User's Guide

HP 70110A

Digital Multimeter

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Safety Symbols

The following safety symbols are used throughout this manual. Familiarize yourself with each of the symbols and its meaning before operating this instrument.

Caution	The *caution* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the instrument. Do not proceed beyond a *caution* sign until the indicated conditions are fully understood and met.

Warning	**The *warning* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a *warning* sign until the indicated conditions are fully understood and met.**

General Safety Considerations

Warning	*Before this instrument is switched on,* **make sure it has been properly grounded through the protective conductor of the ac power cable to a socket outlet provided with protective earth contact.**
	Any interruption of the protective (grounding) conductor, inside or outside the instrument, or disconnection of the protective earth terminal can result in personal injury.
Warning	**There are many points in the instrument which can, if contacted, cause personal injury. Be extremely careful.**
	Any adjustments or service procedures that require operation of the instrument with protective covers removed should be performed only by trained service personnel.
Caution	*Before this instrument is switched on,* make sure its primary power circuitry has been adapted to the voltage of the ac power source.
	Failure to set the ac power input to the correct voltage could cause damage to the instrument when the ac power cable is plugged in.

In This Book

This book describes all of the procedures necessary to use and program the HP 70110A digital multimeter in an HP 70000 Series modular spectrum analyzer system.

Chapter 1 contains a quick start guide to get you up and running.

Chapter 2 contains tasks that allow the user to operate the HP 70110A digital multimeter from the front panel softkeys.

Chapter 3 contains tasks that allow the user to operate the HP 70110A digital multimeter through remote programming.

Chapter 4 contains the specification and characteristics.

Chapter 5 contains softkey menu maps and softkey descriptions.

Chapter 6 provides error messages and codes.

Chapter 7 provides a table of remote programming commands to be used as a quick reference.

Chapter 8 contains the syntax for all remote programming commands.

Chapter 9 contains information about configuring the address of your HP 70110A digital multimeter.

Chapter 10 describes the program loader.

An index is also added at the end of this manual to aid the user in finding key items of interest.

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Figures

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Getting Started

This chapter describes the HP 70110A digital multimeter, how to install it, and how to initially operate it manually. This chapter also shows how to program the module using Standard Commands for Programmable Instruments (SCPI). This chapter contains the following sections:

- Multimeter Overview
- Installation
- Manual Operation
- Remote Operation

Multimeter Overview

This 2-slot wide multimeter can measure dc voltage, ac voltage, ac+dc voltage, 2-wire and 4-wire resistance, dc current, ac current, ac+dc current, frequency, period, and temperature. All measurements are made from the multimeter's front terminals or rear panel inputs. For all types of measurements, you can use the autorange function which automatically selects the measurement range or you can specify a particular measurement range. The multimeter has offset compensation for resistance measurements and autozero for all measurements.

The multimeter measures an analog signal by converting it to a digital value. Once the signal is in digital form, it can be sent to the output buffer or stored in multimeter memory. Input signals are converted to digital values by the multimeter's analog-to-digital (A/D) converter. The method of A/D conversion (integration) can provide normal-mode noise rejection (rejection of noise at multiples of the power line frequency). A GUARD terminal enhances common-mode noise rejection (rejection of noise common to both of the multimeter's input terminals).

Installation

This section contains step-by-step instructions that are required for proper installation of an HP 70110A digital multimeter in an HP 70000 modular measurement system.

Tools needed

Before installation, assemble these tools:

- A long 8 mm hex-ball driver (HP part number 8710-1307) or a short 8 mm hex-ball driver (HP part number 8710-1651)
- A nonconductive stylus, such as a toothpick or similar object, for setting address switches

Antistatic precautions

Electrical components are easily damaged by small amounts of static electricity. If possible, work at a static-safe work station (refer to the *HP 70000 Modular Spectrum Analyzer Installation and Verification Manual* for information).

Installation overview

The installation procedure for the HP 70110A digital multimeter is straightforward. The following five steps are included:

Step 1. Switch Off the AC Line Power

Before removing any existing modules, disconnecting any cables, or installing any new modules, always switch off the ac line power to the display or mainframe with which you are working.

Step 2. Unpack the Multimeter

Unpack your new HP 70110A digital multimeter from its shipping container and inspect it thoroughly to ensure that it was not damaged during shipment. Verify that all parts and materials were included in the shipping container. You should have:

1. HP 70110A digital multimeter
2. User's Guide
3. Connector Kit with:
   - Option 001
   - Option 002

Step 3. Check or Set the HP-MSIB Address

Locate the HP-MSIB address switches on the top panel of your new HP 70110A digital multimeter. Figure 1-1 shows these switches. During the manufacturing process, each module in the HP 70000 modular measurement system is set to a default HP-MSIB address. Check that the HP-MSIB address on your new HP 70110A digital multimeter is set to row 0 and column 22.
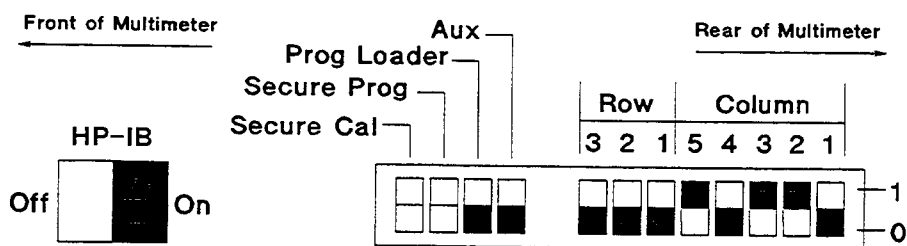
Figure 1-1. HP-MSIB Address Switches

If necessary, use a nonconductive stylus, such as a toothpick or similar object, to set the HP-MSIB address switches. Each module in an HP 70000 modular measurement system must have a unique address.

To configure your new HP 70110A digital multimeter with a different HP-MSIB address other than its default address or to set the other configuration switches, refer to "HP-MSIB Address Switches" in Chapter 9.

