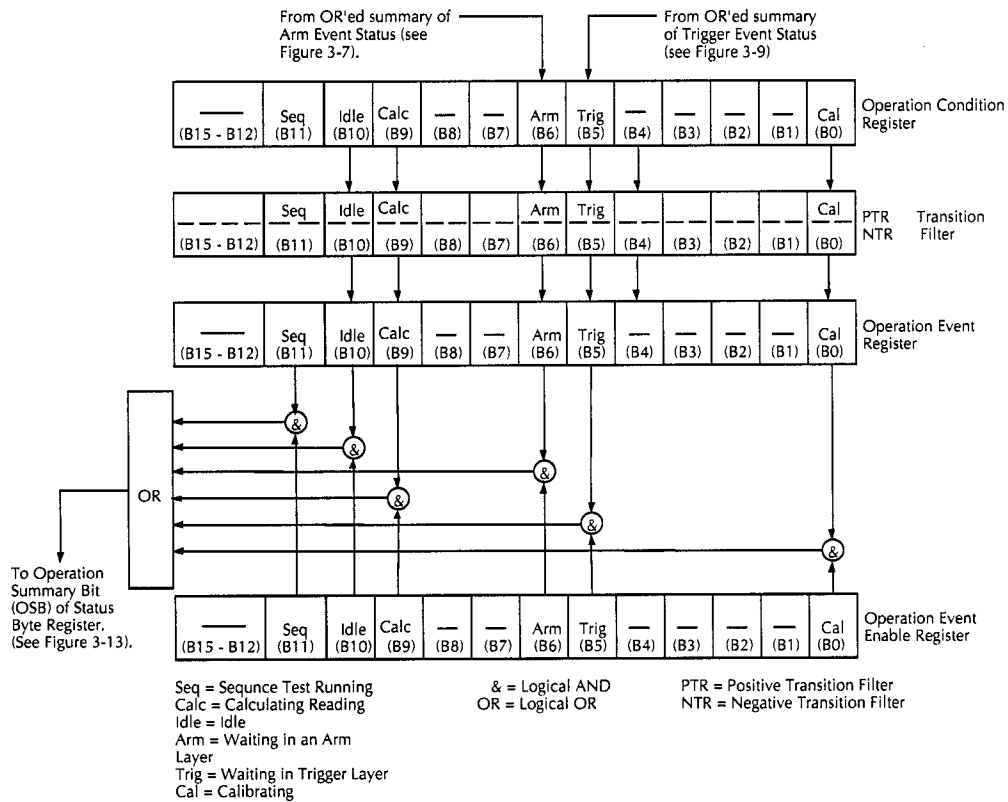
Figure 3-7
Operation event status
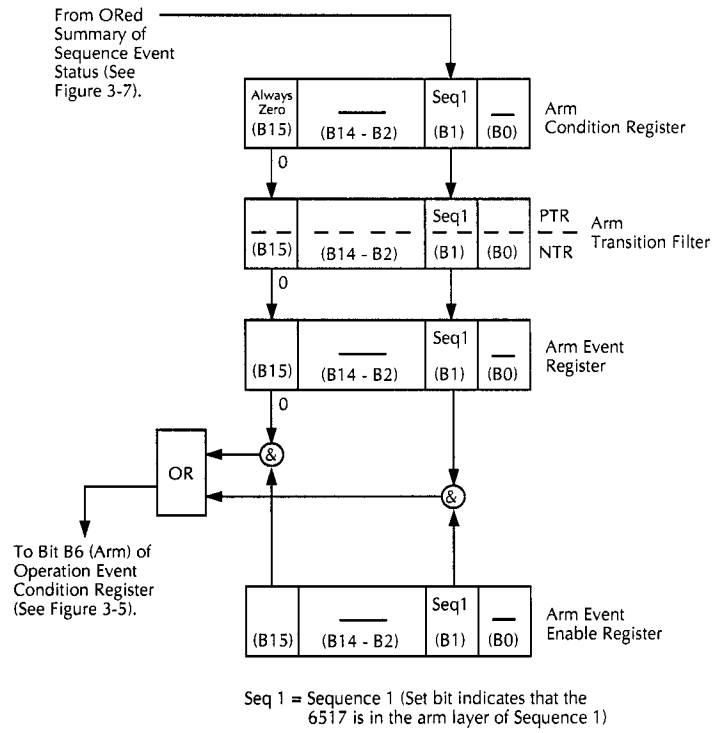
From ORed
Summary of
Sequence Event
Status (See
Figure 3-7).

| Always Zero (B15) | —— (B14 - B2) | Seq1 (B1) | —— (B0) | Arm Condition Register |

0

| _ _ (B15) | _ _ _ _ (B14 - B2) | Seq1 (B1) | _ _ (B0) | PTR / NTR Arm Transition Filter |

0

| (B15) | —— (B14 - B2) | Seq1 (B1) | —— (B0) | Arm Event Register |

0

OR &

To Bit B6 (Arm) of
Operation Event
Condition Register
(See Figure 3-5).

| (B15) | —— (B14 - B2) | Seq1 (B1) | — (B0) | Arm Event Enable Register |

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 3-8
Arm event status

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
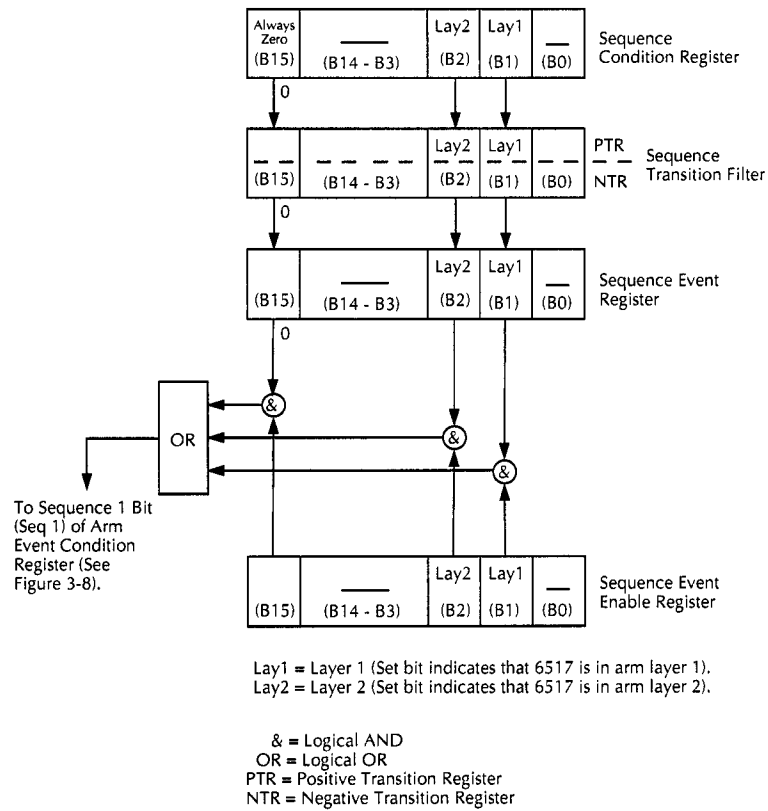
Figure 3-9
Sequence event status
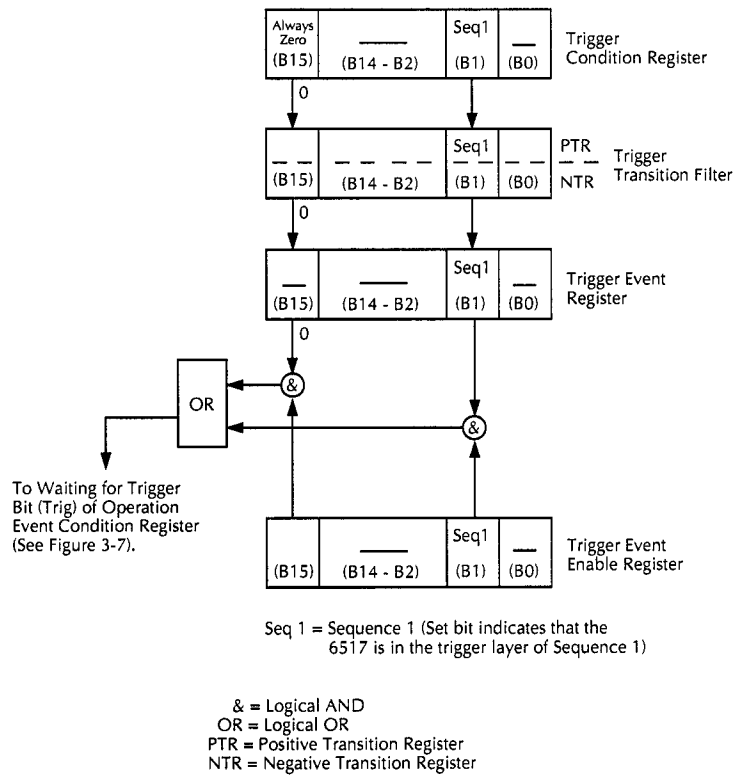
Figure 3-10
Trigger event status
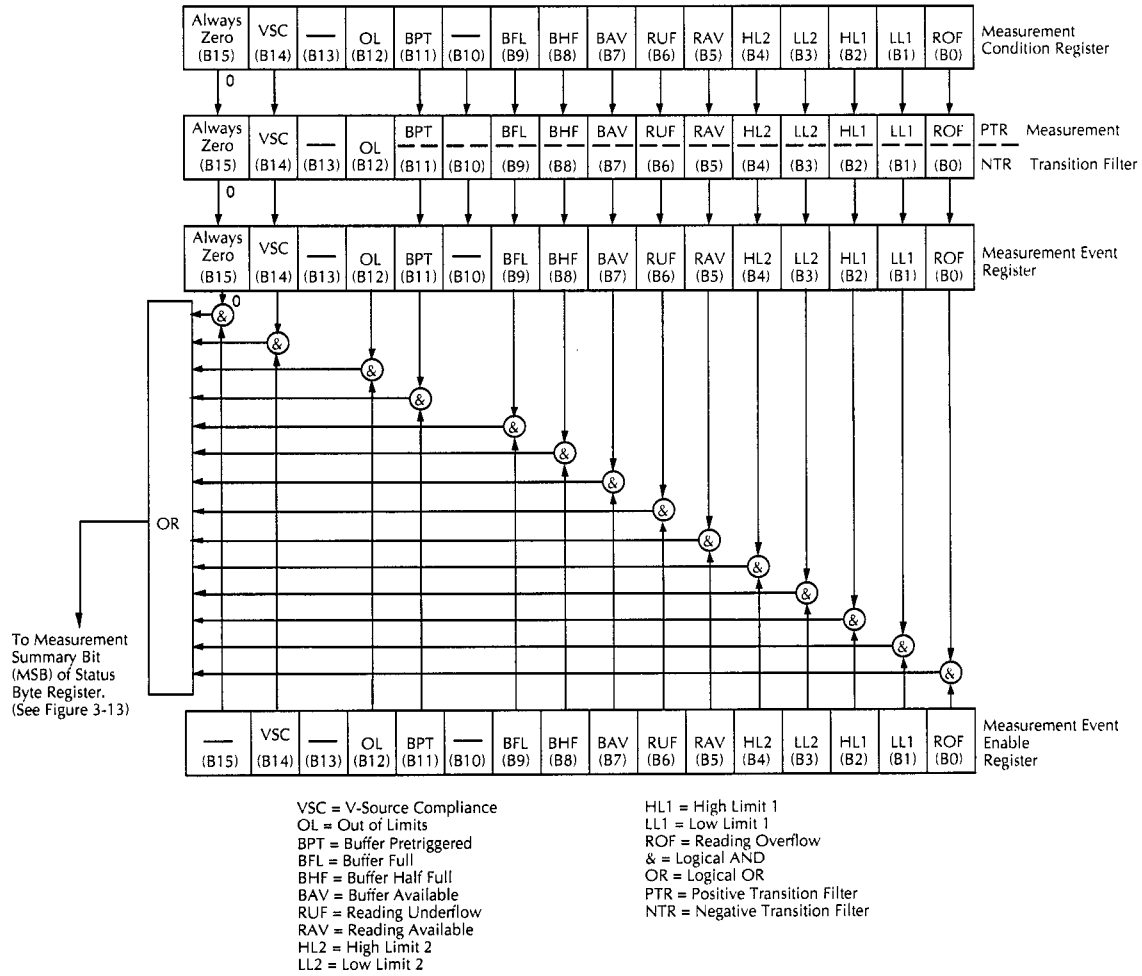
Figure 3-11
Measurement event status
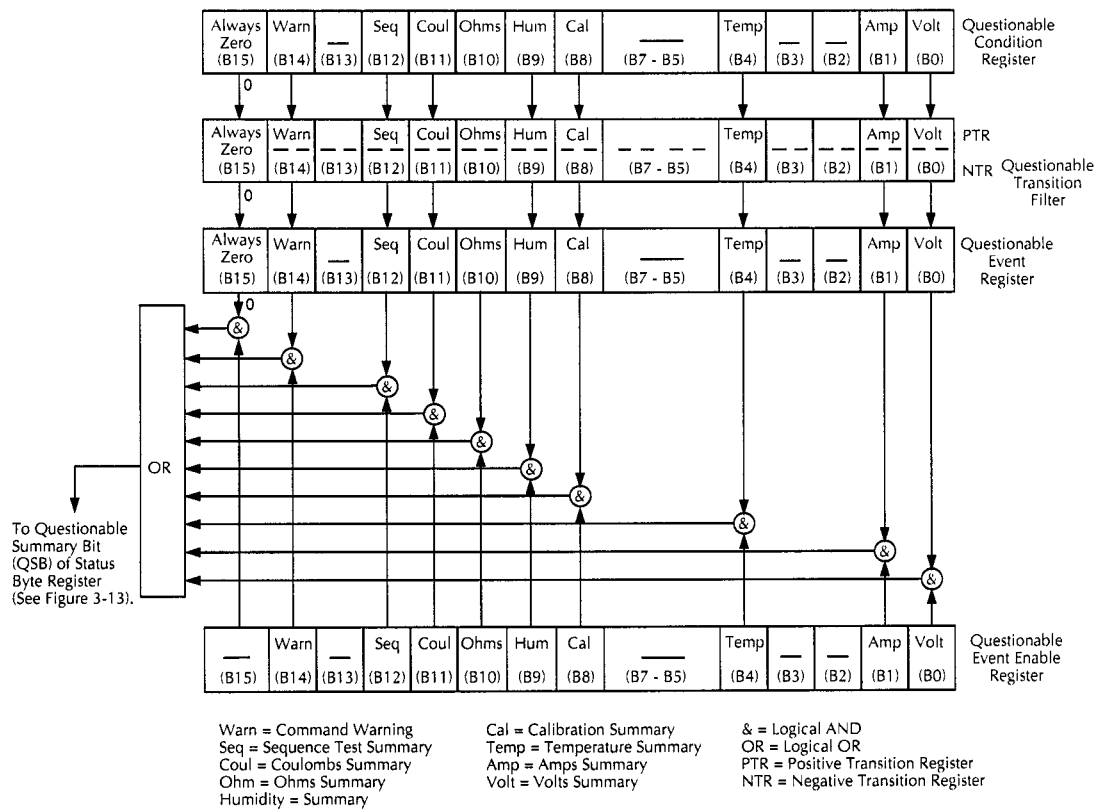
Figure 3-12
Questionable event status

3.8.1 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 paragraph 3.20 for details.

3.8.2 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 corresponding 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 corresponding 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 paragraph 3.20 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

3.8.3 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 paragraph 3.11.3). All other event registers are read using the [:EVENT]? query commands in the STATus Subsystem (see paragraph 3.20).

An event register is cleared when it is read. The following operations clear all event registers:

- Cycling power
- Sending *CLS

3.8.4 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 (i.e. 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 paragraph 3.11.2). All other enable registers are programmed and queried using the :ENABle and :ENABle? commands in the STATus Subsystem (see paragraph 3.20).

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.

3.8.5 Queues

The Model 6517 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 6517 status model (Figure 3-5) 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 6517 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 6517 to talk:

:SYSTem:ERRor?
:STATus:QUEue?

Refer to paragraphs 3.20.7 (:STATus:QUEue?) and 3.21.5 (:SYSTem:ERRor?) for complete information on reading error messages.

3.8.6 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 3-13.

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 paragraph 3.11.12.

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.

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 paragraph (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.
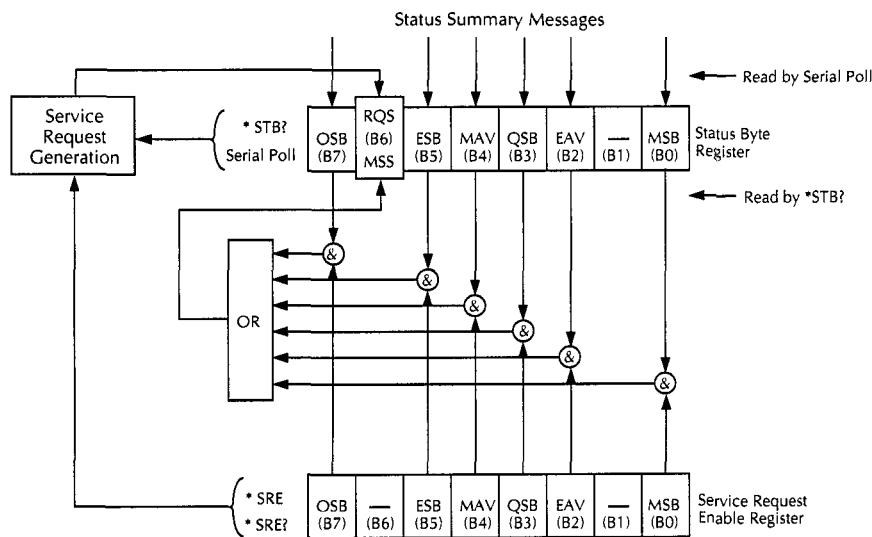
OSB = Operation Summary Bit
MSS = Master Summary Status
RQS = Request for Service
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available
MSB = Measurement Summary Bit

& = Logical AND
OR = Logical OR

Figure 3-13
Status byte and service request (SRQ)

NOTE

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 ì0î 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 paragraph 3.11.11 for details):

*SRE <NRf>

The Service Request Enable Register can be read using the following common query command (see paragraph 3.11.11 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 6517. 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.

The following QuickBASIC 4.5 program (using the KPC-488.2 interface and the CECHP driver) demonstrates how serial poll can be used to detect an SRQ.

```
CLS
OPEN "ieee" FOR OUTPUT AS #1
OPEN "ieee" FOR INPUT AS #2
PRINT #1, "output 27; *cls"   ' ClearStatusByte
                                  Register
PRINT #1, "output 27; *ese 32"' Unmask  command
                                  errors
PRINT #1, "output 27; *sre 32"' Unmaskeventsum-
                                  mary message
PRINT #1, "output 27; *ese"   ' Error - missing
                                  parameter
SLEEP 1
PRINT #1, "SPOLL 27"          ' Serial poll 6517
INPUT #2, S                   ' Read Status Byte
                                  Register
S = S OR 191                  ' OR register with
                                  a mask
IF S = 255 THEN GOSUB srq                        '
Go to subroutine to acknowledge SRQ
END IF
PRINT
END
srq:
PRINT "SRQ Has Occurred ñ RQS (bit B6) is set (1)"
RETURN
```

3.9 Trigger Model (IEEE-488 operation)

The following information describes the operation process of the Model 6517 over the IEEE-488 bus. The flowchart in Figure 3-14, 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 paragraph 3.23. Notice that key SCPI commands are included in the trigger model.

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 3-14, 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 6517 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 6517 must be taken out of remote before it will respond to the TRIG key. Press LOCAL or send LOCAL 16 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 6517.

- 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 via the EXTERNAL TRIGGER connector is received by the Model 6517.
- TLINk — Event detection is satisfied when an input trigger via the TRIGGER LINK is received by the Model 6517.
- 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 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.
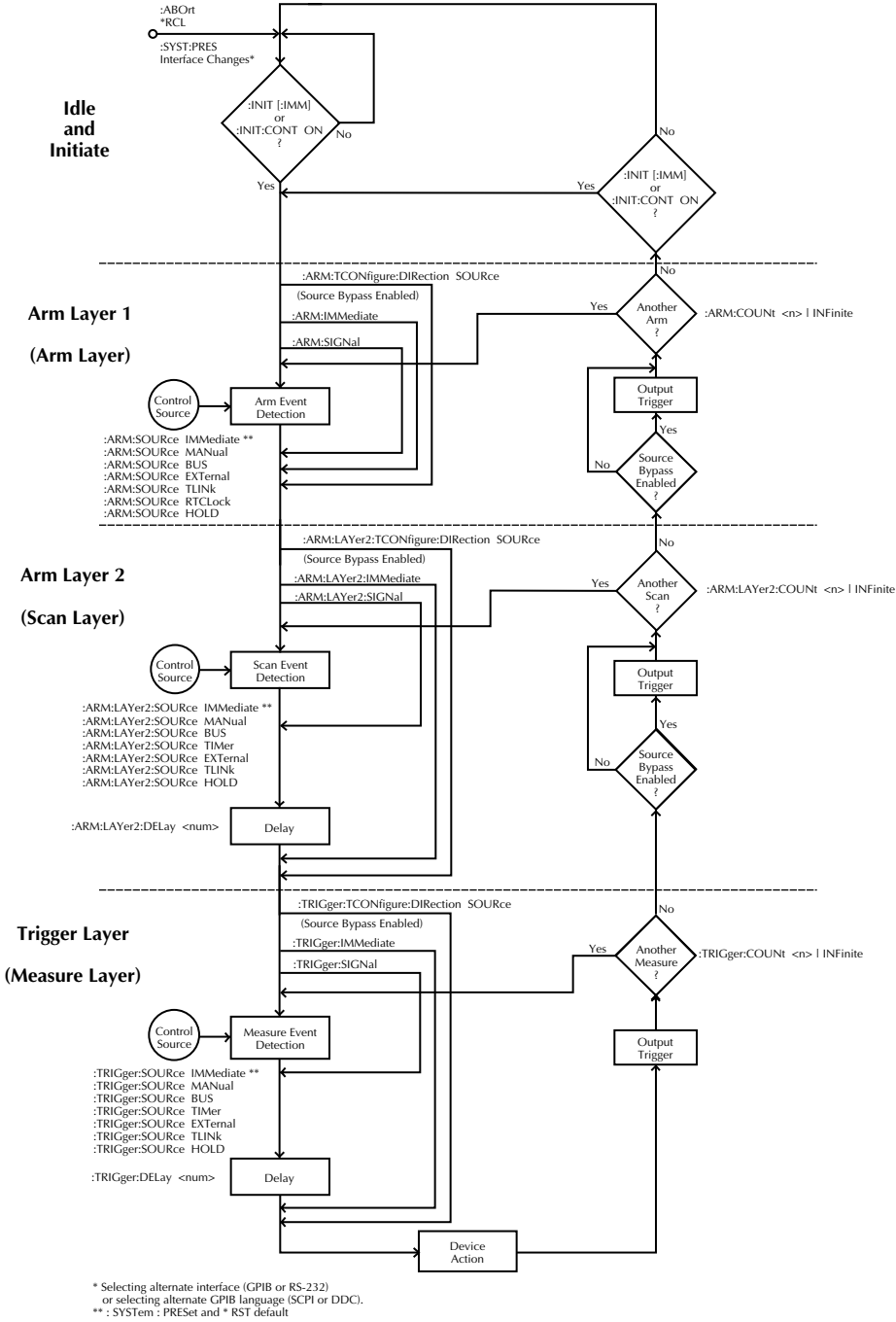
Figure 3-14
Trigger Model (IEEE-488 bus operation)

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 the METER COMPLETE 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 METER COMPLETE connector. 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).

3.10 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.

Command words

Program messages are made up of one or more command words.

1. **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 that 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:

   <b>   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 (e.g., 8), a real number (e.g., 23.6) or an exponent (2.3E6). Example:

   :STATus:MEASurement:ENABle   Set 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 DEFault   Sets timer to 0.1sec.
       :TRIGger:TIMer MINimum   Sets timer to 1msec.
       :TRIGger:TIMer MAXimum   Sets 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 <b> 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

2. **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.

3. **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

4. **Long-form and short-form versions:** A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in this section 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:

A. If the length is four letters or less, there is no short-form version. Example:

     :auto = :auto

B. 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

         Note: The "y" in POLynomial is a vowel. Thus, polynomial = pol.

     b. If the fourth letter of the word is a consonant, retain it but drop all the letters after it. Example:

         :output = :outp

C. 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

D. 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 in-
strument. 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 fol-
lowing command paths are contained in the :STATus subsystem and are used to help explain
how command words are structured to formulate program messages.

```
:STATus                 Path (Root)
   :OPERation              Path
      :PTRansition <NRf>       Command and parameter
      :NTRansition <NRf>       Command and parameter
      :ENABle <NRf>            Command and parameter
   :PRESet                  Command
```

1. **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.

2. **Multiple command messages:** Multiple commands can be sent in the same program mes-
sage 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 com-
   mand (:stat). When the next colon is detected, the path pointer moves down to the next com-
   mand 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 includ-
   ed in the program message. If a colon were included, the path pointer would reset to the root
   level and expect a root command. Since neither :ptr nor :ntr are root commands, an error
   would occur.

3. **Command path rules:**
   A. Each new program message must begin with the root command, unless it is optional (e.g., [:SENSe]). If the root is optional, simply treat a command word on the next level as the root.
   B. The colon (:) at the beginning of a program message is optional and need not be used. Example:

   :stat:pres = stat:pres

   C. 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).
   D. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.
   E. 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.

4. Using common commands and SCPI commands in same message: 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>

5. 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>

6. Command execution rules:
   A. Commands are executed in the order that they are presented in the program message.
   B. An invalid command will generate an error and, of course, not be executed.
   C. Valid commands that precede an invalid command in a multiple command program message will be executed.
   D. 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.

1. **Sending a response message:** After sending a query command, the response message is placed in the Output Queue. When the Model 6517 is then addressed to talk, the response message is sent from the Output Queue to the computer.

2. **Multiple response messages:**

   GPIB — If you send more than one query command in the same program message (see Multiple command messages), the multiple response message for all the queries is sent to the computer when the Model 6517 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.

3. **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 6517 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 6517 to talk.

Rule 2. The complete response message must be received by the computer before another program message can be sent to the Model 6517.

3.11 Common commands

Common commands (summarized in Table 3-2) 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 3-2
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 6517 to the setup configuration stored in the specified memory location.
*RST	Reset command	Returns the Model 6517 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 6517.
*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.

3.11.1 *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 6517:

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.

3.11.2 *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, see paragraph 3.11.3. The Status Byte Register is described in paragraph 3.8.6.

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 3-15 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) = Decimal   32
        QYE (bit B2) = Decimal   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 Event Register can be read by using the *ESE? query command.

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

Figure 3-15
Standard Event Enable Register

3.11.3   *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 3-16). 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.

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

Figure 3-16
Standard Event Status Register

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 6517 is ready to accept new commands. This bit only sets in response to the *OPC? query command (see paragraph 3.11.6).

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 setting conflict errors, and buffer sizing nad mismatch errors).

Bit B4, Execution Error (EXE) — Set bit indicates that the Model 6517 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:

1. IEEE-488.2 syntax error: Model 6517 received a message that does not follow the defined syntax of the IEEE-488.2 standard.
2. Semantic error: Model 6517 received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
3. 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 6517 front panel was pressed.

Bit B7, Power On (PON) — Set bit indicates that the Model 6517 has been turned off and turned back on since the last time this register has been read.

3.11.4 *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 6517, xxxxxxx, yyyyy/zzzzz

where;   xxxxxxx is the serial number
yyyyy/zzzzz is the firmware revision levels of the digital board ROM and display board ROM.

3.11.5 *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 6517 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 6517:

:INITiate:CONTinuous ON :INITiate
*TRG

When the *OPC command is sent, the Model 6517 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 (e.g. trigger model in idle state), the Model 6517 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 6517 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

NOTE

The :INITiate:POFLag command (see paragraph 3.24.1) 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 Trigger Model in paragraph 3.9).

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.

Program fragment
```
GOSUB ReadRegister' Clear register by reading it
PRINT #1, "output 27; :init:cont off; :abort"' Place 6517 in idle
PRINT #1, "output 27; :init; *opc"          ' Start measurements and send
                                              *OPC
SLEEP 2                                      ' Wait two seconds
GOSUB ReadRegister                           ' Read register to show that OPC
                                              is not set
PRINT #1, "output 27; :abort"                ' Place 6517 back in idle
GOSUB ReadRegister                           ' Read register to show that OPC
                                              is now set
END

ReadRegister:
```

```
PRINT #1, "output 27; *esr?"          ' Query Standard Event Status
                                        Register
PRINT #1, "enter 27"                   ' Get response message from 6517
LINE INPUT #2, a$                      ' Read decimal value of register
PRINT a$                               ' Display decimal value of reg-
                                         ister

RETURN
```

3.11.6 *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 6517 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 6517:

:INITiate:CONTinuous ON :INITiate
*TRG

When the *OPC? command is sent, the Model 6517 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 6517 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 (e.g. trigger model in idle state), the Model 6517 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 6517 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

NOTE

> The :INITiate:POFLag command (see paragraph 3.24.1) 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 Trigger Model in paragraph 3.9).

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 6517 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.

NOTE

See *OPC, *TRG and *WAI for more information.

Program fragment

```
PRINT #1, "output 27; :syst:pres"              ' Select defaults
PRINT #1, "output 27; :init:cont off; :abort"' Place 6517 in idle
PRINT #1, "output 27; :arm:coun 1"              ' Program for 5 measurements
                                                  and stop (idle)
PRINT #1, "output 27; :arm:lay2: coun 1"
PRINT #1, "output 27; :trig: coun 5; sour tim"
PRINT #1, "output 27; :init; *opc?"             ' Start measurements and send
                                                  *opc?
PRINT #1, "enter 27"                            ' Get response when 6517 goes
                                                  into idle
LINE INPUT #2, a$                               ' Read contents of Output Queue
PRINT a$                                        ' Display the ASCII "1"
```

3.11.7 *OPT? — option identification query   Determine which option s installed.

Description   The response message provides the model number of the option installed in the option slot of the Model 6517. If there is no option installed, then a zero (0) will be returned.

3.11.8 *RCL — recall   Return to a setup stored in memory.

Parameters   <NRf> = 0 to 9   Specify memory location

This command is used to return the Model 6517 to a setup configuration stored at a memory location. The *SAV command is used to store a setup configuration at a memory location (see paragraph 3.11.10).

The Model 6517 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.

3.11.9 *RST — reset the Model 6517

Description   When the *RST command is sent, the Model 6517 performs the following operations:

1. Returns the Model 6517 to the *RST default conditions (see SCPI tables).
2. Cancels all pending commands.
3. Cancels response to any previously received *OPC and *OPC? commands.

3.11.10 *SAV — save the current setup in memory

Parameters   <NRf> = 0 to 9   Specify memory location

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.

3.11.11 *SRE <NRf> — service request enable   Program Service Request Enable Register
SRE? — service request enable query   Read Service Request Enable Register

<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

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 paragraph 3.8.

The Service Request Enable Register is shown in Figure 3-17. 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) = Decimal	32
	MAV (bit B4) = Decimal	16
	<NRf> =	48

The contents of the Service Request Enable Register can be read using the *SRE? query command.

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

Figure 3-17
Service Request Enable Register

3.11.12 *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 3-18. 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 paragraph 3.8.

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.

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 (2^3)	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

Figure 3-18
Status Byte Register

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 paragraph 3.20 for details).

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 paragraphs 3.21 and 3.20 for details.

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 6517 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 (see paragraph 3.11.2).

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 paragraph 3.20 for details).

3.11.13 *TRG — trigger   Send a GPIB trigger to the Model 6517.

Description   The *TRG command is used to issue a GPIB trigger to the Model 6517. It has the same effect as a group execute trigger (GET).

The *TRG command is used as an arm, scan and/or measure event to control operation. The Model 6517 reacts to this trigger if GPIB is the programmed control source. The control source is programmed from the :TRIGger subsystem (see paragraph 3.23).

*TRG can also be used as the pre-trigger for buffer operation.

3.11.14 *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 6517 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.

3.11.15 *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 6517; :INITiate, :INITiate:CONTinuous ON and *TRG.

NOTE
See *OPC, *OPC? and *TRG for more information.

The :INITiate commands take the Model 6517 out of the idle state. The device operations of :INITiate are not considered complete until the Model 6517 goes back into idle. By sending the

*WAI command after the :INITiate command, all subsequent commands will not execute until the Model 6517 goes back into idle.

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.

Program fragment

```
PRINT #1, "output 27; :syst:pres"          ' Select defaults
PRINT #1, "output 27; :init:cont off; :abort"' Place 6517 in idle
PRINT #1, "output 27; :arm:coun 1"             ' Program for 30 measurements
                                                 and then stop (idle)
PRINT #1, "output 27; :arm:lay2:coun 1"
PRINT #1, "output 27; :trig:coun 30; sour tim"
PRINT #1, "output 27; :init; *wai"            ' Start measurements and send
                                                *wai
PRINT #1, "output 27; :data?"                 ' Query a reading
PRINT #1, "enter 27"                          ' Get reading after 6517 goes
                                                into idle
LINE INPUT #2, a$                             ' Read the reading
PRINT a$                                      ' Display the reading
```

3.12   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. These commands are summarized in Table 3-3.

Table 3-3
Signal oriented measurement command summary

Command	Description
:FETCh?	Requests the latest reading.
:CONFigure:<function>	Places the 6517 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 6517 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 SENSe Subsystem).

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 6517 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 6517 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.

Program fragment `PRINT #1, "output 27; :conf:res"`   `'Perform:CONFigureoperations`

: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.

The :FETCh? for details. Note that an "Init ignored" error will not cancel the execution of the :FETCh? command.

Program fragment
```
PRINT #1, "output 27; :conf:res"        ' Select "one-shot" ohms
PRINT #1, "output 27; :read?"           ' Perform :READ? operations
PRINT #1, "enter 27"                    ' Get response message from
                                          6517
```

:MEASure[:<function>]?

where: <function> = VOLTage[:DC]   Volts function
                    CURRent[:DC]   Amps function
                    RESistance   Ohms function
                    CHARge   Coulombs function

This command combines all of the other signal oriented measurement commands to perform a "one-shot" measurement and acquire the reading.

When this command is sent, the following commands are executed in the order that they are presented.

SCPI command subsystems

SCPI commands are categorized into subsystems and are summarized in Tables 3-4 through 3-16. Following the tables, the subsystems are covered in the following alphabetical order:

3.13 Calculate subsystems — Use :CALCulate1 to configure and control the math operations. Use :CALCulate2 to manipulate readings stored in the buffer, and use :CALCulate3 to configure and control the limit tests.

3.14 :CALibrate subsystem — Use to null input offset current and voltage burden. Note: Use the Model 6517 Calibration Manual to calibrate the instrument

3.15 :DISPlay subsystem — Use to control display readings and messages.

3.16 :FORMat subsystem — Use to select the data format for transferring instrument readings over the bus.

3.17 Output subsystems — Use to control the V-Source and select the polarity for the digital output lines.

3.18 :ROUTe subsystem — Use to control switching.

3.19 Sense subsystems — Use to configure and control the measurement functions.

3.20 :SOURce subsystem — Use to control the digital output port.

3.21 :STATus subsystem — Use to configure and control the status registers.

3.22 :SYSTem subsystem — Commands not covered by the other subsystems.

3.23 :TRACe subsystem — Use to control the reading buffer.

3.24 Trigger subsystem — Use to configure the Trigger Model.

3.25 :TSEQuence subsystem — Use to configure and control test sequences.

3.26 :UNIT subsystem — Use to select temperature units.

SCPI Command Summary

Tables 3-4 through 3-16 summarize the commands for each SCPI subsystem.

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 (<b>) 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 3-4
CALCulate command summary

Command	Description	Default parameter	SCPI	Ref.
:CALCulate[1]	Subsystem to control CALC1:		√	3.13.1
:FORMat <name>	Select math format (NONE, POLYnomial, PERCent, RATio, DEViation, PDEViation, LOG10).	Percent	√	
: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 POLynominal (-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 <b>	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:		√	3.13.2
:FORMat <name>	Select math format: (MEAN, SDEViation, MAXimum, MINimum, PKPK, or NONE).	NONE	√	
:FORMat?	Query math format.		√	
:STATe <b>	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 3-4 (Continued)
CALCulate command summary

Command	Description	Default parameter	SCPI	Ref.
:CALCulate3	Subsystem to control CALC 3 (limit tests):		√	3.13.3
:LIMit[1]	Path to control LIMIT 1 test:		√	
:UPPer	Path to configure upper limit:		√	
[:DATA] <n>	Set upper limit (-9.999999e35 to +9.999999e35).	1	√	
[:DATA]?	Query upper limit.		√	
:SOURce <NRf>	Specify digital output (0 to 15).	0	√	
:SOURce?	Query source.		√	
:LOWer	Path to configure lower limit:		√	
[:DATA] <n>	Set lower limit (-9.999999e35 to +9.999999e35).	-1	√	
[:DATA]?	Query lower limit.		√	
:SOURce <NRf>	Specify digital output (0 to 15).	0	√	
:SOURce?	Query source.		√	
:STATe <b>	Enable or disable limit test.	OFF	√	
:STATe?	Query state of limit test.		√	
:FAIL?	Query test result (1 = pass, 0 = fail).		√	
:CLEAR	Path to clear failed test:		√	
[:IMMediate]	Clear failed test indication.		√	
:AUTO <b>	Enable or disable auto clear.	ON	√	
:AUTO?	Query auto clear.		√	
:LIMit2	Path to control LIMIT 2 test:		√	
:UPPer	Path to configure upper limit:		√	
[:DATA] <n>	Set upper limit (-9.999999e35 to +9.999999e35).	1	√	
[:DATA]?	Query upper limit.		√	
:SOURce <NRf>	Set digital output (0 to 15).	0	√	
:SOURce?	Query source (digital output value).		√	
:LOWer	Path to configure lower limit:		√	
[:DATA] <n>	Specify lower limit (-9.999999e35 to +9.999999e35).	-1	√	
[:DATA]?	Query lower limit.		√	
:SOURce <NRf>	Specify digital output (0 to 15).	0	√	
:SOURce?	Query source (digital output value).		√	
:STATe <b>	Enable or disable limit test.	OFF	√	
:STATe?	Query state of limit test.		√	
:FAIL?	Query test result (1 = pass, 0 = fail).		√	
:CLEAR	Path to clear failed test:		√	
[:IMMediate]	Clear failed test indication.		√	
:AUTO <b>	Enable or disable auto clear.	ON	√	
:AUTO?	Query auto clear.		√	
:PASS	Path to define "pass" digital output pattern.			
:SOURce <NRf>	Specify digital output (0 to 15).	0		
:CLIMits	Command path for composite limits:		√	
:FAIL?	Query composite result of LIMIT 1 and LIMIT 2 tests (1 = pass, 0 = fail).		√	
:BSTRobe	Path to control limit binning strobe:			
:STATe <b>	Enable or disable strobe.	OFF		
:STATe?	Query state of binning strobe.			
:IMMediate	Re-perform limit tests.		√	

Note: ON is the *RST default parameter, and OFF is the :SYSTem:PRESet default.

Table 3-5
CALibration command summary

Command*	Description
:CALibration:UNPRotected :VOFFset :IOFFset	 Null voltage burden Null input offset current

*These are the only two commands accessible to the operator. To calibrate the instrument, refer to the Model 6517 Calibration Manual.

Table 3-6
DISPlay command summary

Command	Description	Default parameter	SCPI
:DISPlay			
[:WINDow[1]]	Path to locate message to top 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 20 characters).		√
:DATA?	Query text message.		√
:STATe <b>	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.		√
:DATA <a>	Define ASCII message "a" (up to 32 characters).	(Note 1)	√
:DATA?	Query text message.		√
:STATe <b>	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 <b>	Enable or disable status message mode.	OFF	
:SMESsage?	Query status message state.		
:ENABle <b>	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 3-7

FORMat command summary

Command	Description	Default parameter	SCPI
:FORMat			
[:DATA] <type>[,<length>]	Select data format: (ASCii, REAL,32, REAL,64, SREal or DREal).	ASCii	√
[:DATA]?	Query data format.		√
:ELEMents <item list>	Specify data elements: (READing, CHANnel, RNUMber, UNITs, TSTamp, STATus, DTEMperature, ETEMperature, HUMidity and VSOurce).	(Note)	
:ELEMents?	Query data elements.		
:BORDer <name>	Select binary byte order: (NORMal or SWAPped).	SWAPped	√
:BORDer?	Query byte order.		√

Note: All elements, except DTEMperature, ETEMperature, HUMidity and VSOurce, are the *RST and :SYSTem:PRESet default.

Table 3-8

OUTput command summary

Command	Description	Default Parameter	SCPI
:OUTPut1			√
[:STATe] <b>	Enable (operate) or disable (standby) V-source output.	OFF	√
:TTL[1]			
:LSENse <name>	Path to set polarity of digital output line 1:		
:LSENse?	Select polarity; active high (AHIGh) or active low (ALOW).	AHIGh	
:TTL2	Query polarity of line 1.		
:LSENse <name>	Path to set polarity of digital output line 2:		
:LSENse?	Select polarity; active high (AHIGh) or active low (ALOW).	AHIGh	
:TTL3	Query polarity of line 2.		
:LSENse <name>	Path to set polarity of digital output line 3:		
:LSENse?	Select polarity; active high (AHIGh) or active low (ALOW).	AHIGh	
:TTL4	Query polarity of line 3.		
:LSENse <name>	Path to set polarity of digital output line 4:		
:LSENse?	Select polarity; active high (AHIGh) or active low (ALOW).	AHIGh	
	Query polarity of line 4.		

Table 3-9

ROUTe command summary

Command	Description	Default parameter	SCPI	Ref.
:ROUTe				
:CLOSe <list>	Path and command to close specified channel:		√	3.18.1
:STATe?	Query closed channel.		√	
:CLOSe? <list>	Query specified channels (1 = closed, 0 = open).		√	
:OPEN <list>	Open specified channel or all channels.		√	3.18.2
:OPEN:ALL	Open all channels.		√	3.18.3
:OPEN? <list>	Query specified channels (1 = open, 0 = closed).		√	
:SCAN	Command path to configure and control scan operations:		√	3.18.4
[: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 <b>	Enable or disable 200V limit for internal card.	ON		
:VSLimit?	Query state of 200V limit			

Table 3-10

SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
[:SENSe[1]]				3.19.1
:FUNCtion <name>	Select measurement function: 'VOLTage[:DC]', 'CURRent[:DC]', 'RESistance', 'CHARge'	'VOLT:DC'	√	3.19.2
:FUNCtion?	Query function.		√	
:DATA	Path to returnreadings:		√	3.19.3
[:LATest]?	Return the last instrument reading.		√	
:FRESh?	Query fresh readings.		√	

Table 3-10 (Continued)

SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
:VOLTage[:DC]	Path to configure volts:		√	
:APERture <n>	Set integration rate in seconds (166.67e-6 to 200e-3).	(Note 1)	√	3.19.4
:AUTO <b>	Enable or disable auto aperture.	OFF		
:AUTO ONCE	Enable and then disable auto aperture.			
:AUTO?	Query auto aperture.			
:APERture?	Query aperture (integration rate).		√	
:NPLCycles <n>	Set integration rate (line cycles; (0.01 to 10).	1	√	3.19.5
:AUTO <b>	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.		√	
:RANGe	Path to configure measurement range:		√	3.19.6
[:UPPer] <n>	Select range (0 to 210).	200	√	
[:UPPer]?	Query range.		√	
:AUTO <b>	Enable or disable auto range.	ON	√	
:AUTO ONCE	Set range based on present input signal.		√	
:ULIMit <n>	Set upper limit for auto range (0 to 210).	200		
:ULIMit?	Query upper limit.			
:LLIMit <n>	Set lower limit for auto range (0 to 210).	200		
:LLIMit?	Query lower limit.			
:AUTO?	Query auto range.		√	
:REFerence <n>	Specify reference (-210 to +210).	0	√	3.19.7
:STATe <b>	Enable or disable reference.	OFF	√	
:STATe?	Query state of reference (0 or 1).		√	
:ACQuire	Use input signal as reference.			
:REFerence?	Query reference value.		√	
:DIGits <n>	Specify measurement resolution (4 to 7).	6		3.19.9
:AUTO <b>	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.			3.19.10
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced).	SCALar		
: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] <b>	Enable or disable digital filter.	(Note 2)		
[:STATe]?	Query state of digital filter.			
:MEDian	Path to control the median filter:			3.19.11
[:STATe] <b>	Enable or disable median filter.	ON		
[:STATe]?	Query state of median filter.			
:RANK <NRf>	Specify rank for median filter (1 to 5).	1		
:RANK?	Query rank.			
:GUARd <b>	Enable or disable guard.	OFF		3.19.13
:GUARd?	Query state of guard.			
:XFEedback <b>	Enable or disable external feedback.	OFF		3.19.15
:XFEedback	Query state of external feedback.			