Step 4. Install Your Multimeter

Install your new HP 70110A digital multimeter into the mainframe. While tightening the hex-nut latch with an 8 mm hex-ball driver, press against your new HP 70110A digital multimeter's front panel. This locks your new HP 70110A digital multimeter into position. Close the mainframe front panel door to cover the hex-lock screw.

Step 5. Switch On the System's AC Line Power

Set the line-voltage selector on your HP 70000 modular measurement system display and mainframe to the voltage corresponding to the power source used. The line-voltage selectors are located on the left side of the HP 70004A color display and on the bottom of the HP 70001A mainframe.

Caution	Before turning this instrument on, make sure the line-voltage selector is set to the voltage of the ac power source:
	■ 115 V position for 90 to 132 Vac line input voltages at 50, 60, or 400 Hz
	■ 230 V position for 198 to 264 Vac line input voltages at 50 or 60 Hz

Switch on the ac line power to the HP 70000 modular measurement system display and mainframe.

Optional. Checking/Replacing Fuses

The input of your HP 70110A digital multimeter is protected with a fuse. In order to replace this fuse, you must remove the input connector as shown in Figure 1-2.
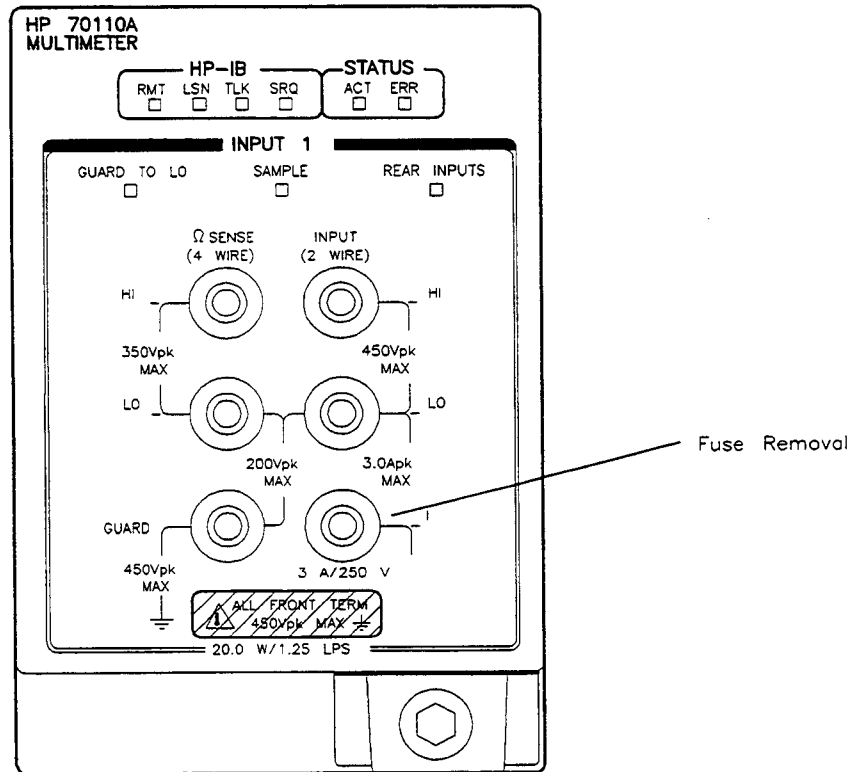
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Figure 1-2. Input Fuse Replacement

To replace the input fuse:

1. Turn the "I" (input current connector) CCW until it stops.
2. Push in and turn the input current connector CW one-half turn.

   The fuse housing should come out so that the fuse can be replaced. Replace this input fuse only with 3 A 250 V fuse (HP part number 2110-0055).

Option 001 contains fuses as shown in Figure 1-3.

To replace the fuses for channels 8 and 9:

1. Push in and turn the fuse holder CCW one-half turn.

   The fuse housing should come out so that the fuse can be replaced. Replace these fuses only with 3 A 250 V fuses (HP part number 2110-0055).
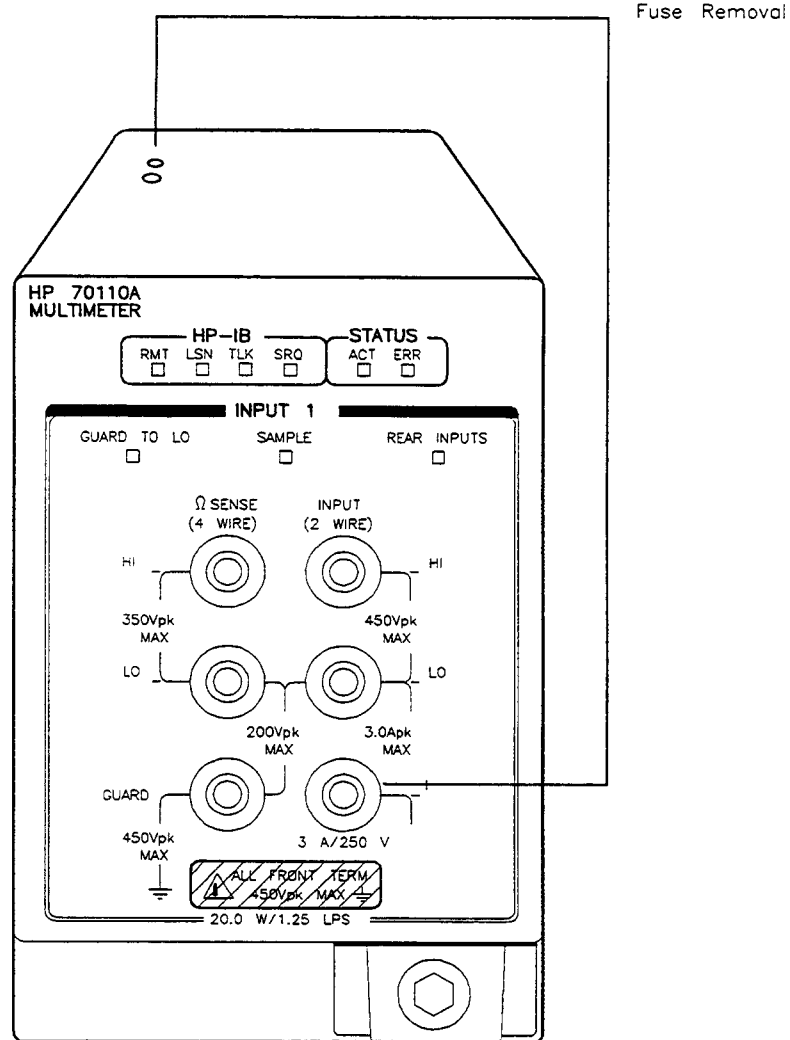
Figure 1-3. Fuse Replacement for an Option 001