Table 3-10 *(Continued)*

SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
:CURRent[:DC]	Path to configure Amps:		√	
:APERture <n>	Set integration rate in seconds (166.67e-6 to 200e-3).	(Note 1)	√	3.19.4
:AUTO <b>	Enable or disable auto aperture.	OFF		
:AUTO ONCE	Enable and then disable auto aperture.			
:AUTO?	Query auto aperture.			
:APERture?	Query aperture (integration rate).		√	
:NPLCycles <n>	Set integration rate (line cycles; 0.01 to 10).	1	√	3.19.5
:AUTO <b>	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.		√	
:RANGe	Path to configure measurement range:		√	3.19.6
[:UPPer] <n>	Select range (0 to 21e-3).	20e-3	√	
[:UPPer]?	Query range.		√	
:AUTO <b>	Enable or disable auto range.	ON	√	
:AUTO ONCE	Set range based on present input signal.		√	
:ULIMit <n>	Set upper limit for auto range (0 to 21e-3).	20e-3		
:ULIMit?	Query upper limit.			
:LLIMit <n>	Set lower limit for auto range (0 to 21e-3).	2-e-12		
:LLIMit?	Query lower limit.			
:AUTO?	Query auto range.		√	
:REFerence <n>	Specify reference (-21e-3 to +21e-3).	0	√	3.19.7
:STATe <b>	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		3.19.9
:AUTO <b>	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.			3.19.10
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced).	SCALar		
: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] <b>	Enable or disable digital filter.	(Note 2)		
[:STATe]?	Query state of digital filter.			
:MEDian	Path to control the median filter:			3.19.11
[:STATe] <b>	Enable or disable median filter.	ON		
[:STATe]?	Query state of median filter.			
:RANK <NRf>	Specify rank for median filter.	1		
:RANK?	Query rank.			
:DAMPing <b>	Enable or disable damping.	OFF		3.19.12
:DAMPing?	Query state of damping.			

Table 3-10 (Continued)

SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
:RESistance	Path to configure resistance:		√	
:APERture <n>	Set integration rate in seconds (166.67e-6 to 200e-3).	(Note 1)	√	3.18.4
:AUTO <b>	Enable or disable auto aperture.	OFF		
: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	√	3.18.5
:AUTO <b>	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:			3.19.6
[:UPPer] <n>	Select range (0 to 100e18).	200e12		
[:UPPer]?	Query range.			
:AUTO <b>	Enable or disable auto range.	ON		
: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.			
:MANual	Path to configure Manual V-Source ohms:			
:CRANge	Path to configure measurement range:			3.19.6
[:UPPer] <n>	Select range (0 to 100e18).	200e12		
[:UPPer]?	Query range.			
:AUTO <b>	Enable or disable auto range.	ON		
:AUTO ONCE	Set range based on present input signal.			
:AUTO?	Query auto range.			
:VSOurce	Path to control the V-Source:			
[:AMPLitude] <n>	Specify V-Source level (0 to 1000V).	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.			
:OPERate <b>	Enable (operate) or disable (standby) V-Source output.	OFF		
:OPERate?	Query state of V-Source.			
:REFerence <n>	Specify ohms reference (-100e18 to +100e18).	0	√	3.18.7
:STATe <b>	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 <b>	Enable or disable amps reference.			3.19.8
:IREFerence?	Query state of amps reference.			
:DIGits <n>	Specify measurement resolution (4 to 7).	6		3.18.9
:AUTO <b>	Enable or disable auto resolution.			
:AUTO ONCE	Enable and then disable auto resolution.			
:AUTO?	Query auto resolution.			
:DIGits?	Query resolution.			

Table 3-10 (Continued)

SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
:RESistance				
:AVERage	Path to control average filter.			3.18.10
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced).	SCALar		
: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 leve (0 to 100%).	(Note 2)		
:NTOLerance?	Query noise tolerance level.			
[:STATe] <b>	Enable or disable digital filter.			
[:STATe]?	Query state of digital filter.			
:MEDian	Path to control median filter.			
[:STATe] <b>	Enable or disable median filter.	ON		
[:STATe]?	Query state of median filter.			
:RANK <NRf>	Specify range (1 to 5).	1		
:RANK?	Query rank.			
:DAMPing <b>	Enable or disable damping.	OFF		3.19.12
:DAMPing?	Query state of damping.			
:VSControl <name>	Select ohms V-Source mode (MANual or AUTO).	MANual		3.19.16
:VSControl?	Query ohms V-Source mode.			
:MSELect <name>	Select ohms measurement type (NORMal or RESistivity).	NORMal		3.19.17
:MSELect?	Query ohms measurement type.			
:RESistivity	Path to configure resistivity:			3.19.18
: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			

Table 3-10 (Continued)
SENSe command summary

Command	Description	Default parameter	SCPI	Ref.
:CHARge	Path to configure Coulombs.		√	
:APERture <n>	Set integration rate in seconds (166.67e-6 to 200e-3).	(Note 1)	√	3.19.4
:AUTO <b>	Enable or disable auto aperture.	OFF		
:AUTO ONCE	Enable and then disable auto aperture.			
:AUTO?	Query auto aperture.			
:APERture?	Query aperture (integration rate).		√	
:NPLCycles <n>	Set integration rate (line cycles; 0.01 to 10).	1	√	3.19.5
:AUTO <b>	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.		√	
:RANGe	Path to configure measurement range:		√	3.19.6
[:UPPer] <n>	Select range (0 to +2.1e-6).	2e-6	√	
[:UPPer]?	Query range.		√	
:AUTO <b>	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	√	3.19.7
:STATe <b>	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		3.19.9
:AUTO <b>	Enable or disable auto resolution.			
:AUTO ONCE	Enable and then disable auto resolution.			
:AUTO?	Query auto resolution.			
:DIGits?	Query resolution.	ON		
:AVERage	Path to control the average filter.			3.19.10
:TYPE <name>	Select filter type (NONE, SCALar, ADVanced).			
: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] <b>	Enable or disable filter.	(Note 2)		
[:STATe]?	Query state of digital filter.			
:MEDian	Path to control the median filter:			
[:STATe] <b>	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:			3.19.14
[:STATe] <b>	Enable or disable auto discharge.	OFF		
[:STATe]?	Query state of auto discharge.			
:LEVel <NRf>	Specify level for LEVel type.	2e-6		
:LEVel?	Query level.			

Notes:
1. 16.67ms for 60Hz power line frequency and 20ms for 50Hz line frequency.
2. *RST — Disables digital filter; :SYSTem:PRESet — No change

Table 3-11

SOURce command summary

Command	Description	Default parameter	SCPI	Ref.
:SOURce		(Note 1)		
:TTL[1]	Path to set digital output line #1:			3.20.21
[:LEVel] <b>	Enable or disable line #1.			
[:LEVel]?	Query state of line #1.			
:TTL2	Path to set digital output line #2:			3.20.21
[:LEVel] <b>	Enable or disable line #2.			
[:LEVel]?	Query state of line #2.			
:TTL3	Path to set digital output line #3:			3.20.21
[:LEVel] <b>	Enable or disable line #3.			
[:LEVel]?	Query state of line #3.			
:TTL4	Path to set digital output line #4:			3.20.21
[:LEVel] <b>	Enable or disable line #4.			
[:LEVel]?	Query state of line #4.			
:VOLTage	Path to set V-Source level:		√	3.20.22
[: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 <b>	Enable or disable voltage limit.	OFF	√	
:STATe?	Query state of voltage limit.		√	
:MCONnect <b>	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 <b>	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:
1. *RST and :SYSTem:PRESet have no affect on the state of the output lines. However, cycling power sets all output lines false (OFF).

Table 3-12

STATus command summary

Command	Description	Default parameter	SCPI	Ref.
:STATus			√	
:MEASurement	Path to control measurement event registers:			
[:EVENt]?	Read the event register.	(Note 2)		3.21.1
:ENABle <NRf>	Program the enable register.	(Note 3)		3.21.2
:ENABle?	Read the enable register.			
:PTRansition <NRf>	Program the positive transition register.	(Note 4)		3.21.3
:PTRansition?	Read the positive transition register.			
:NTRansition <NRf>	Program the negative transition register.	(Note 5)		213.21.4
:NTRansition?	Read the negative transition register.			
:CONDition?	Read the condition register.			
:OPERation	Path to control operation status registers:		√	3.21.5
[:EVENt]?	Read the event register.	(Note 2)	√	
:ENABle <NRf>	Program the enable register.	(Note 3)	√	3.21.1
:ENABle?	Read the enable register.		√	3.21.2
:PTRansition <NRf>	Program the positive transition register.	(Note 4)	√	
:PTRansition?	Read the positive transition register.		√	3.21.3
:NTRansition <NRf>	Program the negative transition register.	(Note 5)	√	
:NTRansition?	Read the negative transition register.		√	3.21.4
:CONDition?	Read the condition register.		√	
:ARM	Path to control arm event registers:		√	3.21.5
[:EVENt]?	Read the event register.	(Note 2)	√	
:ENABle <NRf>	Program the enable register.	(Note 3)	√	3.21.1
:ENABle?	Read the enable register.		√	3.21.2
:PTRansition <NRf>	Program the positive transition register.	(Note 4)	√	
:PTRansition?	Read the positive transition register.		√	3.21.3
:NTRansition <NRf>	Program the negative transition register.	(Note 5)	√	
:NTRansition?	Read the negative transition register.		√	3.21.4
:CONDition?	Read the condition register.		√	
:SEQuence	Path to control sequence status registers:		√	3.21.5
[:EVENt]?	Read the event register.	(Note 2)	√	
:ENABle <NRf>	Program the enable register.	(Note 3)	√	3.21.1
:ENABle?	Read the enable register.		√	3.21.2
:PTRansition <NRf>	Program the positive transition register.	(Note 4)	√	
:PTRansition?	Read the positive transition register.		√	3.21.3
:NTRansition <NRf>	Program the negative transition register.	(Note 5)	√	
:NTRansition?	Read the negative transition register.		√	3.21.4
:CONDition?	Read the condition register.		√	
:TRIGger	Path to control trigger status registers:		√	3.21.5
[:EVENt]?	Read the event register.	(Note 2)	√	
:ENABle <NRf>	Program the enable register.	(Note 3)	√	3.21.1
:ENABle?	Read the enable register.		√	3.21.2
:PTRansition <NRf>	Program the positive transition register.	(Note 4)	√	
:PTRansition?	Read the positive transition register.		√	3.21.3
:NTRansition <NRf>	Program the negative transition register.	(Note 5)	√	
:NTRansition?	Read the negative transition register.		√	3.21.4
:CONDition?	Read the condition register.		√	
				3.21.5

Table 3-12 (Continued)

STATus command summary

Command	Description	Default parameter	SCPI	Ref.
:STATus				
:QUEStionable	Path to control questionable status registers:		√	
[:EVENt]?	Read the event register.	(Note 2)	√	3.21.1
:ENABle <NRf>	Program the enable register.	(Note 3)	√	3.21.2
:ENABle?	Read the enable register.		√	
:PTRansition <NRf>	Program the positive transition register.	(Note 4)	√	3.21.3
:PTRansition?	Read the positive transition register.		√	
:NTRansition <NRf>	Program the negative transition register.	(Note 5)	√	3.21.4
:NTRansition?	Read the negative transition register.		√	
:CONDition?	Read the condition register.		√	3.21.5
:PRESet	Return status registers to default states.		√	3.21.6
:QUEue	Path to access error queue:		√	3.21.7
[: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:

1. 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.

2. Event Registers: Power-up and *CLS – Clears all bits of the registers
                      :STATus:PRESet – No effect.

3. Enable Registers: Power-up and :STATus:PRESet – Clears all bits of the registers
                      *CLS – No effect

4. PTR Registers: Power-up and :STATus:PRESet sets all bits of the registers
                   *CLS – No effect

5. NTR Registers: Power-up and :STATus:PRESet clears all bits of the registers
                   *CLS – No effect

6. Error Queue: Power-up and *CLS – Clears the Error Queue
                 :STATus:PRESet – No effect

7. Enable/Disable Error Queue Messages: Power-up – Clears list of messages
                                         *CLS and :STATus:PRESet – No effect

Table 3-13
SYSTem command summary

Command	Description	Default parameter	SCPI	Ref
:SYSTem				
:PRESet	Return to :SYST:PRES defaults.		√	3.22.1
:POSetup <name>	Select power-on setup: (RST, PRESet or SAV0-SAV9).			3.22.2
:POSetup?	Query power-on setup.			
:VERSion?	Query rev level of SCPI standard.		√	3.22.3
:ERRor?	Query (read) Error Queue.	(Note)	√	3.22.4
:LSYNc	Path to control line synchronization of measurements.			3.22.5
:STATe <b>	Enable or disable line sync.			
:STATe?	Query line sync.	OFF		3.22.6
:KEY <NRf>	Simulate key-press (1 to 31; see Figure 3-40).			
:KEY?	Query the last "pressed" key.			
:CLEar	Clears messages from the Error Queue.		√	3.22.7
:DATE <yr>, <mo>, <day>	Set date.		√	3.22.8
:DATE?	Query date.		√	3.22.9
:TIME <hr>, <min>, <sec>	Set time (24-hour format).		√	3.22.10
:TIME?	Query time.		√	
:TSTamp	Path to configure and control timestamp.			3.22.11
:TYPE <name>	Select timestamp type (RELative or RTClock).			
:TYPE?	Query timestamp type.			3.22.12
:RELative	Path to reset timestamp.			
:RESet	Reset relative timestamp to 0 sec.			
:RNUMber	Path to reset reading number.			
:RESet	Reset reading number to zero			
:ZCHeck <b>	Enable or disable zero check			3.22.12
:ZCHeck?	Query state of zero check.			
:ZCORrect	Path to control zero correct.			3.22.12
[:STATe] <b>	Enable or disable zero correct.	OFF		
[:STATe]?	Query state of zero correct.			
:ACQuire	Acquire zero correction value.			
:TSControl <b>	Enable or disable external temperature readings.	OFF		3.22.12
:TSControl?	Query state of external temperature readings.			
:HLControl <b>	Enable or disable the A/D hardware limit.	ON		3.22.13
:HLControl?	Query state of hardware limit.			
:HSControl <b>	Enable or disable humidity readings.	OFF		3.22.13
:HSControl?	Query state of humidity readings.			
:LOCal	Take 6517 out of remote (RS-232 only).			3.22.13
:REMote	Put 6517 in remote (RS-232 only).			
:LLOCkout <b>	Enable or disable local lockout (RS-232 only).	OFF		3.22.14
:MACRo				3.22.14
:TRIGger	Paths to configure Basic triggering.			3.22.14
[:EXECute]	Select basic triggering.			3.22.15
:MODE <name>	Specify trigger mode (CONTinuous or ONEShot).	CONTinuous		
:SOURce <name>	Specify source (IMMediate, MANual, BUS, EXTernal or TIMer).	IMMEdiate		
:TIMer <n>	Specify timer interval; 0.001 to 99999.999 (sec).	0.1		

Note: Clearing the Error Queue: Power-up and *CLS – Clears the Error Queue
*RST, :SYSTem:PRESet and :STATus:PRESet – No effect

Table 3-14

TRACe command summary

Command	Description	Power-up defaults*	SCPI	Ref.
:TRACe|:DATA	Use :TRACe or :DATA as root command.			23
:CLEar	Clear readings from buffer.			3.23.1
:FREE?	Query bytes available and bytes in use.		√	3.23.2
:POINts <n>	Specify size of buffer.		√	3.23.3
:AUTO <b>	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.			3.23.4
: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.		√	
:FEED?	Query source of readings for buffer.		√	
:DATA?	Read all readings in the buffer.		√	3.23.5
:TSTamp	Path to select timestamp format for buffer readings.			3.23.6
:FORMat <name>	Select timestamp format (ABSolute or DELTa).			
:FORMat?	Query timestamp format.			
:ELEMents <name>	Select reaeding elements (TSTamp, HUMidity, CHANnel, ETEMperature, VSOurce, NONE).			3.23.7

*:SYSTem:PRESet and *RST have no effect on the commands in this subsystem.

Table 3-15

Trigger command summary

Command	Description	Default parameter	SCPI	Ref.
:INITiate	Subsystem command path:		√	3.24.1
[:IMMediate]	Initiate one trigger cycle.		√	
:CONTinuous <b>	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.		√	3.24.2
:ARM[:SEQuence[1]]	Path to configure arm layers:		√	
[:LAYer[1]]	Path to program Arm Layer 1:		√	
:IMMediate	Loop around control source.		√	3.24.3
:COUNt <n>	Specify arm count (1 to 99999, or INF).	1	√	3.24.4
:COUNt?	Query arm count.		√	
:SOURce <name>	Select control source (HOLD, IMMediate, RTCLock, MANual, BUS, TLINk or EXTernal).	IMMediate	(Note 2)	3.24.6
:SOURce?	Query control source.		√	
:SIGNal	Loop around control source.		√	3.24.8
:TCONfigure	Path to configure Triggers:			3.24.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor).			
:DIRection?	Query direction.	ACCeptor		
:ASYNchronous	Path to configure asynchronous Trigger Link:			
:ILINe <NRf>	Select input line (1 to 6).			
:ILINe?	Query input line.	2		
:OLINe <NRf>	Select output line (1 to 6).			
:OLINe?	Query output line.	1		
:RTCLock	Path to configure the RTCLock control source:			3.24.10
: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.		√	3.24.3
:COUNt <n>	Specify scan count (1 to 99999 or INF).	(Note 3)	√	3.24.4
:COUNt?	Query scan count.		√	
:DELay <n>	Program delay (0 to 999999.999 sec)	0	√	3.24.5
:DELay?	Query delay.		√	
:SOURce <name>	Select control source (HOLD, IMMediate, TIMer, MANual, BUS, TLINk or EXTernal).	IMMediate	(Note 2)	3.24.6
:SOURce?	Query control source.		√	
:TIMer <n>	Set timer interval (0 to 999999.999 sec).	0.1	√	3.24.7
:TIMer?	Query timer.		√	
:SIGNal	Loop around control source.		√	3.24.8
:TCONfigure	Path to configure Triggers:			3.24.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	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.			

Table 3-15 (Continued)

Trigger command summary

Command	Description	Default parameter	SCPI	Ref.
:TRIGger[:SEQuence[1]]	Path to program Trigger Layer:		√	
:IMMediate	Loop around control source.		√	3.24.3
:COUNt <n>	Set measure count (1 to 99999, or INF).	(Note 3)	√	3.24.4
:COUNt?	Query measure count.		√	
:DELay <n>	Set delay (0 to 999999.999 sec)	0	√	3.24.5
:DELay?	Query delay.		√	
:SOURce <name>	Select control source (HOLD, IMMediate, TIMer, MANual, BUS, TLINk or EXTernal).	IMMediate	(Note 2)	3.24.6
:SOURce?	Query control source.		√	
:TIMer <n>	Set timer interval (0 to 999999.999 sec).	0.1	√	3.24.7
:TIMer?	Request the programmed timer interval.		√	
:SIGNal	Loop around control source.		√	3.24.8
:TCONfigure	Path to configure Triggers:			3.24.9
:PROTocol <name>	Select protocol (ASYNchronous or SSYNchronous).	ASYNchronous		
:PROTocol?	Query protocol.			
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	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.			
:SSYNchronous	Path to configure semi-synchronous Trigger Link:			
:LINE <NRf>	Select trigger line (1 to 6).	1		
:LINE?	Query trigger line.			

Notes:
1. Defaults for continuous initiation:
   :SYSTem:PRESet enables continuous initiation
   *RST disables continuous initiation
2. 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.
3. Defaults for count (Arm Layer 2 and Trigger Layer):
   :SYSTem:PRESet sets the count to INF (infinite).
   *RST sets the count to 1.