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Manual Operation

If you are not using a 60 Hz power source, (that is, 50 or 400 Hz), you need to reset the line frequency expected by the HP 70110A digital multimeter. The HP 70110A digital multimeter measures an analog signal source by converting it to a digital value. Input signals are converted to digital values by the HP 70110A digital multimeter's A/D converter. The A/D converter is responsible for many of its operating characteristics. One of these includes its ac line rejection. By integrating measurements over a harmonic of the line frequency this type of unwanted noise is rejected from the final measurement value. Once set, the power line frequency is stored in non-volatile memory and is not affected by resets or power-on cycles.

To reset the line frequency:

1. Press the Setup softkey.
2. Press the 1 of 2 more softkey.
3. Press the 50/400 LF: 60 Hz softkey with 60 Hz underlined.

   Successive presses of this last key will toggle between 60 Hz and 50/400 Hz operation. The current condition of this setting is shown by underlining either 60 Hz or 50/400 Hz.

Note	The reason there are only two settings, is that 50 Hz is a subharmonic of 400 Hz so the same reference clock rate can be used for the A/D converter.

To assure that the HP 70110A digital multimeter is in good operating condition, you can perform self-test and auto cal from the display. This combination of routines will insure a greater than 95% probability that all measurement circuitry and instrument calibration is functioning properly.

To perform self-test:

1. Press the State softkey.
2. Press the TEST SELF softkey.

   This routine typically takes less than 15 seconds to complete. The HP 70110A digital multimeter will show PASSED on screen if successful.

To perform auto cal:

1. Press the State softkey.
2. Press the CAL AUTO softkey.

   This routine typically takes less than 40 seconds to complete. The HP 70110A digital multimeter will show PASSED on screen if successful.

Remote Operation

Programming the Multimeter

To program the multimeter using the Standard Commands for Programmable Instruments (SCPI), you must first set the module address. See *Setting the HP-MSIB Address* in Chapter 9.

Before continuing with the remainder of this manual, you will want to verify communication between the multimeter, the mainframe, and your computer. This section shows how to perform the multimeter self-test, how to reset and clear the multimeter, and how to read the error queue.

Performing a Self-Test

After the multimeter completes its power-on sequence, it is ready for use. Sending the self-test command is an easy way to verify that you are properly addressing the multimeter. The self-test is also useful in locating

intermittent problems that might occur during operation. The following commands perform the multimeter's self-test:

*TST? or TEST?

These commands return a number to show whether the self-test passed or failed. (Refer to Table 1-1.) The number is sent to the output buffer. To return the multimeter to a known state after a self-test, you may want to reset the multimeter. (Refer to "Resetting the Multimeter").

Table 1-1. Multimeter Self-Test Codes

Weighted Value	Description
0	All tests passed.
1	Inguard UART failure.
2	Inguard CPU failure.
4	Inguard link failure.
8	Integrator convergence error.
16	Front end zero measurement error.
32	Gain test error.
64	Amps function error.
128	AC amplifier's dc offset test failure.
256	AC flatness check failure.
512	Ohms precharge failure.
2048	System RAM checksum failure.
4096	Calibration memory checksum failure.
8192	Autocalibration memory checksum failure.
16384	ROM checksum failure.

If the multimeter does not respond to the self-test, the specified address may be incorrect. Chapter 9 in this manual reviews the multimeter addressing convention. If the multimeter responds with a number other than "0", you may have to return the multimeter to Hewlett-Packard for repair.

Resetting the Multimeter

The *RST (reset) command resets the multimeter to its power-on state. The reset function aborts any measurements in progress and clears any reading in the multimeter's internal reading buffer. Table 1-2 shows the multimeter's power-on settings.

Table 1-2. Multimeter *RST and Power-On Settings

Item	Related Commands	Power-On State
ac bandwidth	[SENSe:]DETector:BANDwidth	20 (Slow Mode)
Autorange	[SENSe:]CURRent:RANGe:AC:AUTO [SENSe:]CURRent:RANGe[:DC]:AUTO [SENSe:]RESistance:RANGe:AUTO [SENSe:]VOLTage:RANGe:AC:AUTO [SENSe:]VOLTage:RANGe[:DC]:AUTO	On
Autozero	CALibration:ZERO:AUTO	On
Boot Source	DIAGnostic:BOOT:SOURce	INST
Delay Time	TRIGger:DELay	Default (see Table 3-12)
Function	[SENSe:]FUNCtion[:ON]	dc voltage
Input Coupling	INPut:COUPling	ac voltage
Input Guard	INPut:GUARd	Low
Input Impedance	INPut:IMPedance:AUTO	On
Input Routing	ROUTe:TERMinals	FRONt
Input Terminals	INPut:STATe	On
Integration Time in power line cycles	[SENSe:]CURRent:AC:NPLCycles [SENSe:]CURRent[:DC]:NPLCycles [SENSe:]RESistance:NPLCycles [SENSe:]VOLTage:AC:NPLCycles [SENSe:]VOLTage:[DC]:NPLCycles	1 Power Line Cycle
Integration Time in seconds	[SENSe:]CURRent:AC:APERture [SENSe:]CURRent[:DC]:APERture [SENSe:]RESistance:APERture [SENSe:]VOLTage:AC:APERture [SENSe:]VOLTage:[DC]:APERture	1.67E-02 (60 Hz) 2E-02 (50 Hz)
Limit Test	CALCulate:LIMit:STATe	Off