Table 3-16

:TSEQuence command summary

Command	Description	Default parameter	SCPI	Ref.
:TSEQuence	•			
:ARM	Arms selected test sequence.			3.25.1
:ABORt	Stops a test sequence in process.			3.25.1
:TYPE <name>	Specify test; DLEakage, CLEakage, CIResistance, RVCoefficient, SRESistivity, VRESistivity, SIResistivity, SQSWeep, STSWeep.	DLEakage		3.25.1
:TYPE?	Query test type.			
:TSOurce <name>	Specify trigger source; MANual, IMMediate, BUS, TLINk. EXTernal, LCLosure.	MANual		3.25.1

Table 3-16 (Continued)

:TSEQuence command summary

Command	Description	Default parameter	SCPI	Ref.
:TSEQuence				
:TSOurce?	Query trigger source.			
:TLINe \<NRf>	Specify TLINk line; 1 to 6.	1		3.25.1
:TLINe?	Query TLINk line.			
DLEakage	Diode leakage test path:			
:STARt \<NRf>	Specify start voltage; -1000 to 1000.	+1V		3.25.2
:STARt?	Query start voltage.			
:STOP \<NRf>	Specify stop voltage; -1000 to 1000.	+10V		3.25.3
:STOP?	Query stop voltage.			
:STEP \<NRf>	Specify step voltage; -1000 to 1000.	+1V		3.25.4
:STEP?	Query step voltage.			
:MDELay \<NRf>	Specify measure delay; 0 to 99999.9(sec).	1 sec		3.25.5
:MDELay?	Query measure delay.			
:CLEakage	Capacitor leakage test path:			
:SVOLtage \<NRf>	Specify bias voltage (-1000 to 1000).	+1V		3.25.6
:SVOLtage?	Query bias voltage.			
:STIME \<NRf>	Specify bias time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query bias time.			
:DTIMe \<NRf>	Specify discharge time; 0 to 9999.9 (sec).	2 sec		3.25.8
:DTIMe?	Query discharge time.			
:CIResistance	Cable insulation resistance test path:			
:SVOLtage \<NRf>	Specify bias voltage; -1000 to 1000.	+1V		3.25.6
:SVOLtage?	Query bias voltage.			
:STIME \<NRf>	Specify bias time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query bias time.			
:RVCoefficient	Resistor voltage coefficient test path:			
:SVOLtage[1] \<NRf>	Specify source voltage 1; -1000 to 1000.	+1V		3.25.6
:SVOLtage[1]?	Query source voltage.			
:MDELay[1] \<NRf>	Specify measure delay 1; 0 to 99999.0 (sec).	1 sec		3.25.5
:MDELay[1]?	Query measure delay.			
:SVOLtage2 \<NRf>	Specify source voltage 2; -1000 to 1000.	+2V		3.25.6
:SVOLtage2?	Query source voltage.			
:MDELay2 \<NRf>	Specify measure delay 2; 0 to 99999.9 (sec).	2 sec		3.25.5
:MDELay2?	Query measure delay.			
:SRESistivity	Surface resistivity test path:			
:PDTime \<NRf>	Specify pre-discharge time; 0 to 99999.9 (sec).	0.2 sec		3.25.9
:PDTime?	Query pre-discharge time.			
:SVOLtage \<NRf>	Specify bias voltage; -1000 to 1000.	+500V		3.25.6
:SVOLtage?	Query bias voltage.			
:STIME \<NRf>	Specify bias time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query bias time.			
:MVOLtage \<NRf>	Specify measure votlage; -1000 to 1000.	+500V		3.25.10
:MVOLtage?	Query measure voltage.			
:MTIMe \<NRf>	Specify measure time; 0 to 99999.9 (sec).	0 sec		3.25.11
:MTIMe?	Query measure time.			
:DTIMe \<NRf>	Specify discharge time; 0 to 99999.9 (sec).	2 sec		3.25.8
:DTIMe?	Query discharge time.			
:VRESistivity	Volume resistivity test path:			
:PDTime \<NRf>	Specify pre-discharge time; 0 to 99999.9 (sec).	10 sec		3.25.9
:PDTime?	Query pre-discharge time.			
:SVOLtage \<NRf>	Specify bias voltage; -1000 to 1000.	+500V		3.25.6
:SVOLtage?	Query bias voltage.			

Table 3-16 (Continued)
:TSEQuence command summary

Command	Description	Default parameter	SCPI	Ref.
:TSEQuence				
:VRESistivity				
:STIME <NRf>	Specify bias time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query bias time.			
:MVOLtage <NRf>	Specify measure voltage; -1000 to 1000.	+500V		3.25.10
:MVOLtage?	Query measure voltage.			
:MTIMe <NRf>	Specify measure time; 0 to 99999.9 (sec).	0 sec		3.25.11
:MTIMe?	Query measure time.			
:DTIMe <NRf>	Specify discharge time; 0 to 99999.9 (sec).	2 sec		3.25.8
:DTIMe?	Query discharge time.			
:SIResistance	Surface Insulation Resistance test path:			
:SVOLtage <NRf>	Specify bias voltage; -1000 to 1000.	+50V		3.25.6
:SVOLtage?	Query bias voltage.			
:STIME <NRf>	Specify bias time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query bias time.			
:MVOLtage <NRf>	Specify measure voltage; -1000 to 1000.	+100V		3.25.10
:MVOLtage?	Query measure voltage.			
:MTIMe <NRf>	Specify measure time; 0 to 99999.9 (sec).	1 sec		3.25.11
:MTIMe?	Query measure time.			
:SQSWeep	Square wave sweep test path:			
:HLEVel <NRf>	Specify high level voltage; -1000 to 1000.	+1V		3.25.12
:HLEVel?	Query high level voltage.			
:HTIMe <NRf>	Specify high level time; 0 to 99999.9 (sec).	1 sec		3.25.13
:HTIMe?	Query high level time.			
:LLEVel <NRf>	Specify low level voltage; -1000 to 1000.	-1V		3.25.14
:LLEVel?	Query low level voltage.			
:LTIMe <NRf>	Specify low level time; 0 to 99999.9 (sec).	1 sec		3.25.15
:LTIMe?	Query low level time.			
:COUNt <NRf>	Specify number cycles.			3.25.16
:COUNt?	Query cycle count.			
:STSWeep	Staircase sweep test path:			
:STARt <NRf>	Specify start voltage; -1000 to 1000.	+1V		3.25.2
:STARt?	Query start voltage.			
:STOP <NRf>	Specify stop votlage; -1000 to 1000.	+10V		3.25.3
:STOP?	Query stop voltage.			
:STEP <NRf>	Specify step voltage; -1000 to 1000.	+1V		3.25.4
:STEP?	Query step voltage.			
:STIME <NRf>	Specify step time; 0 to 99999.9 (sec).	1 sec		3.25.7
:STIME?	Query step time.			

Table 3-17
:UNIT command summary

Command	Description	Power-up defaults
:TEMPerature <name>	Select temperature units (C, CEL, F, FAR, K).	C
:TEMPerature?	Query temperature units.	

3.13   Calculate subsystems

The commands in this subsystem are used to configure and control the three Calculate subsystems and are summarized in Table 3-4.

3.13.1   :CALCulate[1]

This subsystem is used to configure and control the Polynomial and Percent math calculations. Detailed information on math calculations is provided in paragraph 2.18.

: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 :STATe), 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 <b>

:CALCulate[1]:STATe <b>   Control CALC 1

Parameters   <b> = 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).

: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 (equivalent to :CALCulate[1]:IMMediate; DATA?)

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 (i.e. waiting for a trigger), the displayed reading will not update to the 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.

Program fragment

```
PRINT #1, "output 27; :syst:pres?"      ' Select defaults
PRINT #1, "output 27; :trig:sour bus"   ' Place 6517 in one-
                                        ' shot measure mode
SLEEP 3                                 ' Wait three seconds
PRINT #1, "output 27; :calc:form pol"   ' Select polynomial math
                                        ' calculation
PRINT #1, "output 27; :calc:kmat:ma0f 50"  ' Set "a0" to 50
PRINT #1, "output 27; :calc:stat on"    ' Enable calculation
SLEEP 3                                 ' Wait three seconds
PRINT #1, "output 27; :cal:imm"         'Performcalculation(adds50
                                        ' to reading)
```

3.13.2   :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.

Details on MEAN, SDEV, MAX and MIN are provided in paragraph 2.16.3.

PKPK = MAX - MIN

where   MAX is the largest reading in the buffer
         MIN is the lowest reading in the buffer

:STATe <b>

:CALCulate2:STATe <b>   Control CALC 2

Parameters   <b> =   0 or OFF   Disable CALC 2 calculation
                          1 or ON   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 (equivalent to :CALCulate2:IMMediate; DATA?)

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 :STATe). 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.

Program fragment

This example assumes that there are readings stored in the buffer and CALC 2 is enabled:

```
PRINT #1, "output 27; :calc2:form max"      ' Select MAX format
PRINT #1, "output 27; :calc2:imm?"          ' Perform math and query
                                            ' result
PRINT #1, "enter 27"                        ' Get response message from 6517
```

: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.

3.13.3   :CALCulate3

This Calculate subsystem is used to configure and control the limit tests (LIMIT 1 test and LIMIT 2 test). See paragraph 2.19.6 for details on limit tests.

[: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	Specify limit value
	DEFault	Set specified upper limit to 1
		Set specified lower limit to -1
	MINimum	Set specified limit to -9.999999e35
	MAXimum	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 1u is 1uA for the amps function and 1uC 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:

Digital Output	Decimal Weight
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 (see paragraph 3.17).

Note that when the binning strobe is enabled (see :BSTRobe command path), 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 <b>

:CALCulate3:LIMit[1]:STATe <b>	Control LIMIT 1 test
:CALCulate3:LIMit2:STATe <b>	Control LIMIT 2 test

Parameters

<b> =	1 or ON	Enable specified limit test
	0 or OFF	Disable specified limit test

Query

:STATe?   Query state of specified limit test

Description

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.

Note that when a limit test (LIMIT 1 or LIMIT 2) is enabled, the digital output port cannot be controlled from the Source Subsystem.

A fail indication (see :FAIL?) for LIMIT 1 or LIMIT 2 is cleared when the respective limit test is disabled.

:FAIL?

:CALCulate3:LIMit[1]:FAIL?	Read LIMIT 1 test results
:CALCulate3:LIMit2:FAIL?	Read LIMIT 2 test results

These commands are used to read the results of LIMIT 1 and LIMIT 2 tests:

0 = Limit test passed
1 = Limit test failed

Description

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 Measurement Event Register (see paragraph 3.21.1).

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).

:CLEar commands
[:IMMediate]

:CALCulate3:LIMit[1]:CLEar[:IMMediate]   Clear LIMIT 1 test failure
:CALCulate3:LIMit2:CLEar[:IMMediate]   Clear LIMIT 2 test failure

Description   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).

:AUTO <b>

:CALCulate3:LIMit[1]:CLEar:AUTO <b>   Control auto-clear; LIMIT 1
:CALCulate3:LIMit2:CLEar:AUTO <b>   Control auto-clear; LIMIT 2

Parameters   <b> = 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:

Digital Output	Decimal Weight
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 paragraph 3.17).

Note that when the binning strobe is enabled (see :BSTRobe command path), 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 <b>

:CALCulate3:BSTRobe:STATe <b>   Control binning strobe

Parameters

<b> = 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 (e.g., 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.

Program fragment

```
PRINT #1, "output 27; :trig:sour bus"    ' Place 6517 in one-shot mode
SLEEP 3                                   ' Wait three seconds
PRINT #1, "output 27; :calc3:imm"        ' Re-perform limit test
```

3-69

3.14   :CALibration subsystem

There are two calibrate commands that are accessible to the operator. These commands are used to null out input bias current and voltage burden. These commands are summarized in Table 3-5. To calibrate the instrument, refer to the Model 6517 Calibration Manual.

:VOFFset

:CALibration:UNPRotected:VOFFset   Null voltage burden

Description   This action command is used to null voltage burden. Before sending this command connect a short to the input triax connector. Function changes and measurements cannot be made during the calibration process.

:IOFFset

:CALibration:UNPRotected:IOFFset   Null input offset current

Description   This action command is used to null input offset current. Before sending this command, cap the input triax connector. Function changes and measurements cannot be made during the calibration process.

3.15 :DISPlay subsystem

The display subsystem controls the display of the Model 6517 and is summarized in Table 3-6.

: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 <b>

:DISPlay[:WINDow[1]]:TEXT:STATe <b>   Control message; top display
:DISPlay:WINDow2:TEXT:STATe <b>   Control message; bottom display

Parameters   <b> = 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 test 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 as follows:

00000000000000000000

The response message for :disp:wind2:attr? (secondary display) will display 1s at the character positions for SAVESETUP as follows:

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 6517 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 <b>

:DISPlay:SMESsage <b>	Control status message

Parameters

<b> =	0 or OFF	Disable status messages
	1 or ON	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 2-5 lists the status messages.

:ENABle <b>

:DISPlay:ENABle <b>   Control display circuitry

<b> =   0 or OFF   Disable display circuitry
        1 or ON   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 6517 into local.

3.16   :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. (i.e. SENSE: DATA? or CALC:DATA? is always be sent in ASCII.) These commands are summarized in Table 3-7.

[:DATA] <type>[,length]

:FORMat[:DATA] <type>[,<length>]   Specify data format

Parameters   <type>[,<length>] = ASCii   ASCII format
                                            REAL,32   IEEE754 single precision format
                                            REAL,64   IEEE754 double precision format
                                            SREal   IEEE754 single precision format
                                            DREal   IEEE754 double precision format

NOTE: When using the ASCii, SREal or DREal 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 3-19 shows the ASCII format that includes all the data elements.

REAL,32 or SREal will select the binary IEEE754 single precision data format. Figure 3-20 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 DREal selects the binary IEEE754 double precision data format and is shown in Figure 3-21 (normal byte order shown). This format is similar to the single precision format except that it is 64 bits long.
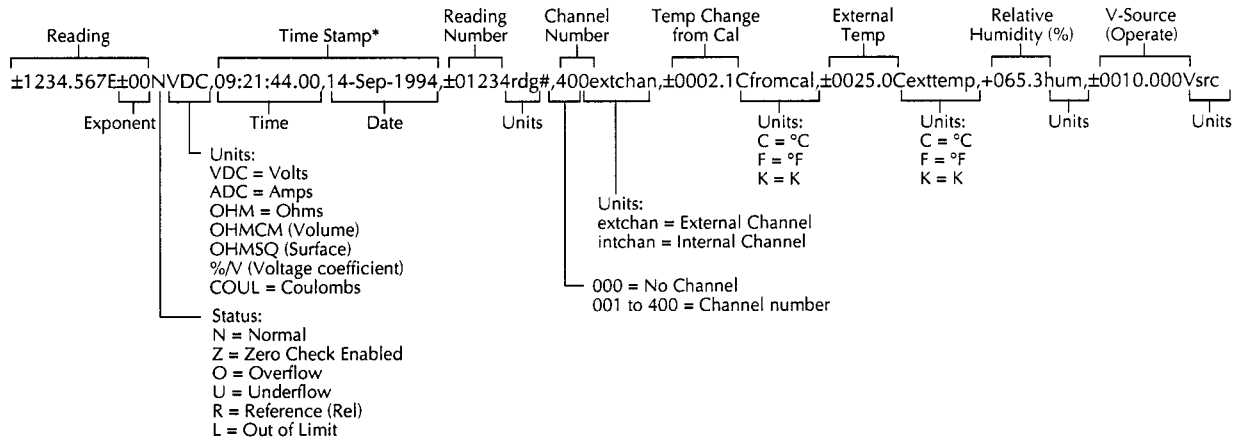
Figure 3-19
ASCII data format

Figure 3-20
IEEE754 single precision data format (32 data bits)
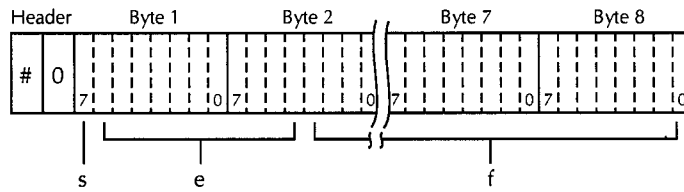
Bytes 3, 4, 5, and 6 not shown.

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.

Figure 3-21
IEEE754 double precision data format (64 data bits)

: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
                                  DTEMperature   Includes change from calibration temperature
                                  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

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 3-19, 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 (i.e. :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 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 timestamp, 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 timestamp is available to reference each reading to a point in time. There are two basic types of timestamps; real-time timestamp and relative time timestamp. The real-time timestamp provides the time (24-hour clock format) and date for each reading sent over the bus. The relative timestamp operates as a timer that starts at zero seconds when the instrument is turned on or when the relative timestamp is reset (:SYSTem:TSTamp:RELative:RESet). The timestamp 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 timestamped 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 timestamp is expressed as the days, hours, minutes and seconds between each reading, while the relative timestamp is expressed as seconds between each reading. When using the absolute format for the relative timestamp, any pre-trigger readings will have a negative timestamp.

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.

DTEMperature: The Model 6517 has an internal temperature measurement sensor mounted inside its case. When the instrument is calibrated, the temperature is stored in memory. This element indicates the change in temperature from when it was calibrated. The temperature sensor is enabled or disabled from the :SYSTem Subsystem. A reading of 9999.99 means temperature is disabled. Temperature can be expressed in °C, °F or K. See :UNIT Subsystem to change temperature units.

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 3-19 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 3-19.

:BORDer <name>

:FORMat:BORDer <name>   Specify binary byte order

Parameters   <name> = NORMal   Normal byte order for binary formats
                        SWAPped   Reverse byte order for binary formats

Query   :BORDer?   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   ooo   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   ooo   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 SWAPped selection is simply ignored when the ASCII format is selected.

3.17   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 3-8.

:OUTPut1 Subsystem
[:STATe] <b>

:OUTPut1:[:STATe] <b>   Control V-Source

Parameters   <b> =   ON or 1   Enable V-Source (operate)
                    OFF or 0   Disable V-Source (standby)

Query   [:STATe]?   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 :SOURce subsystem (see paragraph 3.19).

Note that the V-Source for Auto-V-Source Ohms is controlled from the :SENSe Subsystem (see paragraph 3.19.6; Ohms ranges).

:OUTPut2 Subsystem ?
:LSENse <name>

:OUTPut:TTL[1]:LSENse <name>   Set polarity of line #1
:OUTPut:TTL2:LSENse <name>   Set polarity of line #2
:OUTPut:TTL3:LSENse <name>   Set polarity of line #3
:OUTPut:TTL4:LSENse <name>   Set polarity of line #4

Parameters   <name> = AHIGh   Set polarity of specified line to active high.
                            ALOW   Set polarity of specified line to active low.

Query   :LSENse?   Query polarity of specified line

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 (see paragraph 3.19).

3.18   :ROUTe subsystem

The commands in this subsystem are used to configure and control switching and are summarized in Table 3-9.

3.18.1   :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   The :CLOSe \<list> command is used to close a channel on an optional scanner card installed in the Model 6517. 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.

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.

List =   (@ 2)   Single channel.
         (@ 2,4,6)   Multiple channels separated by commas (,).
         (@ 1:10)   Range of channels (1 though 10). Range limits separated by a colon (:).
         (@ 1:5,7)   Range entry and single entry separated by a comma.

After sending this query command and addressing the Model 6517 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.

STATe?

:ROUTe:CLOSe:STATe?   Query closed channel.

Description   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 6517 to talk, the channel list is sent to the computer.

3.18.2   :OPEN \<list>

:ROUTe:OPEN \<list>   Open closed channel

Parameters   \<list> = (@ chanlist)   Specify channel to open
                ALL   Open all channels

where; chanlist = 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 the :CLOSe command for examples to express a chanlist.

After sending this query command and addressing the Model 6517 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.

3.18.3 :OPEN:ALL

:ROUTe:OPEN:ALL   Open closed channel

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.

3.18.4 :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 though 8). Range limits separated by a colon (:).
           (@ 1:5,7)   Range entry and single entry separated by a comma.

Refer to Section 2 of this manual and the instruction manual for the scanner card for details on scanning.

: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   :EXTernal?   Query programmed number of external channels
              :EXTernal? DEFault   Query *RST default channel number value
              :EXTernal? MINimum   Query minimum channel number value
              :EXTernal? MAXimum   Query maximum channel number value

Description   The Model 6517 can operate with an external switch system, such as the Keithley Model 7001 or 7002. The Model 6517 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 6517 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 6517 scans the channels of the internal switching card according to how the scan is configured (see :ROUTe:SCAN[:INTernal]). EXTernal is used to measure channels that are controlled by an external switch system. When EXTernal is selected, the Model 6517 scans the channels of the external scanner card. The :ROUTe:SCAN:EXTernal command is used to specify the number of external channels to scan.

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 \<b>

:ROUTe:SCAN:VSLimit \<b>   Control 200V V-Source Limit

Parameters   \<b> =   0 or OFF   Disable 200V V-Source Limit
                 1 or ON   Enable 200V V-Source Limit

Query   :VSLimit?   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 :SOURce:VOLTage:LIMit 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.

3.19   :SENSe1 subsystem

The :SENSe1 subsystem is used to configure and control the measurement functions of the Model 6517. The commands for this subsystem are summarized in Table 3-10.

3.19.1   [:SENSe[1]] subsystem

This Sense 1 Subsystem is used to configure and control the measurement functions of the Model 6517 (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.

3.19.2   :FUNCtion <name>   [:SENSe[1]]:FUNCtion <name>   Select measurement function.

Parameters	<name> = 'VOLTage[:DC]'	Select Volts
	'CURRent[:DC]'	Select Amps
	'RESistance'	Select Ohms
	'CHARge'	Select Coulombs

Query   :FUNCtion?   Query currently programmed function.

Description   The :FUNCtion 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:

:func 'volt' = :func "volt"

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.

3.19.3   :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 the :FORMat Subsystem to select data elements.

[:LATest]?

[:SENSe[1]]:DATA[:LATest]?   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 (see the CALCulate subsystem 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 (see previous command) after a reading query.

:FRESh?

[:SENSe[1]]:DATA:FRESh?   Return new reading.

This query command is used to return a new (fresh) reading. This command 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.

3.19.4 :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> =	166.6666666667e-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	166.6666666667e-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 6517 can be set using either of two commands; NPLCycle (paragraph 3.19.5) 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. Refer to Section 2 for details on integration (SPEED). The relationship between NPLC and aperture is expressed as follows:

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. (Note: 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 (see:LSYNc command 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. See paragraph 2.12.8 for more details.

:AUTO <b>|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   <b> =   1 or ON   Enable auto aperture
                                   0 or OFF   Disable auto aperture
                                   ONCE   Enable and then disable auto aperture

Query   :AUTO?   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 2-17 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 in paragraph 3.19.4.

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.

3.19.5   :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 6517 can be set using either of two commands; :APERture (paragraph 3.19.4) or :NPLCycle. Aperture specifies time (in seconds)

per integration, while NPLC expresses the integration period by basing it on the power line frequency. See paragraph Section 2 for details on integration (SPEED).

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 :NPLCycle 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 command 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. See paragraph 2.19.8 for more details.

:AUTO <b> | 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   <b> = 1 or ON   Enable auto NPLC
                0 or OFF   Disable auto NPLC
                ONCE   Enable and then disable auto NPLC

Query   :AUTO?   Query state of auto NPLC

Description 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 2-17 provides the integration times for SET-BY-RSLN (AUTO).

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE 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.

:NPLC:AUTO is coupled to the command that manually sets the NPLC value (:NPLC <n>). When auto NPLC is enabled, the parameter value for :NPLC <n> 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 :NPLC <n> command disables auto NPLC.

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 :APERture command disables auto NPLC.

3.19.6   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   <n> =   0 to 210   Expected reading in volts
                            0 to 21e-3   Expected reading in amps
                            0 to 2.1e-6   Expected reading in coulombs
                            DEFault   210 (volts)
                                             21e-3 (amps)
                                             2.1e-6 (coulombs)
                    MINimum   0 (all functions)
                    MAXimum   Same as DEFault

Query   :RANGe[:UPPer]?   Query programmed measurement range
                 :RANGe[:UPPer]? DEFault   Query *RST default range
                 :RANGe[:UPPer]? MINimum   Query lowest measurement range
                 :RANGe[:UPPer]? MAXimum   Query highest measurement range

Description   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 6517 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 (<n>) = 0.01 (or 10e-3) in order to select the 20mA range.