Table 1-2. Multimeter *RST and Power-On Settings (continued)

Item	Related Commands	Power-On State
Multiplexer State	ROUTe:OPEN	All channels open
Offset Compensation	[SENSe:]RESistance:OCOMpensated	Off
Range	[SENSe:]RESistance:RANGe [SENSe:]CURRent:AC [SENSe:]CURRent[:DC] [SENSe:]VOLTage:AC [SENSe:]VOLTage[:DC]	Autorange
Readings per Trigger	SAMPle:COUNt	1 reading
Reference Frequency	SYSTem:LFRequency	Last value programmed
Resolution	[SENSe:]CURRent:AC:Resolution [SENSe:]CURRent[:DC]:Resolution [SENSe:]RESistance:Resolution [SENSe:]VOLTage:AC:Resolution [SENSe:]VOLTage[:DC]:Resolution	based on aperture and NPLCycles settings
Sample Source	SAMPle:SOURce	Immediate
Sample Timer Interval	SAMPle:TIMer	1 second
Trigger Buffer	TRIGger:BUFFered	Off
Trigger Count	TRIGger:COUNt	1
Trigger Slope	TRIGger:SLOPe	Negative
Trigger Source	TRIGger:SOURce	Immediate

Table 1-3. Multimeter Power-On Settings

Item	Related Commands	Power-On State
Power-On Status Clear	*PSC	Last value programmed
Event Status Clear	*ESE	Last value programmed
Service Request Enable	*SRE STATus:QUEStionable:ENABle STATus:OPERation:ENABle STATus:QUEStionable:NTRansition STATus:OPERation:NTRansition STATus:QUEStionable:PTRansition STATus:OPERation:PTRansition	Last value programmed Always 0 Always 0 Always 0 Always 0 32767 32767

Clearing the Multimeter

The HP-IB CLEAR command clears the multimeter preparing it to receive a command. Clearing the multimeter allows you to regain control of the multimeter without cycling power. Clearing the multimeter also clears the HP-IB input and output buffers.

Reading the Error Queue

When the multimeter detects an error condition, it stores an error number and corresponding message in its error queue.

To read the error queue:

1. Send the following command:

    SYSTem:ERRor?

One error is removed from the error queue each time the SYSTem:ERRor? command is executed. The errors are cleared in a first-in, first-out order. This means that if several errors are waiting in the queue, each query returns the oldest (not the most recent) error. That error is then removed from the queue.

When the error queue is empty, subsequent SYSTem:ERRor? queries return +0, "No error". To clear all errors from the error queue, execute the *CLS (clear status) command.

The error queue can hold a maximum of 12 errors. If more than 12 errors are generated, the last error in the queue will be −350 "Too many errors". No additional errors are accepted by the queue until you begin reading and removing errors.

Note	See Chapter 6 for a complete listing of error numbers and messages for the multimeter.

Initial Operation

To verify that the multimeter is operating properly, use the following program to make a simple dc voltage measurement using the MEASure command. The example is written in the HP BASIC program language. The Hewlett-Packard Interface Bus (HP-IB) interface select code is 7, and the multimeter's HP-IB address is 22.

10 OUTPUT 722; "MEAS:VOLT:DC?"	*Function: dc voltage; autorange on; trigger multimeter immediately; send reading to output buffer*
20 ENTER 722; Rdg	*Enter reading into computer*
30 PRINT Rdg	*print reading*
40 END	

2

Front Panel Measurement Tasks

This chapter describes basic front panel operating procedures for the HP 70110A digital multimeter. Operating procedures for ac voltage, dc voltage, 2-wire and 4-wire resistance, ac current, dc current, as well as frequency and period measurements are covered in this section.

This chapter contains the following sections:

- Voltage
- Resistance
- Current
- Frequency and Period
- Triggering Measurements
- Math Operations
- State

Voltage

DC Voltage Measurement

Press Measure then DCV.

AC Voltage Measurement

Press Measure then ACV. While active, successive pressing of the ACV key will toggle between ac and dc coupling and show coupling condition as AC ONLY or AC + DC.

Input Connections

For voltage measurements, the input voltage is connected to the INPUT HI and LO terminals. This is true for both front and rear terminal operation. When using one of the optional multiplexers, (Option 001 and Option 002), the input is connected to the HI and LO inputs of a particular channel.

Note   For Option 001, channels 8 and 9 are for current measurements only.

To toggle between front and rear inputs:

1. Press the Setup softkey.

2.
         INPUT

Press the FR REAR softkey.

When using one of the optional multiplexers (Option 001 or Option 002) this softkey reads
INPUT
FR SCAN.

Range Selection

The HP 70110A digital multimeter Auto-Range feature automatically selects the appropriate range to measure the voltage applied. The Auto-Range feature is disabled by selecting Manual Ranging. There are five voltage measurement ranges available: 30 mV, 300 mV, 3 V, 30 V, and 300 V. The default range is Auto-Range.

To select Manual Ranging and maintain the present range:

1. Press the Setup softkey.
2.
        RANGE

Press the AUTOMAN softkey.

             RANGE

Successive key presses of AUTOMAN will toggle between Auto-Range and Manual Ranging. The current condition will be shown by underlining of either AUTO or MAN.

To select Manual Ranging and change the range:

1. Press the Setup softkey.
2.
        RANGE

Press the AUTOMAN softkey.
3. Use the ⬆ or ⬇ to select the proper range.
4. Use the RPG to select the proper range.
5. Use the number keys to enter the highest expected measurement value. The HP 70110A digital multimeter will select the lowest range capable of measuring the entered value.