:AUTO <b> | 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   <b> =   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 (see paragraph 2.12.4 for details).

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 dis-

abled, 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 :AUTO: ULIMit and :AUTO:LLIMit commands).

: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

:ULIMit?	Query upper range limit :ULIMit?
DEFault	Query *RST default upper limit :ULIMit?
MINimum	Query lowest allowable upper limit :ULIMit?
MAXimum	Query largest allowable upper limit
:LLIMit?	Query lower range limit :LLIMit?
DEFault	Query *RST default lower limit :LLIMit?
MINimum	Query lowest allowable lower limit :LLIMit?
MAXimum	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.

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.

The lower range limit is selected by specifying the lowest expected reading that you expect to measure.

Note: See next command to set the autorange limit for coulombs.

:LGRoup <name>

[:SENSe[1]]:CHARge:RANGe:AUTO:LGRoup <name>	Select coulombs autorange limit

Parameters

<name> =	HIGH	200nC to 2μC autorange limit
	LOW	2nC to 20nC autorange limit

Query	:LGRoup?	Query coulombs autorange limit

Description   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).

Ohms Ranges:

[:UPPer] <n>

[:SENSe[1]:RESistance[:AUTO]:RANGe[:UPPer] <n>   Set measurement range for Auto V-Source Ohms
[:SENSe[1]:RESistance:MANual:CRANge[:UPPer] <n>   Set measurement range for Manual V-Source Ohms

Parameters   <n> =   0 to 100e18   Expected reading in ohms
DEFault   100e18
MINimum   0
MAXimum   Same as DEFault

Query   [:UPPer]?   Query programmed measurement range
[:UPPer]? DEFault   Query *RST default range
[:UPPer]? MINimum   Query lowest measurement range
[:UPPer]? MAXimum   Query highest measurement range

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 6517 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 <b> | 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   <b> =   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 (see paragraph 2.12.4 for details).

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 next commands).

: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

:ULIMit?	Query upper range limit
:ULIMit? DEFault	Query *RST default upper limit
:ULIMit? MINimum	Query lowest allowable upper limit
:ULIMit? MAXimum	Query largest allowable upper limit
:LLIMit?	Query lower range limit
:LLIMit? DEFault	Query *RST default lower limit
:LLIMit? MINimum	Query lowest allowable lower limit
:LLIMit? MAXimum	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 1GΩ, let the parameter (<n>) = 1e9.The lowest (most sensitive) range that can measure 1GΩ is the 2GΩ range. Thus, the 2GΩ range is selected as the upper range limit. With this upper limit, the instrument cannot uprange to the 20GΩ (or higher) measurement range.

The lower range limit is selected by specifying the lowest expected reading that you expect to measure.

:VSOurce:RANGe <n>

[:SENSe[1]:RESistance:MANual:VSOurce:RANGe <n>   Set V-Source range for Manual V-Source Ohms

Parameters

<n> = 0 to 1000   Specify output in volts
       DEFault   100V range
       MINimum   100V range
       MAXimum   1000V range

Query	:RANGe?	Query V-Source range
	:RANGe? DEFault	Query *RST default V-Source range
	:RANGe? MINimum	Query lowest allowable range
	:RANGe? MAXimum	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 (see next command) is greater than 100V. A setting conflict error will result.

:VSOurce[:AMPLitude] <n>

[:SENSe[1]:RESistance:MANual:VSOurce[:AMPLitude] <n>   Set V-Source level for Manual V-Source Ohms

Parameters

<n> =	-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

[:AMPLitude]?	Query programmed V-Source level
[:AMPLitude]? DEFault	Query *RST default V-Source level
[:AMPLitude]? MINimum	Query lowest allowable level
[:AMPLitude]? MAXimum	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 previous command). When on the 100V range, attempts to set the amplitude to a value that exceeds 100V will result in a Setting Conflicts 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 next command).

:VSOurce:OPERate <b>

[:SENSe[1]:RESistance:MANual:VSOurce:OPERate <n>

Parameters

<b> =	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.

3.19.7 **: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

:REFerence?	Query programmed reference value
:REFerence? DEFault	Query *RST default reference value
:REFerence? MINimum	Query lowest allowable reference value
:REFerence? MAXimum	Query largest allowable reference value

Description

These commands are used to establish a reference value for the specified function. When Reference is enabled (see :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 (see :CREFerence for details).

From the front panel, reference is called relative (REL). See Section 2 for more information on 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 <b>

[: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

<b> =		
	1 or ON	Enable reference
	0 or OFF	Disable reference

Query

:STATe?	Query state of reference

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 :REFerence for details.

3.19.8   :IREFerence <b>   [:SENSe[1]]:RESistance:IREFerence <b>   Control amps reference

Parameters   <b> = 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 (see paragraph 3.19.7) and this command is used to enabe the amps reference for ohms, the current value used to compute resistance (Iohm) 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.

3.19.9   :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 3H digit resolution let <n> = 3.5, for 4Hd let <n> = 4.5, and so on. Internally, the instrument rounds the entered parameter value to the nearest integer.

:AUTO <b> I ONCE

[:SENSe[1]]:VOLTage[:DC]:DIGits:AUTO <b>IONCE	Control auto resolution; Volts
[:SENSe[1]]:CURRent[:DC]:DIGits:AUTO <b>IONCE	Control auto resolution; Amps
[:SENSe[1]]:RESistance:DIGits:AUTO <b>IONCE	Control auto resolution; Ohms
[:SENSe[1]]:CHARge:DIGits:AUTO <b>IONCE	Control auto resolution; Coulombs

Parameters <b> = 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

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 (see Table 2-18).

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.

3.19.10 :AVERage commands

The :AVERage commands are used to configure and control the digital filter. See paragraph 2.17 for details.

: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. These filter modes are explained in paragraph 2.17.1.

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] <b>

[:SENSe[1]]:VOLTage[:DC]:AVERage[:STATe] <b>	Control filter; Volts
[:SENSe[1]]:CURRent[:DC]:AVERage[:STATe] <b>	Control filter; Amps
[:SENSe[1]:RESistance:AVERage[:STATe] <b>	Control filter; Ohms
[:SENSe[1]]:CHARge:AVERage[:STATe] <b>	Control filter; Coulombs

Parameters   <b> = 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 "Setting 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? DEFault	Query *RST default noise tolerance
:NTOLerance? MINimum	Query lowest allowable noise tolerance
:NTOLerance? MAXimum	Query 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. See paragraph 2.17.1 for details.

3.19.11 :MEDian Commands

Refer to paragraph 2.17.2 for details on using the median filter.

[:STATe] <b>

[:SENSe[1]]:VOLTage[:DC]:MEDian[:STATe] <b>	Control median; Volts
[:SENSe[1]]:CURRent[:DC]:MEDian[:STATe] <b>	Control median; Amps
[:SENSe[1]]:RESistance:MEDian[:STATe] <b>	Control median; Ohms
[:SENSe[1]]:CHARge:MEDian[:STATe] <b>	Control median; Coulombs

Parameters   <b> =   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 rnage (1 to 5) as follows:

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.

3.19.12 :DAMPing <b>

[:SENSe[1]]:CURRent:DC:DAMPing <b>	Control damping for Amps
[:SENSe[1]]:RESistance:DAMPing <b>	Control damping for Ohms

Parameters   <b> =   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).

3.19.13 :GUARd <b>

[:SENSe[1]]:VOLTage:DC:GUARd <b>   Control guard for Volts

Parameters   <b> =   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. For detailed information on guard, see paragraphs 2.4.4 and 2.5.3 (Guarding).

3.19.14 :ADISCharge Commands

Auto discharge is used to reset the charge reading to zero. See paragraph 2.8 for more information.

[:STATe] <b>

[:SENSe[1]]:CHARge:ADIScharge[:STATe] <b>   Control auto discharge

Parameters   <b> =   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 next command).

: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.

3.19.15 :XFEedback <b> [:SENSe[1]]:VOLTage[:DC]:XFEedback <b>

Parameters   <b> = 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 paragraph 2.11 for information on external feedback.

3.19.16 :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 Manua lV-Source ohms or Auto V-Source ohms. With MANual selected, you can set the V-Source level for ohms measurements. See paragraph 3.19.6 (Ohms Ranges) to configure and control the V-Source for Manual V-Source ohms measurements.

                With AUTO selected, the V-Source level is automatically set for the ohms measurement (40V or 400V).

3.19.17 :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 paragraph 3.19.18 to configure resistivity measurements.

3.19.18 :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 6517 through the safety interlock cable. Also, when using the Model 8009, you do not need to use the :USER commands (:RSELect, :KSURface and :KVOLume).

For detailed information on resistivity measurements, refer to paragraph 2.7.2.

:FSELect <name>

[:SENSe[1]]:RESistance:RESistivity:FSELect <name>   Specify test fixture

Parameters   <name> = M8009   Model 8009 Resistivity Test Fixtire

                       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 entered is the sample thickness for volume resistivity (see next command).

Specify USER when using any other resistivity test fixture. When using this type of test fixture, you will have to be 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 6517 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 fxiture

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 (in mm) between the guarded electrode and the ring electrode.

See paragraph 2.7.2 (Surface Resistivity) for detailed information on surface resistivity measurements.

:KVOLume <NRf>

[:SENSe[1]]:RESistance:RESistivity:USER:KVOLume <NRf>   Specify Kv parameter for volume resistivity

Parameters   <NRf> = 0.001 to 999.999   Kv parameter

Query   :KVOLume?   Query programmed Kv parameter

Description   This command is used to specify the Kv parameter for volumeresistivity measurements when using a user-supplied test fixture. This command is not needed when using the Model 8009 test fixture.

Kv is the effective area of the guarded electrode for the particular electrode arrangement employed and is calculated as follows:

Note: The following calculation assumes that the effective area coefficient (B) is zero, which is typically used for volume resistivity.

$$Kv = \pi(D1/2)^2 \quad (\text{for B=0})$$

where; D1 = Outside diameter of guarded electrode.

If using a different value for B, use the calculation shown in paragraph 2.7.2 (Volume Resistivity).

3.20 :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 3-11.

3.20.1 Digital Output Commands

[:LEVel] <b>

:SOURce:TTL[1]:[LEVel] <b>	Control digital output line #1
:SOURce:TTL2:[LEVel] <b>	Control digital output line #2
:SOURce:TTL3:[LEVel] <b>	Control digital output line #3
:SOURce:TTL4:[LEVel] <b>	Control digital output line #4

Parameters   <b> =   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 subsystem). 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.

3.20.2 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 and :LIMit). When on the 100V range, attempts to set the amplitude to a level that ex-

ceeds the 100V range will result in a Setting Conflicts 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 paragraph 3.17).

: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 setting 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 ±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 <b>

:SOURce:VOLTage:LIMit:STATe <b>   Control voltage limit

Parameters   <b> =   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 <b>

:SOURce:VOLTage:MCONnect <b>   Control LO connection

Parameters   <b> =   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 <b>

:SOURce:CURRent:RLIMit:STATe <b>   Control resistance current limit

Parameters   <b> =   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 1MΩ 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.

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

3.21 :STATus subsystem

The STATus subsystem is used to control the status registers of the Model 6517. These registers and the overall status structure is explained in paragraph 3.8. The commands in this subsystem are summarized in Table 3-12.

3.21.1 [:EVENt]?

:STATus:MEASurement[:EVENt]?Read Measurement 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 6517 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 Figures 3-22 through 3-27. Note that reading an event register clears the bits in that register.

For example, assume that reading the Measurement 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 Measurement Event Register are set.

The significance of a set bit in these registers depends on how the transition filter is programmed (see :PTRansition and :NTRansition commands). 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:

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 — Not used.

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 (i.e. noise spikes) exceed the range limit (PTR).

Bit B13 — Not used.

Bit B14 (VSC) — Set bit indicates that the V-source is in compliance (PTR).

Bit B15 — Always zero.

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	—	OL	BPT	—	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2^{14})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Measurement Event Set
0 = Measurement Event Cleared

Events : VSC = V-Source Compliance
OL = Out of Limits
BPT = Buffer Pretriggered
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 3-22
Measurement Event Register

Questionable Event Register:

Bit B0, Volts Summary (Volt) — Set bit indicates that na invalid volts measurement has occurred (PTR), or a subsequent valid volts measuurement 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.

Bits 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).

Bits B10, Ohms Summary (Ohm) — Set bit indicates that an invalid ohms measurement has occurred (PTR), or a subsequent valid ohms measurement has occurred (NTR).

Bits B11, Coulombs Summary (Coul) — Set bit indicates that an invalid Coulombs measurement has occurred, or a subsequent valid coulombs measurement has occurred (NTR).

Bits B12, Sequence Test Summary (Seq) — Set bit indicates that a sequence test has been aborted (PTR).

Bits B13 — Not used.

Bit B14, Command Warning (Warn) — Set bit indicates that a Signal Oriented Measurement Command parameter has been ignored (PTR), or a subsequent Signal Oriented Measurement 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.

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})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Questionable Event Bit Set
0 = Questionable Event Bit Cleared

Events : Warn = Command Warning   Cal = Calibration Summary
Seq = Sequence Test Summary   Temp = Temperature
Coul = Coulombs   Amp = Amps Summary
Hum = Humidity Summary   Volt = Volts Summary

Figure 3-23
Questionable Event Register

Operation Event Register:

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 through B14 — Not used.

Bit B15 — Always zero.

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 6517
Calc = Calculating Reading
Arm = Waiting for Arm
Trig = Waiting for Trigger
Meas = Measuring
Cal = Calibrating

Figure 3-24
Operation Event Register

Trigger Event Register:

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 B12 through B14 — Not used

Bit B15 — Always zero.

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

Figure 3-25
Trigger Event Register

Arm Event Register:

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.

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

Figure 3-26
Arm Event Register

Sequence Event Register:

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 B12 through B14 — Not used

Bit B15 — Always zero.

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

Figure 3-27
Sequence Event Register

3.21.2   :ENABle <NRf>

:STATus:MEASurement:ENABle <NRf>	Program Measurement 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> =			<NRf> =	
0	Clear register		128	Set bit B7
1	Set bit B0		256	Set bit B8
2	Set bit B1		512	Set bit B9
4	Set bit B2		1024	Set bit B10
8	Set bit B3		2048	Set bit B11
16	Set bit B4		4096	Set bit B12
32	Set bit B5		16384	Set bit B14
64	Set bit B6		65535	Set all bits

Query   :ENABle?   Query enable register

Description   These commands are used to set the contents of the event enable registers (see Figures 3-28 through 3-33). 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.

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.

The decimal weighting of the bits for each event enable register are included in Figures 3-28 through 3-33. 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 Measurement Event Enable Register, send the following command:

:stat:meas:enab 544

where;   BFL (bit B9) = Decimal   512
         RAV (bit B5) = Decimal   32
         _____
         <NRf> =   544

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	—	OL	BPT	—	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2^{14})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Enable Measurement Event
         0 = Disable (Mask) Measurement Event

Events : VSC = V-Source Compliance
         OL = Out of Limits
         BPT = Buffer Pretriggered
         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 3-28
Measurement 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})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Enable Questionable Event
        0 = Disable (Mask) Questionable Event

Events : Warn = Command Warning   Cal = Calibration Summary
         Seq = Sequence Test Summary   Temp = Temperature
         Coul = Coulombs   Amp = Amps Summary
         Hum = Humidity Summary   Volt = Volts Summary

Figure 3-29
Questionable 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 (1011)	1024 (210)	512 (29)	—	—	64 (26)	32 (25)	—	—	—	—	1 (20)
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 6517
Arm = Waiting for Arm
Trig = Waiting for Trigger
Meas = Measuring
Cal = Calibrating

Figure 3-30
Operation Event Enable Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Trigger Event
0 = Disable (Mask) Trigger Event

Event : Seq1 = Sequence 1

Figure 3-31
Trigger Event Enable Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Arm Event
0 = Disable (Mask) Arm Event

Event : Seq1 = Sequence 1

Figure 3-32
Arm 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

Figure 3-33
Sequence Event Enable Register

3.21.3 :PTRansition <NRf>

:STATus:MEASurement:PTRansition <NRf>	Program Measurement 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> =	0	Clear register	<NRf> = 128	Set bit B7
	1	Set bit B0	256	Set bit B8
	2	Set bit B1	512	Set bit B9
	4	Set bit B2	1024	Set bit B10
	8	Set bit B3	2048	Set bit B11
	16	Set bit B4	4096	Set bit B12
	32	Set bit B5	16384	Set bit B14
	64	Set bit B6	65535	Set all bits

Query   :PTRansition?   Query PTR register

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 Measurement Transition Filter is set, then the buffer full event is programmed for a positive transition. The BFL bit (B9) in the Measurement Event Register sets when the trace buffer becomes full. For details on register structure, see paragraph 3.8.

The PTR registers are shown in Figures 3-34A through 3-39A. 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

Effects of positive transitions on the Measurement Event Register:

Measurement event	Positive transition effect on Measurement 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 full	Sets B8 when the trace buffer becomes half full.
Buffer full	Sets B9 when the trace buffer becomes full.
Buffer pretriggered	Sets B11 when the trace buffer pretrigger event occurs.
Out of Limits	Sets B12 when a noise spike occurs.
V-source compliance	Sets B14 when V-source goes in compliance.

Bit Position	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	VSC	—	OL	BPT	—	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2^{14})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

Events : VSC = V-Source Compliance
OL = Out of Limits
BPT = Buffer Pretriggered
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	—	OL	BPT	—	BFL	BHF	BAV	RUF	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	—	16384 (2^{14})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

Events : VSC = V-Source Compliance
OL = Out of Limits
BPT = Buffer Pretriggered
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 (PTR) Register

Figure 3-34
Measurement Transition Filter

Effects of positive transitions on the 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.

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})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

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})	8192 (2^{13})	4096 (2^{12})	2048 (2^{11})	—	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

Value : 1 = Enable Negative Transition
       0 = Disable Negative 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

B) Negative Transition (NTR) Filter

Figure 3-35
Questionable Transition Filter

Effects of positive transitions on the 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.

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 (2^{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 (2^{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

Figure 3-36
Operation Transition Filter

Effects of positive transitions on the Trigger Event Register:

Trigger event	Positive transition effect on Trigger Event Register
Sequence 1	Sets B1 when waiting in Trigger Layer.

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

Figure 3-37
Trigger Transition Filter

Effects of positive transitions on the Arm Event Register:

Arm event	Positive transition effect on Arm Event Register
Sequence 1	Sets B1 when in an arm layer.

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

Figure 3-38
Arm Transition Filter

Effects of positive transitions on the 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.

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

Figure 3-39
Sequence Transition Filter

3.21.4 **:NTRansition** **<NRf>** :STATus:MEASurement:NTRansition <NRf>   Program Measurement 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> =			<NRf> =	
0	Clear NTR register		128	Set bit B7
1	Set bit B0		256	Set bit B8
2	Set bit B1		512	Set bit B9
4	Set bit B2		1024	Set bit B10
8	Set bit B3		2048	Set bit B11
16	Set bit B4		4096	Set bit B12
32	Set bit B5		16384	Set bit B14
64	Set bit B6		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 of the Measurement Transition Filter is set, then the buffer full event is programmed for a negative transition. The BFL bit (B9) in the Measurement Event Register sets when the trace buffer is no longer full. For details on register structure, see paragraph 3.8.

The NTR registers are shown in Figures 3-34B through 3-39B. 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

Effects of negative transitions on the 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.
Buffer pretriggered	Sets B11 when the trace buffer pretrigger operations are completed.
Out of Limits Error	Sets bit B12 when the out of limits error has cleared.

Effects of negative transitions on the 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 temperaure 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.

Effects of negative transitions on the 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.

Effects of negative transitions on the Trigger Event Register:

Trigger event	Negative transition effect on Trigger Event Register
Sequence 1	Sets B1 when leaving the Trigger Layer.

Effects of negative transitions on the Arm Event Register:

Arm event	Negative transition effect on Arm Event Register
Sequence 1	Sets B1 when leaving an arm layer.

Effects of negative transitions on the 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.

3.21.5   :CONDition?

:STATus:MEASurement:CONDition?	Read Measurement Condition Register :
STATus:QUEStionable:CONDition?	Read Questionable Condition Register
:STATus:OPERation:CONDition?	Read Operation Condition Register
:STATus:OPERation:TRIGger:CONDition?	Read Trigger Condition Register
:STATus:OPERation:ARM:CONDition?	Read Arm Condition Register
:STATus:OPERation:ARM:SEQuence:CONDition?	Read Sequence Condition Register

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 (paragraph 3.8) 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 6517 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 Measurement Condition Register is set indicating that the trace buffer is full.

3.21.6   :PRESet

:STATus:PRESet	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.

3.21.7 :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 "old-est" 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 defined messages. The messages are listed in Table 2-5.

After this command is sent and the Model 6517 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 :SYS-Tem:ERRor? query command (see System subsystem).

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:

Numlist =	-110	Single message.
	-110, -140, -222	Messages separated by commas.
	-110:-222	Range of messages (-100 through -222).
	-110:-222, -230	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>

:STATus:QUEue:DISable <list>   Disable messages for Error Queue

Parameters

<list> = (numlist)

where; numlist is a specified list of messages that you wish to disable for the Error Queue.

Query

:DISable?   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 2-5). See :QUEue:ENABle for examples to express a numlist.

Program fragment

```
PRINT #1, "output 27; :stat:que:        ' Disable messages and query
dis(-140:-150); dis?"
PRINT #1, "enter 27"                     ' Get response message from 6517
```

:CLEar

:STATus:QUEue:CLEar   Clear Error Queue

Description

This action command is used to clear the Error Queue of messages.

3.22   :SYSTem subsystem

The SYSTem subsystem contains miscellaneous commands that are summarized in Table 3-13.

3.22.1   :PRESet

:SYSTem:PRESet   Return to :SYSTem:PRESet defaults

Description   This command returns the instrument to states optimized for front panel operation. :SYStem:PRESet defaults are listed in the SCPI tables (Tables 3-4 through 3-16).