Measurement Resolution

Integration Time

Measurement resolution is changed by increasing or decreasing the integration time of the measurement. Increasing the integration time reduces measurement noise. Decreasing integration time permits faster readings. The integration time is dependent on the power line frequency and is expressed in number of power line cycles (NPLC). There are six integration times available; 100 PLC, 10 PLC, 1 PLC, 0.1 PLC, 0.005 PLC, and 0.0005 PLC. The greater the PLC number, the quieter and more accurate the reading will be and the slower the measurement speed. The default is 1 PLC.

To change the integration time, NPLC:

1. Press the Setup softkey.
2.
        NPLC

Press the aprture softkey.

3. Press the appropriate key from the right-hand menu.

This right-hand menu also shows the actual aperture time of the integration in seconds.

Autozero

With autozero on, the HP 70110A digital multimeter internally disconnects the input signal after each measurement and takes a zero reading. It then subtracts the zero reading from the preceding measurement. This minimizes the effects of offset voltages present on the HP 70110A digital multimeter's input circuitry from affecting measurements. The default is for autozero to be on. With autozero off, the HP 70110A digital multimeter takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time there is a function or range change. Turning autozero off results in faster readings and reduced measurement accuracy.

To turn autozero off:

1. Press the Setup softkey.
2. Press the more 1 of 2 softkey.
3. Press the ZEROING AUTOOFF softkey.

Successive pressing of the last key will toggle between the autozero on and autozero off conditions. The current state of autozero will be shown by underlining of AUTO or OFF.

Number of Digits Displayed

The HP 70110A digital multimeter allows you to reduce or increase the number of digits displayed on screen. You can choose a display of $3\frac{1}{2}$, $4\frac{1}{2}$, $5\frac{1}{2}$, or $6\frac{1}{2}$ digits. The $\frac{1}{2}$ digit refers to the most significant digit, which is limited to a value of 0, 1, 2, or 3. The default number of digits displayed is $6\frac{1}{2}$, (most significant digit plus 6 digits).

Note
👉

The HP 70110A digital multimeter will only display the useful resolution of the measurement. For example, if you choose a short integration time which results in $3\frac{1}{2}$ digits of resolution the HP 70110A digital multimeter will display a maximum of $3\frac{1}{2}$ digits regardless of the number of digits you have requested.

To select the number of digits to be displayed:

1. Press the Setup softkey.
2. Press the #digits display softkey.
3. Press the appropriate key from the right-hand menu.

Fixed Impedance

When making dc voltage measurements, you can fix the input impedance to 10 MΩ. This is useful to prevent a change in input impedance, (caused by a range change), from affecting the measurement. Table 2-1 shows the input impedances with fixed impedance on and fixed impedance off. Default is for fixed impedance to be off.

Table 2-1. Input Impedance for Fixed Impedance ON/OFF

mode Parameter	30 mV, 300 mV, 3 V DCV ranges	30V, 300 V DCV ranges
OFF or 0	10 GΩ	10 MΩ
ON or 1	10 MΩ	10 MΩ

To turn Fixed Impedance on:

1. Press the Setup softkey.
2.
   more

   Press the 1 of 2 softkey.
3.
   FIXED Z

   Press the ON OFF softkey.

Successive key presses of this last key will toggle between the on and off conditions. The present condition of fixed impedance will be shown by underlining of either ON or OFF.

Note	Fixed Impedance is temporarily disabled when you change from dc voltage measurements to ac voltage, ac or dc current, frequency, or period measurements. Fixed Impedance remains enabled when you change from dc voltage to 2-wire or 4-wire resistance measurements. When Fixed Impedance is on and you are in a resistance measurement mode, the HP 70110A digital multimeter measures the 10 MΩ (Fixed Impedance) resister.

AC Bandwidth

When making ac voltage measurements, you can select either a slow or fast mode. The slow mode is for signals below 400 Hz. In the slow mode, a longer time constant is used for the input filter and a longer delay is used. The fast mode is for signals greater than or equal to 400 Hz and allows you to make a series of measurements in a shorter amount of time.

To select the fast ac mode:

1. Press the Setup softkey.
2.
   more

   Press the 1 of 2 softkey.
3.
   AC BNWD

   Press the FASTSLO softkey.

Successive key presses of the last key will toggle between the fast and slow ac modes. The present condition of ac bandwidth will be shown by underlining of either FAST or SLO.

Resistance

2-Wire and 4-Wire Ohms Measurement

Press Measure then OHMS , while active, successive pressing of the OHMS key will toggle between 2-wire and 4-wire conditions and show present setting by underlining 2W or 4W.

Input Connections

For 2-wire ohms measurements, the unknown resistance is connected to the INPUT (2 WIRE) HI and LO terminals. This applies to both the front and rear terminal operation. When using one of the multiplexer options, (Option 001 or Option 002), the unknown resistance would be connected to the HI and LO inputs of a particular channel. For Option 001, channels 0 through 7 are available for 2-wire ohms measurements. For Option 002, 2-wire ohms measurements can be made on channels 0 through 9. For all options, multiplexed input channels are located on the rear panel.