3.22.2   :POSetup \<name>

SYSTem:POSetup \<name>   Program power-on defaults

Parameters   \<name> = RST   Select *RST defaults on power up
                                PRESet   Select :SYSTem:PRESet defaults on power up
                                SAVX   Select saved defaults on power up

where; X = 0 to 9

Query   :POSetup?   Query power-on setup

Description   This command is used to select the power-on defaults. With RST selected, the instrument powers up to the *RST default conditions. With PRES selected, the instrument powers up to the :SYStem:PRESet default conditions. Default conditions are listed in the SCPI tables (Tables 3-4 through 3-16).

With one of the SAV parameters selected, the instrument powers-on to the setup that is saved in the specified memory location using the *SAV command.

3.22.3   :VERSion?

:SYSTem:VERSion?   Read SCPI version

Description   This query command is used to read the version of the SCPI standard being used by the Model 6517. Example code:

1991.0

The above response message indicates the version of the SCPI standard.

3.22.4   :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 defined messages. Table 2-5 lists the messages.

NOTE: The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command (see STATus subsystem).

3.22.5   :LSYNc:STATe <b>   :SYSTem:LSYNc:STATe <b>   Control line synchronization

Parameters   <b> = O 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. See paragraph 2.19.7 for details on line synchronization.

3.22.6   :KEY <NRf>   :SYSTem:KEY <NRf>   Simulate key-press

Parameters

<NRf> =			<NRf> =	
1	Range Up Arrow		16	NEXT
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 3-40 also provides the key-press code.

The :KEY command allows you to select the NEXT displays over the bus. Sending :SYS-Tem: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 6517 is addressed to talk, the key-press code number for the last key pressed (either physically or with :KEY) is sent to the computer.
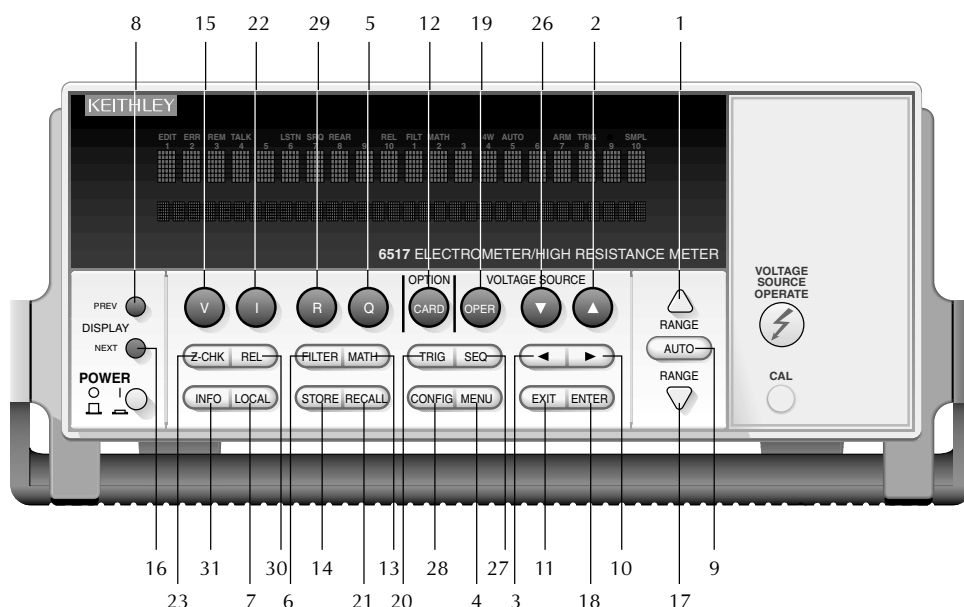
Figure 3-40
Key-press codes

3.22.7 :CLEar

:SYSTem:CLEar   Clear Error Queue

Description   This action command is used to clear the Error Queue of messages.

3.22.8   :DATE <yr>, <mo>, <day>   :SYSTem:DATE <yr>, <mo>, <day>   Set date for clock

Parameters   <yr> = 1994 to 2093   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 (i.e. February 30, 1995) result in an error and the previous date is retained.

3.22.9   :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 59.99   Specify second (rounded to 1/100 sec.)

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 (i.e. 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.

3.22.10   :TSTamp commands

The following commands are used to configure and control the timestamp. For more information on timestamp, see paragraphs 3.16 (:FORMat:ELEMents) and 3.23.7 (:TRACe:TSTamp :FORMat).

:TYPE <name>

:SYSTem:TSTamp:TYPE <name>   Select timestamp type

Parameters   <name> = RELative   Select relative-time timestamp
RTClock   Select real-time timestamp

Query   :TYPE? Query   timestamp type

Description   This command is used to select the timestamp type. RTClock selects the real-time clock timestamp. Readings are reference to the date and time. RTClock is a 100 year (max) calendar with 10msec resolution.

RELative selects the relative-time timestamp. Readings are referenced (in seconds) to a timer. The timer starts at zero seconds when the instrument is turned on or when the timestamp is reset (see next command). RELative is a 55 day (max) clock with 1usec resolution.

:RELative:RESet

:SYSTem:TSTamp:RELative:RESet   Reset relative timestamp to 0.

Description   This action command is used to reset the relative-time timestamp to zero seconds.

3.22.11 :RNUMber:RESet   :SYSTem:RNUMber:RESet   Reset reading number to zero

Description   When the reading number is included as a GPIB data element (see paragraph 3.16; :FOR-MAT:ELEMents), each reading sent over the bus is assigned a number starting at #0. The reading number resets to zero when the instrument is turned on or when this action command is asserted.

3.22.12 Zero check and zero correct commands

:ZCHeck <b>

:SYSTem:ZCHeck <b>   Control Zero Check

Parameters   <b> = 0 or OFF   Disable Zero Check
             1 or ON   Enable Zero Check

Query   :ZCHeck?   Query state of Zero Check

Description   This command is used to enable or disable Zero Check. See paragraph 2.13 for details on Zero Check.

:ZCORrect[:STATe] <b>

:SYSTem:ZCORrect[:STATe] <b>   Control Zero Correct

Parameters   <b> = 0 or OFF   Disable Zero Correct
             1 or ON   Enable Zero Correct

Query   :ZCORrect?   Query state of Zero Correct

Description   This command is used to enable or disable Zero Correct. There are two methods to perform zero correction. The first method is consistent with the way zero correction is performed from the front panel. That is, zero correct is enabled, and then this command is used to enable zero correct. The following command sequence performs zero correction:

:SYSTem:ZCHeck ON   ' Enable zero check
:SYSTem:ZCORrect ON   ' Perform zero correction

The second method to perform zero correction is to first acquire the zero correct value, and then use this command to enable zero correct. The zero correction is done with zero check disabled. The following command sequence demonstrates this method.

:SYSTem:ZCHeck ON   ' Enable zero check
:SYSTem:ZCORrect:ACQuire   ' Acquire zero correct value
:SYSTem:ZCHeck OFF   ' Disable zero check
:SYSTem:ZCORrect ON   ' Perform zero correction

See :ZCORrect:ACQuire for more information.

:ZCORrect:ACQuire

:SYSTem:ZCORrect:ACQuire   Acquire zero correct value

Description   This command is used to acquire a zero correct value for zero correction. The value can only be acquired while zero check is enabled. The internal offset will become the correction value.

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.

3.22.13 A/D Controls

:TSControl <b>

:SYSTem:TSControl <b>   Control external temperature readings

Parameters   <b> = 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 6517 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. See paragraphs 3.17 (:FORMat:ELEMents) and 3.23 (:TRACe:ELEMents).

:HSControl <b>

:SYSTem:HSControl <b>   Control humidity readings

Parameters   <b> = 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 6517 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. See paragraphs 3.17 (:FORMat:ELEMents) and 3.23 (:TRACe:ELEMents).

:HLControl <b>

:SYSTem:HLControl <b>   Control A/D hardware limit

Parameters   <b> = 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 "Out-OfLimit" 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.

3.22.14 RS-232 Interface Commands

The following commands are provided for control (enabled or disabled) of front panel keys while using the RS-232 interface.

:LOCal

:SYSTem:LOCal   Take 6517 out of remote

Description   Normally, the Model 6517 is in local during RS-232 communications. In this state, front panel keys are operational. However, the user may wish to lock out front keys during RS-232 communications (see :LLOCkout).

This action command is used to take the Model 6517 out of the remote state and enables the operation of front panel keys. Note that this command can only be sent over the RS-232 interface.

:REMote

:SYSTem:REMote   Place the Model 6517 in remote

Description   This action command is used to place the Model 6517 in the remote state. In remote, the front panel keys will be locked out if local lockout is enabled (see :LLOCkout). Note that this command can only be sent over the RS-232 interface.

:LLOCkout <b>

:SYSTem:LLOCkout <b>   Enable or disable front panel keys

Parameters   <b> =   0 or OFF   Disable local lockout
                       1 or ON   Enable local lockout

Query   :LLOCkout?   Query state of local lockout

Description   This command is used to enable or disable local lockout. If enabled, the front panel keys are locked out (non-operational) when the instrument is in remote (see :REMote). If disabled, the front panel keys are operational in remote. The instrument must be in remote in order to use this command.

Taking the instrument out of remote (see :LOCal) restores front panel keys operation, but does not change the status of the :LLOCkout command.

Note that this command can only be sent over the RS-232 interface.

3.22.15 Basic Trigger Commands

The following commands are used to configure the Model 6517 for basic triggering. See paragraph 2.15 for details on basic triggering.

:MODE <name>

:SYSTem:MACRo:TRIGger:MODE <name>   Specify trigger mode

Parameters   <name> = CONTinuous   Continuous trigger mode
                       ONEShot   One-shot trigger mode

Description   This command is used to specify the basic trigger mode. With CONTinuous triggering, the Model 6517 will continuous trigger readings after the selected source event occurs (see :SOURce). With ONEShot selected, a single reading will be triggered every time the selected source event occurs.

:SOURce \<name>

:SYSTem:MACRo:TRIGger:SOURce \<name>   Specify control source

Parameters   \<name> = IMMediate   Immediate triggering
MANual   Manual trigger event
BUS   Bus trigger event
EXTernal   External trigger event
TIMer   Timer trigger event

Description   This command is used to specify which control source will be used as the trigger event for instrument readings. If in the continuous trigger mode (see :MODE), the instrument will continuously make readings when the specified event occurs. If in the one-shot mode, each event will cause a single-reading to occur.

With IMMediate selected, the trigger event will be satisfied immediately. In IMMediate, readings will be made continuously.

With MANual selected, the trigger event occurs when the front panel TRIG key is pressed. Note that the instrument must be in local in order for the TRIG key to be active.

With BUS selected, the trigger event occurs when a bus trigger (*TRG or GET) is sent. With EXTernal selected, the trigger event occurs when an input trigger is received via the rear panel EXT TRIG IN connector.

While in the one-shot mode, with TIMer selected, trigger events occur at a programmed timer interval. Each time the programmed interval elapses, a reading is triggered. Use the :TIMer \<n> command to set the timer interval.

:TIMer \<n>

:SYSTem:MACRo:TRIGger:TIMer \<n>   Set the timer interval

Parameters   \<n> = 0.001 to 99999.999   Specify timer interval in seconds
DEFault   0.1 seconds
MINimum   0.001 seconds
MAXimum   99999.999 seconds

This command is used to specify the time interval for the timer. The :SOURce TIMer command is used to select the timer as the control source.

[:EXECute]

:SYSTem:MACRo:TRIGger:[EXECute]   Select basic triggering

Description   When this action command is sent, the instrument will exit from advanced triggering and select basic triggering. For example, the following command triggers one reading every one second:

:SYSTem:MACRo:TRIGger:MODE ONE;SOURce TIMer;TIMer 1000;EXECute

3.23   :TRACe subsystem

The commands in this subsystem are used to configure and control data storage into the buffer. The commands are summarized in Table 3-14. See paragraph 2.16 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.

3.23.1   :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.

3.23.2   :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 6517 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.

3.23.3   :POINts <n>

:TRACe:POINts <n>
Specify buffer size

Parameters   <n> = 1 to MAXimum   Specify number or readings
              DEFault   100
              MAXimum   See table 2-22
              MINimum   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.

:AUTO <b>

:TRACe:POINts:AUTO <b>   Control auto buffer sizing

Parameters   <b> = 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 :TRIGger:COUNt 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"

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 6517 is addressed to talk. This command can be used to monitor the storage process.

3.23.4   :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. When a pre- trigger store is started (see :FEED:CONTrol), readings are continuously stored in the buffer. When the pre-trigger event occurs (see :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 paragraph 2.16.1 for more information on pre-trigger.

:READings \<n\>

:TRACe:FEED:PRETrigger:AMOunt:READings \<n\>   Specify number of pre-trigger readings

Parameters	\<n\> = 0 to MAXimum	Specify number or readings
	DEFault	Half of MAXimum
	MAXimum	Buffer size as programmed by :TRACe:POINts
	MINimum	0
Query	:READings?	Queries number of pre-trigger readings
	:READings? DEFault	Queries *RST default number of readings
	:READings? MAXimum	Queries largest allowable number of readings
	:READings? MINimum	Queries lowest allowable number of readings

Description   This command is used to specify how much of the defined buffer (:POINts) will be used to store pre-triggered readings. This command is essentially the same as the :PERCent command except the amount is expressed as an exact value instead of a percent.

Sending a value that exceeds the defined size of the buffer (see :POINts) generates an error. The command is ignored.

:SOURce \<name\>

:TRACe:FEED:PRETrigger:SOURce \<name\>   Specify pre-trigger event

Parameters   \<name\> = EXTernal   Use External Trigger as pre-trigger event
                  TLINk   Use Trigger Link as pre-trigger event
                  BUS   Use bus trigger as pre-trigger event
                  MANual   Use TRIG key as pre-trigger event

Query   :SOURce?   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 (:CONTrol, PRETrigger), readings are continuously stored in the buffer while waiting for the pre-trigger source event.

With EXTernal source selected, an external trigger via the rear panel EXTERNAL TRIGGER Input provides the pre-trigger event.

With TLINk selected, an input trigger via the Trigger Link provides the pre-trigger event. The Trigger Link line used for the input trigger is programmed from the Trigger subsystem (see :TRIGger:TCONfigure command path).

With BUS selected, a GPIB bus trigger (GET or *TRG) provides the pre- trigger event.

With MANual selected, pressing the front panel TRIG key provides the pre-trigger event.

:CONTrol \<name\>

:TRACe:FEED:CONTrol \<name\>   Specify buffer control

Parameters   \<name\> = NEVer   Disables buffer storage
                  NEXT   Fills buffer and stops
                  ALWays   Continuously stores readings in buffer
                  PRETrigger   Use Pretrigger mode to store readings

Query   :CONTrol?   Query buffer control

Description   This command is used to select the buffer control. With NEVer 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 NONE (see :TRACe:FEED NONE). When NEXT is selected, the storage process starts, fills the buffer and then stops. The buffer size is specified by the :POINts command.

When ALWays 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.

When PRETrigger is selected, the buffer stores readings continuously (like ALWays) until the programmed pre-trigger event occurs. When the pre-trigger event occurs, the section of the buffer specified for post-trigger readings fill with new readings. The storage process stops when the post trigger portion of the buffer becomes full with new readings (see :TRACe:FEED:PRETrigger).

3.23.5 :DATA?   :TRACe:DATA?   Send buffer readings

Description   When this command is sent and the Model 6517 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.

Note that the buffer elements selected by :TRACe:ELEMents (see paragraph 3.23.7) must match the bus elements selected by :FORMat:ELEMents (see paragraph 3.16). Otherwise, the following error will occur when using this command to send buffer readings over the bus.

+313 Buffer & format element mismatch

3.23.6 :TSTamp:FORMat <name>   :TRACe:TSTamp:FORMat <name>   Select timestamp format

Parameters   <name> = ABSolute   Reference to first buffer reading
                           DELTa   Time between buffer readings

Query   :FORMat?   Query timestamp format

Description   This command is used to select the timestamp format for buffer readings. With ABSolute selected, each timestamp is referenced to the first reading stored in the buffer. With DELTa selected, timestamps provide the time between each buffer reading. See paragraphs 3.16 (:FORMat:ELEMents) and 3.22 (:SYSTem:TSTamp) for more information.

3.23.7 :ELEMents <item list>   :TRACe:ELEMents <item list>   Select elements for buffer

Parameters   <item list> = TSTamp   Includes timestamp
                              HUMidity   Includes humidity
                              CHANnel   Includes channel number
                              ETEMperature   Includes external temperature
                              VSOurce   Includes V-source
                              NONE   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. A detailed description for each element is provided in paragraph 3.16 (:FORMat:ELEMents).

3.24 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 paragraph 2.7 and 3.9 for details). These commands and subsystems are summarized in Table 3-15.

3.24.1   :INITiate commands

[:IMMediate]

:INITiate[:IMMediate]   Take 6517 out of idle

Description   This command takes the Model 6517 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 next command).

:CONTinuous <b>

:INITiate:CONTinuous <b>   Control continuous initiation

Parameters   <b> = 0 or OFF   Disable continuous initiation
                1 or ON   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   Include No-Operation-Pending flag
                EXCLude   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, refer to paragraphs 3.11.5 (*OPC) and 3.11.6 (*OPC?).

3.24.2   :ABORt

:ABORt   Abort operation

When this action command is sent, the Model 6517 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.

3.24.3 **: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 Trigger Model (Figure 3-14) 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.

3.24.4 **: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   Specify count
                         INF   Sets count to infinite
                         DEFault   Sets count to 1
                         MINimum   Sets count to 1
                         MAXimum   Sets count to 99999

Query   :COUNt?   Queries programmed count
            :COUNt? DEFault   Queries *RST default count
            :COUNt? MINimum   Queries lowest allowable count
            :COUNt? MAXimum   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.

3.24.5 **: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. Note that the Arm Layer Arm Layer 1) does not use a delay.

3.24.6   **: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 via the Trigger Link is received. With EXTernal selected, operation continues when an External Trigger is received.

A real-time clock event is available for the arm layer (Arm Layer 1). With RTCLock selected, event detection is satisfied at the programmed date and time allowing operation to continue on in the Trigger Model. See paragraph 3.24.10 to set the date and time for the RTCLock control source.

A TIMer event is available for the scan and measure layers. With TIMer selected for the specified layer, the event occurs at the beginning of the timer interval, and every time it times out. For example, if the measure layer timer is programmed for a 30 second interval, the first pass through the measure layer control source occurs immediately. Subsequent scan events will then occur every 30 seconds. The interval for the timer is set using the :TIMer command.

3.24.7   **:TIMer <n>**   :ARM:[SEQuence[1]]:LAYer2:TIMer <n>   Set interval for scan layer timer
                              :TRIGger:[SEQuence[1]]:TIMer <n>   Set interval for measure layer timer

Parameters   <n> =   0.001 to 999999.999   Specify timer interval in seconds
                         DEFault   0.1 second
                         MINimum   0.001 second
                         MAXimum   999999.999 seconds

Query   :TIMer?   Query programmed timer interval
            :TIMer? DEFault   Query *RST default timer interval
            :TIMer? MINimum   Query lowest allowable timer interval
            :TIMer? MAXimum   Query largest allowable timer interval

Description   These commands are used to set the interval for the scan layer and measure layer timers. Note that the timer is in effect only if the timer is the selected control source. Also, note that the arm layer (Arm Layer 1) does not use a timer.

3.24.8   :SIGNal

:ARM[:SEQuence[1]][:LAYer[1]]:SIGNal	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:SIGNal	Bypass scan control source
:TRIGger[:SEQuence[1]]:SIGNal	Bypass measure control source

Description   These action commands are used to bypass the specified control source and also when you do not wish to wait for the programmed event. Keep in mind that the instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error occurs and this command is ignored.

3.24.9   TCONfigure commands

:PROTocol <name>

:TRIGger[:SEQuence[1]]:TCONfigure:PROTocol <name>   Specify Trigger Link protocol

<name> =	ASYNchronous	Asynchronous Trigger Link mode
	SSYNchronous	Semi-synchronous Trigger Link mode

Query   :PROTocol?   Query programmed Trigger Link protocol

Description   This command is used to select the protocol for the measure layer Trigger Link. With ASYNchronous selected, separate trigger lines are used for input and output triggers. With SSYNchronous selected, a single trigger line is used for both input and output triggers.

Note that the arm and scan layers only use the asynchronous Trigger Link mode and therefore, do not have to be selected.

:DIRection <name>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:DIRection <name>	Control Arm Source Bypass
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:DIRection <name>	Control Scan Source Bypass
:TRIGger[:SEQuence[1]]:TCONfigure:DIRection <name>	Control Measure Source Bypass

Parameters

<name> =	SOURce	Enable Source Bypass
	ACCeptor	Disable Source Bypass

Query   :DIRection?   Query Source Bypass state

Description   When a source bypass is enabled and the External or Trigger Link control source is selected, operation loops around the appropriate control source on the initial pass through that layer. Note that the source bypass for the scan and measure layers also loops around the delay.

If programmed for another pass through the specified layer (count >1), the bypass loop is not in effect even though it is still enabled. The bypass loop will be in effect if operation first goes back into the previous layer (or idle).

Enabling the Source Bypass for the arm and scan layers also enables their output triggers. When operation leaves the arm or scan layer, the appropriate output trigger pulse occurs. If the Trigger Link (TLINk) control source is selected, the output trigger is available on the programmed Trig-

ger Link output line. For all other control source selections, the output trigger pulse is available at the METER COMPLETE Output connector. The output trigger in these two layers is disabled when the source bypass is disabled.

The output trigger in the measure layer is always enabled and occurs after the device action.

With ACCeptor selected, the bypass is disabled, This simply means that operation will not proceed through the specified layer until the appropriate event occurs.

:ASYNchronous commands
:ILINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; arm layer
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; scan layer
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; measure layer

Parameters   <NRf> = 1 Line #1   <NRf> = 4 Line #4
                         2 Line #2   5 Line #5
                         3 Line #3   6 Line #6

Query   :ILINe?   Query programmed input line #

Description   These commands are used to select an input line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output (see :OLINe) cannot share the same line. If you assign the input to a line that is already being used for the output, an error occurs and the command is ignored.

: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   <NRf> = 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   <NRf> = 4 Line #4
                            2 Line #2   5 Line #5
                            3 Line #3   6 Line #6

Query   :LINE?   Query programmed output line #

Parameters   This command is used to select one of the six trigger lines for the semi-synchronous Trigger Link.