For 4-wire ohms measurements, the unknown resistance is connected to the INPUT HI and LO terminals and to the Ω SENSE (4 WIRE) HI and LO terminals as shown in Figure 2-1.
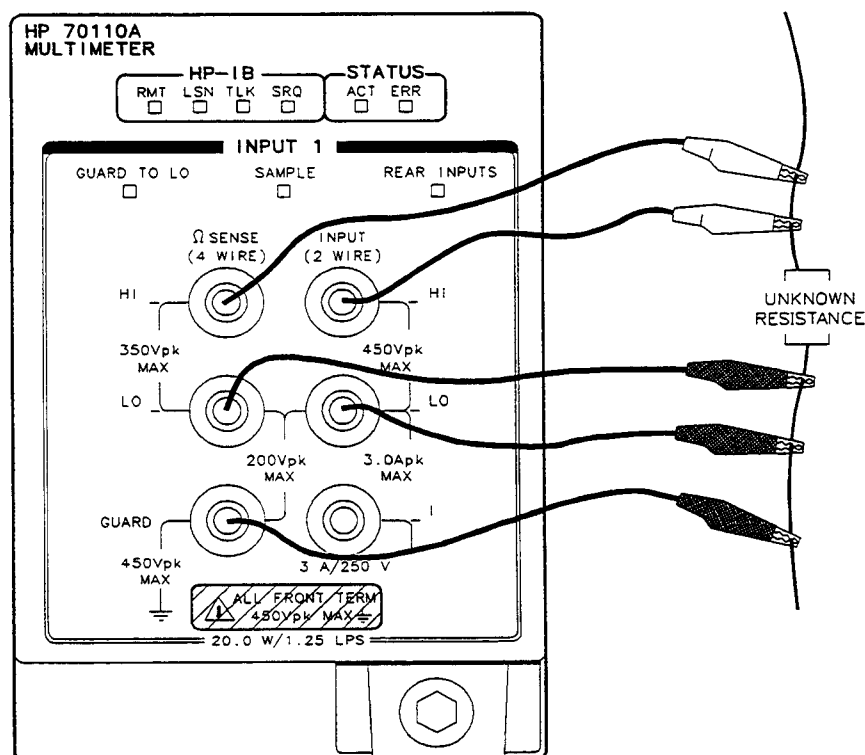
pnb6a

Figure 2-1. 4-Wire Ohm Resistance Measurement

When using one of the multiplexer options, (Option 001 or Option 002), the unknown resistance would be connected to one of the 4-wire channels. For Option 001 the multiplexer is configured into channels 10 through 13 for 4-wire ohms measurements. For Option 002,

4-wire ohms measurements can be made on channels 10 through 14. Table 2-2 shows how to identify INPUT HI and LO and the Ω SENSE (4-WIRE) HI and LO connector pins for 4-wire measurements for the multiplexer options.

Table 2-2. 4-Wire Measurement Connector Pins for Multiplexer Options

Option	Channel	INPUT HI and LO	Ω SENSE HI and LO
001 Armature Relay	10	Ch 0	Ch 4
	11	Ch 1	Ch 5
	12	Ch 2	Ch 6
	13	Ch 3	Ch 7
002 Reed Relay	10	Ch 0	Ch 5
	11	Ch 1	Ch 6
	12	Ch 2	Ch 7
	13	Ch 3	Ch 8
	14	Ch 4	Ch 9

Pressing `Setup` then `INPUT FR REAR` allows you to toggle between front and rear inputs.

Range Selection

The HP 70110A digital multimeter Auto-Range feature automatically selects the appropriate range to measure the resistance being measured. The Auto-Range feature is disabled by selecting Manual Ranging. There are nine resistance measurement ranges available: 30 Ω, 300 Ω, 3 kΩ, 30 kΩ, 300 kΩ, 3 MΩ, 30 MΩ, 300 MΩ, and 3 GΩ. The default range is Auto-Range.

To select Manual Ranging and maintain the present range:

1. Press the `Setup` softkey.
2. Press the `RANGE AUTOMAN` softkey.

Successive key presses of `RANGE AUTOMAN` will toggle between Auto-Range and Manual Ranging. The current condition will be shown by underlining of either AUTO or MAN.

To select Manual Ranging and change the range:

1. Press the `Setup` softkey.
2. Press the `RANGE AUTOMAN` softkey.
3. Use the ⬆ or ⬇ keys to select the proper range.
4. Use the RPG to select the proper range.
5. Use the number keys to enter the highest expected measurement value. The HP 70110A digital multimeter will select the lowest range capable of measuring the entered value.

Measurement Resolution

Integration Time

Measurement resolution is changed by increasing or decreasing the integration time of the measurement. Increasing the integration time reduces measurement noise. Decreasing integration time permits faster readings. The integration time is dependent on the power line frequency and is expressed in number of power line cycles (NPLC). There are six integration times available; 100 PLC, 10 PLC, 1 PLC, 0.1 PLC, 0.005 PLC, and 0.0005 PLC. The greater the PLC number, the quieter and more accurate the reading will be and the slower the measurement speed. The default is 1 PLC.

To change the integration time, NPLC:

1. Press the `Setup` softkey.
2. Press the `NPLC aprture` softkey.
3. Press the appropriate key from the right-hand menu.

   This right-hand menu also shows the actual aperture time of the integration in seconds.

Autozero

With autozero on, the HP 70110A digital multimeter internally disconnects the input signal after each measurement and takes a zero reading. It then subtracts the zero reading from the preceding measurement. This minimizes the effects of offset voltages present on the HP 70110A digital multimeter's input circuitry from affecting measurements. The default is for autozero to be on. With autozero off, the HP 70110A digital multimeter takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time there is a function or range change. Turning autozero off results in faster readings and reduced measurement accuracy.

To turn autozero off:

1. Press the `Setup` softkey.
2. Press the `more 1 of 2` softkey.
3. Press the `ZEROING AUTOOFF` softkey.

   Successive pressing of the last key will toggle between the autozero on and autozero off conditions. The current state of autozero will be shown by underlining of AUTO or OFF.

Offset Compensation

With offset compensation on, the HP 70110A digital multimeter compensates for small extraneous voltages on the 30 Ω through 3 kΩ ranges. Offset compensation does not function on the higher ranges, (30 kΩ through 3 GΩ). The HP 70110A digital multimeter compensates for offset by, first measuring the offset voltage. Next, it sources current and measures the combination of the induced and offset voltages. The HP 70110A digital multimeter then subtracts the offset voltage from the combined voltage leaving only the induced voltage. The induced voltage is then used to determine the resistance; resistance = voltage ÷ current. Table 2-3 shows the maximum offset voltage that can be present on offset compensated

measurements for the various ranges. Also shown are the resulting combined voltages. You can use offset compensation for both 2-wire and 4-wire ohms measurements. Turning offset compensation on is crucial for measurement accuracy when the offset voltage is an appreciable percentage of the combined voltage. Leaving offset compensation off results in faster readings. The default is for offset compensation to be off.

Table 2-3. Maximum Offset Voltage

Range	Maximum Offset for Full Scale Measurements	Maximum Combined Voltage
30 Ω	0.001 V	0.0303 V
300 Ω	0.01 V	0.303 V
3 kΩ	0.1 V	3.03 V

To turn offset compensation on:

1. Press the Setup softkey.
2. Press the more 1 of 2 softkey.
3. Press the OFFCOMP ON OFF softkey.

Successive key presses of this last key will toggle offset compensation between the on and off conditions. The current state of offset compensation will be shown by underlining either ON or OFF.

Number of Digits Displayed

The HP 70110A digital multimeter allows you to reduce or increase the number of digits displayed on screen. You can choose a display of $3\frac{1}{2}$, $4\frac{1}{2}$, $5\frac{1}{2}$, or $6\frac{1}{2}$ digits. The $\frac{1}{2}$ digit refers to the most significant digit, which is limited to a value of 0, 1, 2, or 3. The default number of digits displayed is $6\frac{1}{2}$, (most significant digit plus 6 digits).

Note	The HP 70110A digital multimeter will only display the useful resolution of the measurement. For example, if you choose a short integration time which results in $3\frac{1}{2}$ digits of resolution the HP 70110A digital multimeter will display a maximum of $3\frac{1}{2}$ digits regardless of the number of digits you have requested.

To select the number of digits to be displayed:

1. Press the Setup softkey.
2. Press the #digits display softkey.
3. Press the appropriate key from the right-hand menu.

Current

The HP 70110A digital multimeter measures current by, first placing an internal shunt resistor across the input terminal, (see Table 2-4 for shunt resistor values). Next, the HP 70110A digital multimeter measures the voltage induced across the shunt resistor. Then the HP 70110A digital multimeter calculates the current flowing through the shunt resistor using the equation; current = voltage ÷ resistance.

Table 2-4. Shunt Resistor Values

DCI		ACI	
Range	Shunt Resistor	Range	Shunt Resistor
300 μA	1000 Ω	30 mA	10 Ω
3 mA	100 Ω	300 mA	1 Ω
30 mA	10 Ω	2 A	0.1 Ω
300 mA	1 Ω		
2 A	0.1 Ω		

DC Current

Press Measure then DCI.

AC Current

Press Measure then ACI. While active, successive pressing of the ACI key will toggle between ac and dc coupling and show the present setting as either AC ONLY or AC + DC.

Input Connections

Figure 2-2 shows the front terminal connections for measuring dc, ac, or ac+dc current.
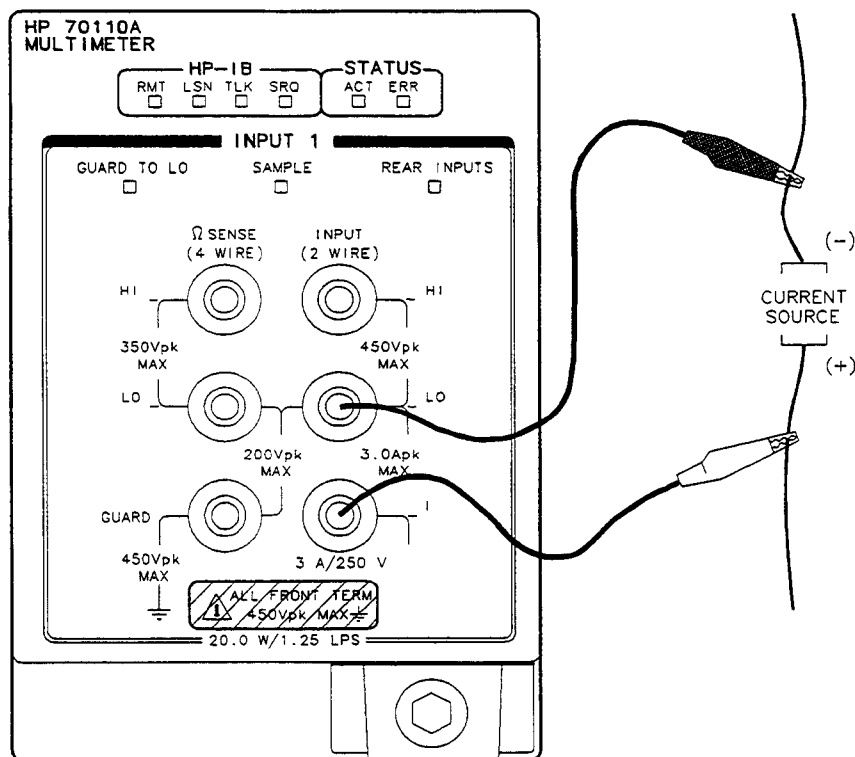
pnb7a

Figure 2-2. Front Terminal Connections for Current

Pressing Setup then FR REAR allows you to toggle between front and rear inputs.

Note

When using one of the optional multiplexers (Option 001 or Option 002)
this key reads INPUT FR SCAN . For Option 001, channels 8 and 9 are for current measurements only.

Range Selection

The HP 70110A digital multimeter Auto-Range feature automatically selects the appropriate range for the current being measured. The Auto-Range feature is disabled by selecting Manual Ranging. There are five dc current measurement ranges available: 300 μA, 3 mA, 30 mA, 300 mA, and 2 A. There are three ac current measurement ranges: 30 mA, 300 mA, and 2 A. The default range is Auto-Range.

To select Manual Ranging and maintain the present range:

1. Press the Setup softkey.
2. Press the RANGE AUTOMAN softkey.

RANGE

Successive key presses of AUTOMAN will toggle between Auto-Range and Manual Ranging. The current condition will be shown by underlining of either AUTO or MAN.