3.24.10 RTCLock commands

The following commands are used to specify the date and time for the RTCLock control source (see paragraph 3.24.6 for details).

:DATE <yr>, <mo>, <day>

:ARM[:SEQuence[1]][LAYer[]]:RTCLock:DATE <yr>, <mo>, <day>   Set date for RTCLock control source

Parameters   <yr> = 1994 to 2093   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 (i.e. February 29, 1994) 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 sec.)

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 (i.e. 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.

3.25 :TSEQuence Subsystem

The commands in this subsystem are used to configure and control the built-in test sequences, and are summarized in Table 3-16. Detailed information on the test sequences are provided in paragraph 2.14.

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.

3.25.1 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). The test will start when the programmed source event occurs (see :TSOurce).

: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 (:ARM) thet est and providing the programmed source event (:TSOurce).

: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

Query   :TYPE?   Query selected test sequence

Description   This command is used to select the desired test sequence. When test sequence is started (see :TSOurce), the selected test will run according to how it is configured. The commands in paragraphs 3.25.2 through 3.25.15 are used to 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 EXTernal selected, the test will start when an external trigger is received via the EXT TRIG IN connector on the rear panel.

With TLINk selected, the test will start when an external trigger is received via 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 Models 8002A and 8009) that incorporate the safety interlock feature.

:TLIne <NRf>

:TSEQuence:TLIne <NRf>   Specify trigger link line

Parameters   <NRf> = 1 Line #1   <NRf> = 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).

3.25.2   :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

Query	:STARt?	Query stop voltage

Description   This configuration command is used for the following tests:

Diode Leakage Test
Staircase Sweep Test

This command is used to specify the start voltage for the specified test.

3.25.3 :STOP <NRf>

:TSEQuence:DLEakage:STOP <NRf>	Stop voltage; diode eakage test
:TSEQuence:STSWeep:STOP <NRf>	Stop voltage; staircase sweep test

Parameters   <NRf> = -100.0 to 100.0   Volts; 100V range
    -1000 to 1000   Volts; 1000V range

Query	:STOP?	Query stop voltage

Description   This configuration command is used for the following tests:

Diode Leakage Test
Staircase Sweep Test

This command is used to specify the stop voltage for the specified test.

3.25.4 :STEP <NRf>

:TSEQuence:DLEakage:STEP <NRf>	Step voltage; diode leakage test
:TSEQuence:STSWeep:STEP <NRf>	Step voltage; staircase sweep test

Parameters   <NRf> =   -100.0 to 100.0   Volts; 100V range
    -1000 to 1000   Volts; 1000V range

Query	:STEP?	Query step voltage

Description   This configuration command is used for the following tests:

Diode Leakage Test
Staircase Sweep Test

This command is used to specify the step voltage for the specified test.

3.25.5 :MDELay <NRf>

TSEQuence:DLEakage:MDELay <NRf>	Measure delay; diode leakage test
:TSEQuence:RVCoefficient:MDELay[1] <NRf>	Measure delay 1; resistor voltage coefficient test
:TSEQuence:RVCoefficient:MDELay2 <NRf>	Measure delay 2; resistor voltage coefficient test

Parameters   <NRf> = 0 to 10000 (Resistor voltage coefficient test)   Delay in seconds
    0 to 99999 (Diode lekage test)   Delay in seconds

Query	:MDELay?	Query measure delay

Description   This configuration command is used for the following tests: Diode Leakage Test Resistor Voltage Coefficient Test

This command is used to specify the measure time for the specified test. Note that the Resistor Voltage Coefficient Test uses two measure delays; delay 1 and delay 2.

3.25.6 **:SVOLtage <NRf>**:TSEQuence:CLEakage:SVOLtage <NRf>   Bias voltage; cap leakage test
:TSEQuence:CIResistance:SVOLtage <NRf>   Bias voltage; cable insulation res test
:TSEQuence:RVCoefficient:SVOLtage[1] <NRf>   Bias voltage 1; Res voltage coef test
:TSEQuence:RVCoefficient:SVOLtage2 <NRf>   Bias voltage 2; Res voltage coef test
:TSEQuence:SRESistivity:SVOLtage <NRf>   Bias voltage; Sur resistivity test
:TSEQuence:VRESistivity:SVOLtage <NRf>   Bias voltage; Vol resistivity test
:TSEQuence:SIResistance:SVOLtage <NRf>   Bias voltage; Sur insulation res 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.

3.25.7 **:STIMe <NRf>**   :TSEQuence:CLEakage:STIMe <NRf>   Bias time; capacitor leakage test
:TSEQuence:CIResistance:STIMe <NRf>   Bias time; cable insulation res test
: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   :STIMe <NRf>   0 to 99999.9 (seconds)

Query   :STIMe?   Query soak time

Description   This configuration command is used for the following tests:

Capacitor Leakage Test
Cable Insulation Resistance Test
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.

3.25.8   **:DTIMe <NRf>**   :TSEQuence:CLEakage:DTIMe <NRf>   Discharge time; cap leakage test

:TSEQuence:SRESistivity:DTIMe <NRf>   Discharge time; sur resistivity test

:TSEQuence:VRESistivity :DTIMe <NRf>   Discharge time; vol resistivity test

Parameters   <NRf> = 0 to 99999.9 (seconds)

Query   :DTIMe?   Query discharge time

Description   This configuration command is used for the following tests:

Capacitor Leakage Test
Surface Resistivity Test
Volume Resistivity Test

This command is used to specify the discharge time for the specified test.

3.25.9   **: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.

3.25.10   **:MVOLtage <NRf>**   :TSEQuence:SRESistivity:MVOLtage <NRf>   Measure voltage; sur resistivity test

:TSEQuence:VRESistivity:MVOLtage <NRf>   Measure voltage; vol esistivity test

:TSEQuence:SIResistance:MVOLtage <NRf>   Measure voltage; sur insul 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.

3.25.11 :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 nsulation resistance test

Parameters   <NRf> = 0 to 99999.9 (seconds)

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

This command is used to specify the measure time for the specified test.

3.25.12 :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.

3.25.13 :HTIMe <NRf>   :TSEQuence:SQSWeep:HTIMe <NRf>   High level time; square wave sweep test

Parameters   <NRf> = 0 to 99999.9 (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.

3.25.14 :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.

3.25.15 :LTIMe \<NRf\>   :TSEQuence:SQSWeep:LTIMe \<NRf\>   Low level time; square wave sweep test

Parameters   \<NRf\> = 0 to 99999.9 (seconds)

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.

3.25.16 :COUNt \<NRf\>   :TSEQuence:SQSWeep:COUNt \<NRf\>   Specify cycle count

Parameters   \<NRf\> = 1 to 3141 Number of cycles to repeat

Query   :COUNt?   Query cycle count

Description   This command is used to specify how many times to repeat the programmed square wave cycle.

3.25.17 Test sequence programming example

The following QuickBASIC 4.5 program uses the CEC/KPC IEEE-488 interface card. The staircase sweep test will meaure current at each voltage step. The test will sweep from 0V to 20V in 2V steps. When the test is finished, the readings (which are stored in the buffer) are dumped to the computer and then displayed on the CRT.

```
' Quick Basic 4.5, CEC/KPC card
'
'$INCLUDE: 'ieeeqb.bi'

CALL initialize(21, 0)
CLS
CALL send(27, "*RST", status%)
CALL send(27, ":CALC1:STAT OFF", status%)
CALL send(27, "*CLS", status%)
CALL spoll(27, KIspoll%, status%)

' Configure status model to SRQ on Buffer Full:

CALL send(27, "STAT:MEAS:ENAB 512", status%)
CALL send(27, "*SRE 1", status%)

' Set to send ascii readings:

CALL send(27, ":FORM:DATA ASCII", status%)
CALL send(27, ":FORM:ELEM READ", status%)

' Select autoranging amps:

CALL send(27, ":SENS:FUNC 'CURR'", status%)
CALL send(27, ":SENS:CURR:RANG:AUTO ON", status%)

' Configure Staircase Sweep from 0V to 20V in 2V steps:

CALL send(27, ":TSEQ:TYPE STSW", status%)
CALL send(27, ":TSEQ:STSW:STAR 0", status%)
CALL send(27, ":TSEQ:STSW:STOP 20", status%)
CALL send(27, ":TSEQ:STSW:STEP 2", status%)
CALL send(27, ":TSEQ:STSW:STIM 0.3", status%)
CALL send(27, ":TSEQ:TSO IMM", status%)
```

```
' Wait for commands to complete processing:

DATA1$ = SPACE$(600)
CALL send(27, "*OPC?", status%)
CALL enter(DATA1$, length%, 27, status%)

' Start Test Sequence:

CALL send(27, ":TSEQ:ARM", status%)

' Wait for SRQ (buffer full):

WaitSRQ:
IF (NOT (srq%)) THEN GOTO WaitSRQ
CALL spoll(27, poll%, status%)
IF (poll% AND 64) = 0 THEN GOTO WaitSRQ

' Dump buffer readings to computer CRT:

CALL send(27, ":TRACE:DATA?", status%)
CALL enter(DATA1$, length%, 27, status%)
A = 1
FOR I = 1 TO 11
        r$ = MID$(DATA1$, A, 13)
        PRINT r$
        A = A + 14
NEXT I

END
```

3.26 UNIT Subsystem

The UNIT subsystem (see Table 3-17) 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.

3.27   RS-232 Serial Interface

The Model 6517 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 6517 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. The connection requirements are covered in paragraph 3.2.2.

The SCPI programming language can be used over the RS-232 Serial Interface to communicate with the Model 6517. The DDC programming language cannot be used over the RS-232 interface.

3.27.1   RS-232 Interface Configuration

Model 6517:

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. For details on using the MAIN MENU, see paragraphs 2.19, 2.19.2 and Table 2-12. Paragraph 2.3.5 provides general rules to navigate through the menu structure.

1. Select the RS-232 interface as follows:
    *   Press   MENU
    *   Select   COMMUNICATIONS
    *   Select   RS-232

> NOTE
>
> 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. Continue on to select the interface mode. Select SEND-RECEIVE to send and receive commands, or select TALK-ONLY to send readings directly to a listener (i.e. serial printer).
    *   Select   CONTROL
    *   Select   SEND-RECEIVE or TALK-ONLY
3. Set the BAUD rate, number of data BITS, type of PARITY and the number of STOP bits as follows:

*   Select   BAUD
*   Select   19200, 9600, 4800, 2400, 1200, 600 or 300
*   Select   BITS
*   Select   7 or 8
*   Select   PARITY
*   Select   NONE, ODD or EVEN
*   Select   STOP
*   Select   1 or 2

4. 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, STATUS

Data elements can be selected over the RS-232 interface using the :FORMat:ELEMents command (see paragraph 3.15). 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 cho: ON
*   Use VT-100 Terminal Emulation
*   Make sure the RS-232 parameters (baud rate, data bits, parity, and stop bits) of your computer matches the RS-232 parameters of the Model 6517.

3.27.2   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 6517 does not support any form of hardware flow control. Software flow control is in the

form of X_ON (^Q) and X_OFF (^S) characters. If the input queue of the Model 6517 becomes more that 3/4 full (2048 characters maximum), the instrument issue an X_OFF command. The control program should respond to this and stop sending characters until the Model 6517 issues the X_ON, which it will do once its input buffer has dropped below half-full. The Model 6517 also recognizes X_OFF and X_ON sent from the controller. An X_OFF will cause the Model 6517 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 6517 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 (see paragraph 3.26.3).

The Model 6517 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:LOCal   Take the 6517 out of remote
:SYSTem:REMote   Put the 6517 in remote
:SYSTem:LLOCkout <b>   Enable or disable local lockout

See paragraph 3.22.14 for more information on using these commands.

3.27.3 RS-232 Interface Error Messages

The following error messages are associated with RS-232 interface operation. These error messages are also listed in Table 2-5. Note that any of the following errors will set bit B11 of the Operation Condition Register.

+800   "RS-232 Framing error detected" — Start or stop bit mismatch between computer and Model 6517.

+801   "RS-232 Parity error detected" — Parity type mismatch between computer and Model 6517.

+802   "RS-232 Overrun detected" — Data received before previous data can be read.

+803   "RS-232 Break detected" — Message indicates that a Break occurred (device-clear occurs).

+804   "RS-232 Noise detected" — Noisy signals could corrupt the 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 (<LF>) 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" — You tried to select a data format (using :FORMat:DATA) other than ASCII.

3.27.4 Downloading commands using ProComm

There are several communication programs that can be used to send commands to the Model 6517. The following summarizes the procedure to use ProComm to download a command file to the Model 6517.

1. Using a text editor, type the commands into a file and save it. An example file is shown as follows:

   :syste:pres
   :func 'curr'
   :curr:rang 1e6
   :syst:zch off
   :data:fresh?

2. Go into PCPlus terminal and set the communications settings to match the settings of Model 6517 (baud rate, data bits, parity and stop bits).

3. Press the PageUp key on the computer keyboard. PCPlus will prompt you to type in a file name. After typing in the file name, press the Enter key. The command file will be sent to the Model 6517.

3.28 DDC programming language

The Model 6517 can be controlled over the GPIB interface using Device-Dependent Command (DDC) programming. The DDC programming language is selected from the COMMUNICATION item of the MAIN MENU (see paragraph 3.4).

Appendix G lists and summarizes the DDC commands. For detailed information on Device-Dependent Command programming, refer to the Model 617 instruction manual.

A

Specifications

MODEL 6517 SPECIFICATIONS

VOLTS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(%rdg + counts)/°C
2 V	10 µV	0.025 + 4	0.003 + 2
20 V	100 µV	0.025 + 3	0.002 + 1
200 V	1 mV	0.06 + 3	0.002 + 1

Note: [1]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.

NMRR: 60dB on 2V, 20V, >55dB on 200V, at 50Hz or 60Hz ±0.1%.

CMRR: >120dB at DC, 50Hz or 60Hz.

INPUT IMPEDANCE: >200TΩ in parallel with 20pF, < 2pF guarded (10MΩ with zero check on).

SMALL SIGNAL BANDWIDTH AT PREAMP OUTPUT: Typically 100kHz (–3db).

AMPS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C ±(%rdg + counts)/°C
20 pA	100 aA[2]	1 + 30	0.1 + 5
200 pA	1 fA[2]	1 + 5	0.1 + 1
2 nA	10 fA	0.2 + 30	0.1 + 2
20 nA	100 fA	0.2 + 5	0.03 + 1
200 nA	1 pA	0.2 + 5	0.03 + 1
2 µA	10 pA	0.1 + 10	0.005 + 2
20 µA	100 pA	0.1 + 5	0.005 + 1
200 µA	1 nA	0.1 + 5	0.005 + 1
2 mA	10 nA	0.1 + 10	0.008 + 2
20 mA	100 nA	0.1 + 5	0.008 + 1

Note: [1]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.
[2]aA =10^{-18}A, fA=10^{-15}A.

INPUT BIAS CURRENT: <3fA at TCAL. Temperature coefficient = 0.5fA/°C.

INPUT BIAS CURRENT NOISE: <750aA p-p (capped input), 0.1Hz to 10Hz bandwidth, damping on. Digital filter = 40 readings.

INPUT VOLTAGE BURDEN at TCAL ± 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, nA, 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, 9ms on nA ranges, 1ms on µA and mA ranges.

NMRR: >95dB on pA, 60dB on nA, µA, and mA ranges at 50Hz or 60Hz ±0.1%.

COULOMBS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1,2] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(%rdg + counts)/°C
2 nC	10 fC	0.4 + 5	0.04 + 3
20 nC	100 fC	0.4 + 5	0.04 + 1
200 nC	1 pC	0.4 + 5	0.04 + 1
2 µC	10 pC	0.4 + 5	0.04 + 1

Note: [1]Charge acquisition time must be <1000s, derate 1% for each additional 10,000s.
[2]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.

INPUT BIAS CURRENT: <4fA at TCAL. Temperature coefficient = 0.5fA/°C.

OHMS

RANGE	5½ DIGIT RESO-LUTION	ACCURACY[1] (10-100% Range) 18°-28°C (1 Yr.) ± (% rdg + cts)	TEMPERATURE COEFFICIENT (10-100% Range) 0°-18°C & 28°-50°C ± (% rdg + cts)	TEST VOLTS	AMPS RANGE
2 MΩ	10 Ω	0.125 + 1	0.01 + 1	40 V	200 µA
20 MΩ	100 Ω	0.125 + 1	0.01 + 1	40 V	20 µA
200 MΩ	1 kΩ	0.15 + 1	0.015 + 1	40 V	2 µA
2 GΩ	10 kΩ	0.225 + 1	0.035 + 1	40 V	200 nA
20 GΩ	100 kΩ	0.225 + 1	0.035 + 1	40 V	20 nA
200 GΩ	1 MΩ	0.35 + 1	0.110 + 1	40 V	2 nA
2 TΩ	10 MΩ	0.35 + 1	0.110 + 1	400 V	2 nA
20 TΩ	100 MΩ	1.025 + 1	0.105 + 1	400 V	200 pA
200 TΩ	1 GΩ	1.15 + 1	0.125 + 1	400 V	20 pA

Note: [1]Specifications are for auto V-source ohms, when properly zeroed 5½ digit, 1 PLC, median filter on, digital filter = 10 readings. If user select-able voltage is required, use manual mode. Manual mode displays resistance (up to 10^{18}Ω) calculated from measured current. Accuracy is equal to 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.

VOLTAGE SOURCE

RANGE	STEP SIZE	ACCURACY (1 Yr.) 18°– 28°C ±(% setting+offset)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(% setting+offset)/°C
100 V	5 mV	0.15 + 10 mV	0.005 + 1 mV
1000 V	50 mV	0.15 + 100 mV	0.005 + 10 mV

MAXIMUM OUTPUT CURRENT:

±10mA; active current limit at <11.5mA for 100V range.

±1mA; active current limit at <1.15mA for 1000V range.

SETTLING TIME:

<8ms to rated accuracy for 100V range.

<50ms to rated accuracy for 1000V range.

NOISE:

<150µV p-p from 0.1Hz to 10Hz for 100V range.

<1.5mV p-p from 0.1Hz to 10Hz for 1000V range.

TEMPERATURE (THERMOCOUPLE)

THERMO-COUPLE TYPE	RANGE	ACCURACY (1 Yr.)[1] 18°– 28°C ±(% rdg + °C)
K	–25°C to 150°C	± (0.3% ± 1.5°C)

Note: [1]Excluding probe errors, TCAL ± 5°C, 1 PLC integration time.

HUMIDITY

RANGE	ACCURACY (1 Yr.)[1] 18°– 28°C ±(% rdg + % RH)
0 - 100%	± (0.3% +0.5)

Note: [1]Humidity probe accuracy must be added. This is ± 3% RH, for Model 6517-RH, up to 65°C probe environment, not to exceed 85°C.

IEEE-488 BUS IMPLEMENTATION

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

IMPLEMENTATION: SCPI (IEEE-488.2, SCPI-1994.0); DDC (IEEE-488.1).

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

PROGRAMMABLE PARAMETERS: Function, Range, Zero Check, Zero Sup-press, EOI (DDC mode only), Trigger, Terminator (DDC mode only), 100-Reading Storage (DDC mode), 15706 Max. Reading Storage (SCPI mode), Calibration (SCPI mode only), V-Source Output, Display Format, SRQ, Status (including V-Source I-Limit), Output Format, Guard.

ADDRESS MODES: TALK ONLY and ADDRESSABLE.

TRIGGER TO READING DONE: 150ms typical, with external trigger.

RS-232 IMPLEMENTATION:

Supports: SCPI 1994.0.

Baud Rates: 300, 600, 1200, 2400, 4800, 9600, 19.2k.

Protocols: Xon/Xoff, 7 or 8 bit ASCII, parity-odd/even/none.

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): Typically $10^{10}\Omega$ in parallel with 500pF.

INPUT CONNECTOR: Three lug triaxial on rear panel.

2V ANALOG OUTPUT: 2V for full range input. Inverting in Volts mode. Output impedance 10kΩ.

PREAMP OUTPUT: Provides a guard output for Volts 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.

EMI/RFI: Meets VDE-0871 and FCC Class B limits.

TEST SEQUENCES: Device-Characterization (Diode, Capacitor, Cable, Resistor), Resistivity, Surface-Insulation-Resistance, Sweep.

READING STORAGE: 100 readings (DDC mode), 15706 max. readings (SCPI mode).

READING RATE:

To internal buffer	125 readings/second[1]
To IEEE-488 bus	115 readings/second[1,3]
To front panel	17 readings/second[2]
Bus transfer	2500 readings/second[3]

Note: [1] 0.01 PLC, digital filters off, front panel off, temperature + RH off.

[2] 1.00 PLC, digital filters off, temperature + RH off.

[3] Binary transfer mode.

DIGITAL FILTER: Median and averaging.

ENVIRONMENT:

Operating: 0°-50°C; relative humidity 70% non-condensing, up to 35°C.

Storage: –25° to +65°C.

WARM-UP: 1 hour to rated accuracy (see manual for recommended procedure).

POWER: 105–125V or 210–250V (external switch selected), 90–110V (internal modification required), 50–60Hz, 50VA.

PHYSICAL:

Case Dimensions: 90mm high × 214mm wide × 369mm deep (3½ in. × 8½ in. × 14½ in.).

Working Dimensions: From front of case to rear including power cord and IEEE-488 connector: 15.5 inches.

Net Weight: <4.6 kg (<10.1 lbs.).

Shipping Weight: <9.5 kg (<21 lbs.).

ACCESSORIES SUPPLIED:

Model 237-ALG-2 Low Noise Triax Cable, 3-slot Triax to Alligator clips 2m (6.6 ft.).

Model 8607 Safety High Voltage Dual Test Leads.

Model 6517-TP Thermocouple Input Lead.

CS-459 Interlock Connector.

Specifications subject to change without notice.

A.1 Accuracy calculations

The information shows how to calculate accuracy for volts, amps, ohms and coulombs.

A.1.1 Calculating volts accuracy

From the specifications, Volts is calculated as follows:

Accuracy = ±(% rdg + 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 specs:

Accuracy = ±(0.025% of 1V + 4 counts)
  = ±(0.00025V + 4 counts)
  = ±(0.00025V + 0.00004V)
  = ±0.00029V

  Note: 4 counts on the 2V range equals 0.00004 V

Thus, the accuracy range for the 1.00000V reading is 0.99971V to 1.00029V.

A.1.2 Calculating amps accuracy

From the specifications, Amps is calculated as follows:

Accuracy = ±(% rdg + 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 specs:

Accuracy = ±(0.1% of 10mA + 5 counts)
  = ±(0.01mA + 5 counts)
  = ±(0.01mA + 0.0005mA)
  = ±0.0105mA

  Note: 5 counts on the 20mA range equals 00.0005mA

Thus, the accuracy range for the 10.0000mA reading is 9.9895mA to 10.0105mA.

A.1.3 Calculating ohms accuracy

The following information shows how to calculate ohms accuracy for both Auto V-Source Ohms and Manual V-Source Ohms.

Auto V-Source ohms

From the specifications, Auto V-Source Ohms accuracy is calculated as follows:

Accuracy = ±(% rdg + counts)

The following example shows how to compute Auto V-Source Ohms accuracy for the 2MΩ range:

Assume that the resistor you are measuring is reading exactly 1.00000MΩ on the 2MΩ range.

From the specs:

Accuracy = ±(0.125% of 1MΩ + 1 count)
  = ±(1250Ω + 1 count)
  = ±(1250Ω + 10Ω)
  = ±1260Ω

  Note: 1 count on the 2MΩ range (0.00001MΩ) equals 10Ω

Thus, the accuracy range for the 1.00000MΩ Auto V-Source reading is 0.99874MΩ to 1.00126MΩ.

Manual V-Source ohms

Accuracy for Manual V-Source Ohms is determined by calculating the accuracy of the amps measurement and the accuracy of the V-Source. Accuracy for ohms is then calculated (R = V/I) using the worst case amps and volts readings.

The following example shows how to compute Manual V-Source Ohms accuracy:

Assume that the test voltage is set for 100.000V, AUTO measurement range is enabled, and the resistor you are measuring is reading exactly 01.0000MΩ. Also assume that the amps reading is 1.000e-04 A (100.000µA) on the 200µA range. This reading is available as a multiple (NEXT) display (MEAS and SRC).

Amps accuracy for the 100µA reading (200µA range) is calculated as follows:

Accuracy = ±(% rdg + counts)
  = ±(0.1% of 100µA + 5 counts)
  = ±(0.1µA + 5 counts)
  = ±(0.1µA + 0.005µA)
  = ±(0.105µA)

Note: 5 counts on the 200µA range equals 000.005µA

Thus, the accuracy range for a 100.000µA reading is 99.895µA to 100.105µA.

V-Source accuracy (100V on the 100V range) is calculated as follows:

Accuracy = ±(% setting + offset)
       = ±(0.15% of 100V + 10mV)
       = ±(0.15V + 0.01V)
       = ±(0.16V)

Thus, the accuracy range for the 100V V-Source setting is 99.84V to 100.16V.

Ohms can then be calculated (R = V/I) using amps and V-Source accuracy as follows:

$$\text{Ohms Upper Limit Accuracy} = \frac{100.16\text{V}}{99.895\mu A}$$

$$= 1.00265\text{M}\Omega$$

$$\text{Ohms Lower Limit Accuracy} = \frac{99.84\text{V}}{100.105\mu A}$$

$$= 0.99735\text{M}\Omega$$

$$\text{Accuracy} = \pm2650\Omega$$

Thus, the accuracy range for the 01.0000MΩ Manual V-Source reading is 00.9974MΩ to 01.0027MΩ.

A.1.4 Calculating coulombs accuracy

From the specifications, Coulombs is calculated as follows:

Accuracy = ±(% rdg + counts)

The following example shows how to compute accuracy for the 2µC range:

Assume that the charge you are measuring is reading exactly 1.00000µC on the 2µC range.

From the specs:

Accuracy = ±(0.4% of 1µC + 5 counts)
       = ±(0.004µC + 5 counts)
       = ±(0.004µC + 0.00005µC)
       = ±0.00405µC

Note: 5 counts on the 2µC range equals 0.00005µC

Thus, the accuracy range for the 1.00000µC reading is 0.99595µC to 1.00405µC.

B

Interface Function Codes

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 Model 6517 are listed in Table B-1. The codes define Model 6517 capabilities as follows:

Table B-1
Model 6517 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

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 6517 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).

C

ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

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.

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	"	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	'	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	'	MLA 12
45	2D	-	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	«	MTA 30
95	5F	æ	UNL

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

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 represent secondary address resulting in MSA (My Secondary Address).

D

IEEE-488 Bus Overview

Introduction

Basically, the IEEE-488 bus is simply 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 a 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 set up for controlled operation is shown in Figure D-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.
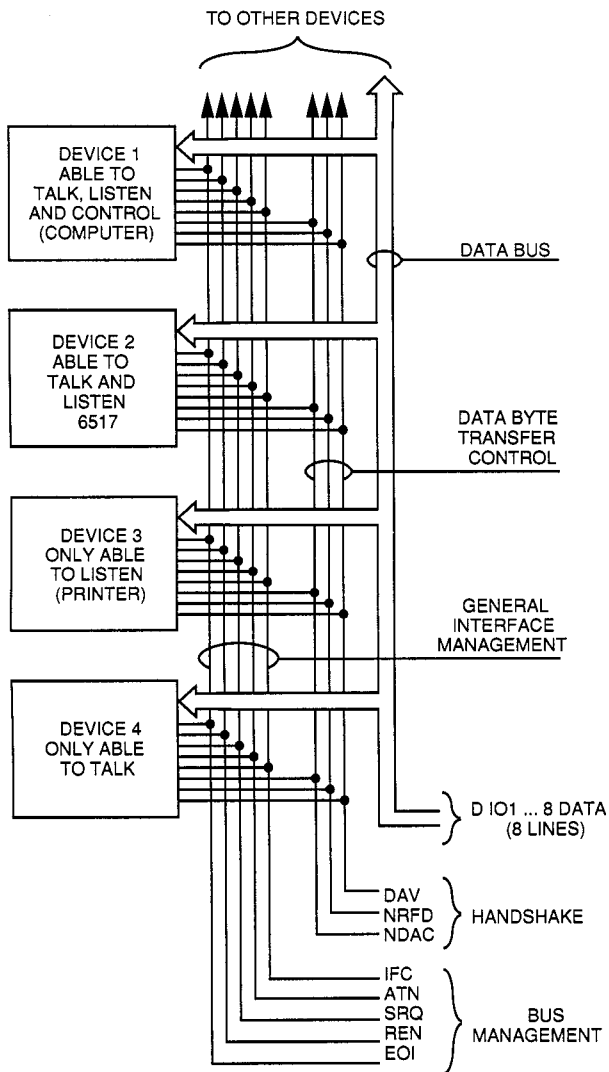
Figure D-1
IEEE-488 bus configuration

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The IEEE-488 bus is limited to 15 devices, including the controller. Thus, 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 would 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 ORing the primary address with $20. For example, if the pri-

mary 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 Model 6517, 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.

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 data lines used to transmit both data and multiline commands and are bidirectional. 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 in that the state of this line determines how information on the data bus is to be 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 to indicate to any listening devices whether or not data bus information is valid.

NRFD (Not Ready For Data) — The acceptor controls the state of NRFD. It is used to signal to the transmitting device to hold off 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 D-2. Once data is placed on the data lines, the source checks to see that NRFD 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 NRFD have the correct status. If the source is a controller, NRFD and NDAC must be stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating 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.
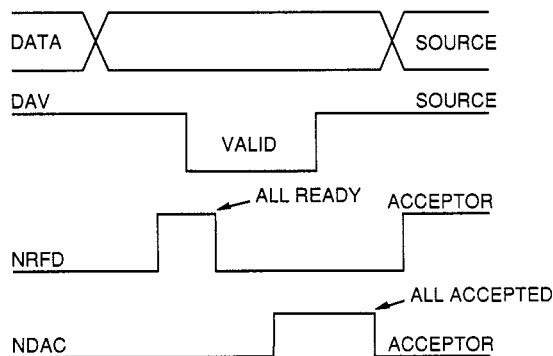
Figure D-2
IEEE-488 handshake sequence

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 three 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 which 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 purpose are summarized in Table D-1.

Table D-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 our 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 particular 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, thus 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. As with all multiline commands, these commands are transmitted with ATN true.

LLO (Local Lockout) — LLO is sent to the instrument to lock out the LOCAL key and thus all their front panel controls.

DCL (Device Clear) — DCL is used to return instruments to some 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.

Address 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 6517) 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 in that ATN is false when the commands are transmitted.

SCPI commands

SCPI commands are commands that are particular to each device on the bus. These commands are designated by the instrument manufacturer, and are based on the instrument model defined by the Standard Commands for Programmable Instruments (SCPI) Consortium's SCPI standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a particular operation, such as setting a range or closing a relay. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

Command codes

Command codes for the various commands that use the data lines are summarized in Figure D-3. Hexadecimal and the decimal values for the various commands are listed in Table D-2.

Row	D3 D2 D1 D0	0(A) X000	0(B) Command	1(A) X001	1(B) Command	2(A) X010	2(B) Primary Address	3(A) X011	3(B) Primary Address	4(A) X100	4(B) Primary Address	5(A) X101	5(B) Primary Address	6(A) X110	6(B)	7(A) X111	7(B)
0	0 0 0 0	NUL		DLE		SP	0	0	16	@	0	P	16	`		p	
1	0 0 0 1	SOH	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a		q	
2	0 0 1 0	STX		DC2		"	2	2	18	B	2	R	18	b		r	
3	0 0 1 1	ETX		DC3		#	3	3	19	C	3	S	19	c		s	
4	0 1 0 0	EOT	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d		t	
5	0 1 0 1	ENQ	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e		u	
6	0 1 1 0	ACK		SYN		&	6	6	22	F	6	V	22	f		v	
7	0 1 1 1	BEL		ETB		'	7	7	23	G	7	W	23	g		w	
8	1 0 0 0	BS	GET	CAN	SPE	(	8	8	24	H	8	X	24	h		x	
9	1 0 0 1	HT	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i		y	
10	1 0 1 0	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
11	1 0 1 1	VT		ESC		+	11	;	27	K	11	[	27	k		{	
12	1 1 0 0	FF		FS		,	12	<	28	L	12	\	28	l		|	
13	1 1 0 1	CR		GS		-	13	=	29	M	13	]	29	m		}	
14	1 1 1 0	SO		RS		.	14	>	30	N	14	^	30	n		~	
15	1 1 1 1	SI		US		/	15	?	UNL	O	15	_	UNT	o		DEL	

Group labels:
- Column 0(B): ADDRESSED COMMAND GROUP (ACG)
- Column 1(B): UNIVERSAL COMMAND GROUP (UCG)
- Columns 2–3: LISTEN ADDRESS GROUP (LAG)
- Columns 4–5: TALK ADDRESS GROUP (TAG)
- Columns 2–5: PRIMARY COMMAND GROUP (PCG)
- Columns 6–7: SECONDARY COMMAND GROUP (SDC)

*PPC (PARALLEL POLL CONFIGURE) PPU (PARALLEL POLL UNCONFIGURE), and TCT (TAKE CONTROL) not implemented by Model 6517.

Note: D_0 = DIO1 ... D_7 = DIO8; X = Don't Care.

Figure D-3
Command codes

Table D-2
Hexadecimal and decimal command codes

Command	Hex value	Decimal value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
SCG	60-7F	96-127
UNL	3F	63
UNT	5F	95

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 D-3 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 D-4 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 6517 are listed in Table D-5. Common commands and SCPI commands are not included in this list.

Table D-3
Typical addressed command sequence

Step	Command	ATN state	Data bus ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	;	36	59
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 27.

Table D-4
Typical common command sequence

Step	Command	ATN state	Data bus ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	;	36	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.

Table D-5
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

E

IEEE-488 Conformance Information

Information

The IEEE-488.2 standard requires specific information about how the Model 6517implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. Table E-1 provides a summary of the requirements, and provides the information or references the manual for that information.

Table E-1
IEEE-488 documentation requirements

	Requirement	Description or reference
(1)	IEEE-488 Interface Function Codes.	See Appendix B.
(2)	Behavior of 6517 when the address is set outside the range 0-30.	Cannot enter an invalid address.
(3)	Behavior of 6517 when valid address is entered.	Address changes and bus resets.
(4)	Power-On Setup Conditions.	Determine by :SYSTem:POSetup (para. 3.22.2).
(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 E-2.
(6)	Functional elements required for SCPI commands.	Contained in SCPI command subsystems tables (see Tables 3-4 through 3-16).
(7)	Buffer size limitations for block data.	Block display messages: Top display = 20 characters max. bottom display = 32 characters max.
(8)	Syntax restrictions.	See paragraphs 3.10 through 3.25.
(9)	Response syntax for every query command.	See paragraphs 3.10 through 3.25.
(10)	Device-to-device message transfer that does not follow rules of the standard.	None.
(11)	Block data response size.	See paragraph 3.15.
(12)	Common Commands implemented by 6517.	See paragraph 3.11.
(13)	Calibration query information.	See Calibration Manual.
(14)	Trigger macro for *DDT.	Not applicable.
(15)	Macro information.	Not applicable.

Table E-1 (cont.)
IEEE-488 documentation requirements

	Requirement	Description or reference
(16)	Response to *IDN (identification).	See paragraph 3.11.4.
(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 paragraphs 3.11.9, 3.11.8, 3.11.10, and Tables 3-4 through 3-16.
(20)	*TST information.	See paragraph 3.11.14.
(21)	Status register structure.	See paragraph 3.8.
(22)	equential or overlapped commands.	All are sequential except :INIT and :INIT:CONT ON, which are overlapped.
(23)	Operation complete messages.	*OPC; see paragraph 3.11.5, *OPC?; see paragraph 3.11.6, *WAI; see paragraph 3.11.15.

Table E-2
Coupled commands

Command	Also changes	To	If
:TRIG:COUN	:TRAC:POIN:AUTO	OFF	TRAC:POIN:AUTO is ON and TRIG:COUN is an illegal buffer size
	:TRAC:POIN	TRIG:COUN	TRAC:POIN:AUTO is ON
	:TRAC:FEED:PRET:AMO:READ	TRIG:COUN * TRAC:FEED:PRET:AMO:PERC / 100	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	OFF	
	:TRAC:FEED:CONT	NEV	
	:TRAC:FEED:PRET:AMO:READ	TRAC:POIN * TRAC:FEED:PRET:AMO:PERC / 100	
:TRAC:FEED:PRET:AMO:PERC	:TRAC:FEED:PRET:AMO:READ	TRAC:POIN * TRAC:FEED:PRET:AMO:PERC / 100	
	:TRAC:FEED:CONT	NEV	
:TRAC:FEED:PRET:AMO:READ	:TRAC:FEED:PRET:AMO:PERC	TRAC:FEED:PRET:AMO:READ / TRAC:POIN * 100	
	:TRAC:FEED:CONT	NEV	
:TRAC:CLE	:TRAC:FEED:CONT	NEV	
...:APER	...:APER:AUTO	OFF	
	...:NPLC:AUTO	OFF	
	...:NPLC	APER*line-frequency	
	...:DIG	varies per function	...DIG:AUTO is ON
...:NPLC	...:APER:AUTO	OFF	
	...:NPLC:AUTO	OFF	
	...:APER	NPLC/line-frequency	
	...:DIG	varies per function	...DIG:AUTO is ON
...:DIG	...:DIG:AUTO	OFF	
	...:APER	varies per function	...APER:AUTO is ON
	...:NPLC	varies per function	...NPLC:AUTO is ON
...:RANG:UPP	...:RANG:AUTO	OFF	
...:REF:ACQ	...:REF	presently displayed reading	

Table E-2 (cont.)
Coupled commands

Command	Also changes	To	If
...:DET:FUNC	...:APER	varies per function	...APER:AUTO is ON
	...:DIG	varies per function	...DIG:AUTO is ON
	...:AVER:STAT	varies per function	...AVER:AUTO is ON
	...:AVER:COUN n	varies per functio	...AVER:AUTO is ON
	...:AVER:TCON n	varies per functio	...AVER:AUTO is ON
	...:AVER:ADV:STAT n	varies per functio	...AVER:AUTO is ON
	...:AVER:ADV:NTOL n	varies per functio	...AVER:AUTO is ON
:RES:OCOM	:RES:RANG:UPP	200k	RES:OCOM is ON and RES:RANG:UPP > 200k
	:RES:RANG:AUTO:ULIM	200k	RES:OCOM is ON and RES:RANG:AUTO:ULIM > 200k
	:RES:RANG:AUTO:LLIM	200k	RES:OCOM is ON and RES:RANG:AUTO:LLIM > 200k
:CURR:DC:METH	:CURR:DC:RANG:UPP	12	CURR:DC:METH is ICIR
	:CURR:DC:RANG:AUTO	OFF	
	:CURR:DC:AVER:STAT	varies per function	CURR:DC:METH is ICIR
	:CURR:DC:AVER:COUN	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:TCON	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:ADV:STAT	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:ADV:NTOL	varies per function	CURR:DC:AVER:AUTO is ON CURR:DC:AVER:AUTO is ON
:FREQ:THR:VOLT:TTL	:FREQ:THR:VOLT:RANG	10	
	:FREQ:THR:VOLT:LEV	0.8	
:TEMP:TRAN	:ROUT:SCAN:INT	very complicated algorithm	
	:ROUT:SCAN:INT:FUNC	very complicated algorithm	
	:TEMP:DIG	varies per transducer	TEMP:DIG:AUTO is ON
:TEMP:RTD:TYPE	:TEMP:RTD:ALPH	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:BETA	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:DELT	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:RZER	varies per RTD type	TEMP:RTD:TYPE is not USER
:TEMP:RTD:ALPH	:TEMP:RTD:TYPE	USER	

Table E-2 (cont.)
Coupled commands

Command	Also changes	To	If
: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 (i.e. :VOLT:DC, :RESistance, etc.)

F

SCPI Conformance Information

Introduction

The Model 6517 complies with SCPI version 1991.0. Tables
3-4 through 3-16 list the SCPI confirmed commands, and the
non-SCPI commands implemented by the Model 6517.

G

Device Dependent Command Summary

Mode	Command	Description				
Execute	X	Execute other device-dependent commands.				
Function	F0	Volts				
	F1	Amps				
	F2	Ohms (V/I)				
	F3	Coulombs				
	F4	External feedback				
	F5	Ohms (V/I)				
Range						EXTERNAL
		VOLTS	AMPS	OHMS	COULOMBS	FEEDBACK
	R0	Auto	Auto	Auto	Auto	Auto
	R1	2V	20pA	200TΩ	2nC	2V
	R2	2V	20pA	20TΩ	2nC	2V
	R3	20V	200pA	2TΩ	20nC	20V
	R4	200V	2nA	200GΩ	200nC	200V
	R5	200V	20nA	20GΩ	2μC	200V
	R6	200V	200nA	2GΩ	2μC	200V
	R7	200V	2μA	200MΩ	2μC	200V
	R8	200V	20μA	20MΩ	2μC	200V
	R9	200V	200μA	2MΩ	2μC	200V
	R10	200V	2mA	200kΩ **	2μC	200V
	R11	200V	20mA	200kΩ **	2μC	200V
	R12	*	*	200kΩ **	*	*
		*Disables autorange **Manual ohms only				
Zero Check	C0	Zero check off				
	C1	Zero check on				
Zero Correct	Z0	Zero correct disabled				
	Z1	Zero correct enabled				
Reference	N0	Reference disabled				
	N1	Reference enabled				

Mode	Command	Description
Reading Mode	B0	Electrometer
	B1	Buffer reading
	B2	Maximum reading
	B3	Minimum reading
	B4	Voltage source
Data Store	Q0	Conversion rate
	Q1	One reading per second
	Q2	One reading every 10 seconds
	Q3	One reading per minute
	Q4	One reading every 10 minutes
	Q5	One reading per hour
	Q6	Trigger mode
	Q7	Disabled
Voltage Source Value	V±nnnn.nn or V±n.nnnnE±n	Voltage source value: -1000V to +1000V, 50mV increments
Voltage Source Operate	O0	Source output off (0V)
	O1	Source output on (programmed value)
Data Format	G0	Reading with prefix (NDCV -1.23456E+00)
	G1	Reading without prefix (-1.23456E+00)
	G2	Reading with prefix and buffer suffix (if in B1) (NDCV -1.23456E+00, 012)
Trigger Mode	T0	Continuous, trigger by talk
	T1	One-shot, trigger by talk
	T2	Continuous, trigger by GET
	T3	One-shot, trigger by GET
	T4	Continuous, trigger by X
	T5	One-shot, trigger by X
	T6	Continuous, trigger by external trigger
	T7	One-shot, trigger by external trigger
SRQ	M0	Disable SRQ
	M1	Reading overflow
	N2	Buffer full
	M8	Reading done
	M16	Ready
	M32	Error
EOI and Bus Hold Off	K0	Enable EOI and bus hold-off on X
	K1	Disable EOI, enable bus hold-off on X
	K2	Enable EOI, disable bus hold-off on X
	K3	Disable both EOI and bus hold-off on X
Terminator	Y0	LFCR
	Y1	CRLF
	Y2	LF
	Y3	CR
	Y4	None

Mode	Command	Description

Status Word	U0
	U1
	U2
	U3
	U4
	U5
	U6
	U7
		Status word: 617 FRRCZNTOBGDQMMKYY*
		Error conditions
		Data conditions
		Buffer size and readings stored
		Top display data
		Bottom display data
		Attributes of top display characters**
		Attributes of bottom display characters**
		
		*YY: := LFCR
		       =: CRLF
		       :0 LF
		      =0 CR
		      00 None
		**1 = blinking character, 0 = other

Hit Key	Hn	Hit front panel key. "n" = 1 to 31 (see Figure 3-40 for key-press codes).
Buffer Size	In	"n" = 2 to 15868 (if buffer elements are not changed using Hit Key command).

Index

KEITHLEY

Service Form

Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

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

_____

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

❑ IEEE failure   ❑ Obvious problem on power-up   ❑ Batteries and fuses are OK
❑ Front panel operational   ❑ All ranges or functions are bad   ❑ Checked all cables

Display or output (check one)

❑ Drifts   ❑ Unable to zero
❑ Unstable   ❑ Will not read applied input
❑ Overload

❑ Calibration only   ❑ Certificate of calibration required
❑ Data required
(attach any additional sheets as necessary)

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

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

_____

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

Relative humidity? _____ Other? _____

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

_____

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

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