To select Manual Ranging and change the range:

1. Press the Setup softkey.
2.   RANGE

   Press the AUTOMAN softkey.
3. Use the (⬆) or (⬇) keys to select the proper range.
4. Use the RPG to select the proper range.
5. Use the number keys to enter the highest expected measurement value. The HP 70110A digital multimeter will select the lowest range capable of measuring the entered value.

Measurement Resolution

Integration Time

Measurement resolution is changed by increasing or decreasing the integration time of the measurement. Increasing the integration time reduces measurement noise. Decreasing integration time permits faster readings. The integration time is dependent on the power line frequency and is expressed in number of power line cycles (NPLC). There are six integration times available: 100 PLC, 10 PLC, 1 PLC, 0.1 PLC, 0.005 PLC, and 0.0005 PLC. The greater the PLC number, the quieter and more accurate the reading will be and the slower the measurement speed. The default is 1 PLC.

To change the integration time, NPLC:

1. Press the Setup softkey.
2.   NPLC

   Press the aprture softkey.
3. Press the appropriate key from the right-hand menu.

   This right-hand menu also shows the actual aperture time of the integration in seconds.

Autozero

With autozero on, the HP 70110A digital multimeter internally disconnects the input signal after each measurement and takes a zero reading. It then subtracts the zero reading from the preceding measurement. This minimizes the effects of offset voltages present on the HP 70110A digital multimeter's input circuitry from affecting measurements. The default is for autozero to be on. With autozero off, the HP 70110A digital multimeter takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time there is a function or range change. Turning autozero off results in faster readings and reduced measurement accuracy.

To turn autozero off:

1. Press the Setup softkey.
2.   more

   Press the 1 of 2 softkey.

3.   ZEROING
Press the AUTOOFF softkey.

Successive pressing of the last key will toggle between the autozero on and autozero off
conditions. The current state of autozero will be shown by underlining of AUTO or OFF.

AC Bandwidth

When making ac current measurements, you can select either a slow or fast mode. The slow
mode is for signals below 400 Hz. In the slow mode, a longer time constant is used for the
input filter and a longer delay is used. The fast mode is for signals greater than or equal to
400 Hz and allows you to make a series of measurements in a shorter amount of time.

To select the fast ac mode:

1. Press the Setup softkey.
2.   more
Press the 1 of 2 softkey.
3.   AC BNWD
Press the FASTSLO softkey.

Successive key presses of the last key will toggle between the fast and slow ac modes. The
present condition of ac bandwidth will be shown by underlining of either FAST or SLO.

Frequency and Period

The HP 70110A digital multimeter can make frequency measurements on ac voltage signals
from 10 Hz to 1.5 MHz, or period measurements from 100 msec to 667 nsec. Frequency and
period are the only functions that have constant resolution; always seven digits.

AC Voltage Frequency

Press Measure then ACV:FRQ .

AC Voltage Period

Press Measure then ACV:PER .

Input Connections

For frequency and period measurements the signal is connected to the INPUT HI and LO
terminals. This is true for both front and rear terminal operation. When using one of the
optional multiplexers, (options 001 and 002), the input is connected to the HI and LO inputs
of a particular channel.

Note	For Option 001, channels 8 and 9 are for current measurements only.

Pressing `Setup` then `INPUT FR REAR` allows you to toggle between front and rear inputs.

Range Selection

The HP 70110A digital multimeter Auto-Range feature automatically selects the appropriate range to measure the voltage applied. Manual ranging is not available when making frequency or period measurements.

AC Bandwidth

When making ac frequency or period measurements, you can select either a slow or fast mode. The slow mode is for signals below 400 Hz. In the slow mode, a longer time constant is used for the input filter and a longer delay is used. The fast mode is for signals greater than or equal to 400 Hz and allows you to make a series of measurements in a shorter amount of time.

To select the fast ac mode:

1. Press the `Setup` softkey.
2. Press the `more 1 of 2` softkey.
3. Press the `AC BNWD FASTSLO` softkey.

Successive key presses of the last key will toggle between the fast and slow ac modes. The present condition of ac bandwidth will be shown by underlining of either FAST or SLO.

Triggering Measurements

The HP 70110A digital multimeter must be triggered by some event before it can make a measurement. The default triggering event for front panel operation is automatic triggering. (Refer to Chapter 8.)

Automatic Trigger

Automatic triggering causes the HP 70110A digital multimeter to make a measurement whenever it is not busy doing something else, (for example, performing a remotely generated task).

To select automatic triggering:

1. Press the `Trigger` softkey.
2. Press the `AUTO` softkey.

External Trigger

External triggering allows the user to synchronize the HP 70110A digital multimeter measurement with other instruments or devices. The external trigger is achieved through the rear panel BNC connector, EXT TRIG, at TTL level trigger signals. The HP 70110A digital multimeter will take one measurement for each trigger received.

To select external triggering:

1. Press the `Trigger` softkey.
2. Press the `EXTRNL` softkey.

Single Trigger

Single triggering allows the user to manually trigger a single event from the front panel of the HP 70110A digital multimeter. One measurement is performed with each press of a key.

To select single triggering:

1. Press the `Trigger` softkey.
2. Press the `SINGLE` softkey.

   Successive presses of the `SINGLE` key results in a single measurement per keystroke.

Burst Measurements

The HP 70110A digital multimeter can perform multiple readings per measurement for all three types of trigger events described above. In addition, the time between each reading in a burst measurement can be specified. The default for readings per trigger event is 1. The default time between readings (when the timer is activated) is 1.0 second.

To select the number of readings per trigger:

1. Press the `Trigger` softkey.
2.   `RDNGS/`
   Press the `TRIGGER` softkey.
3. Use the (⇑) or (⇓) keys to select the proper number of readings per trigger.
4. Use the RPG to select the proper number of readings per trigger.
5. Use the number keys to enter the number of readings per trigger.

To place a timing delay between the readings in a multiple reading per trigger mode:

1. Press the `Trigger` softkey.
2.   `TIMER`
   Press the `ON OFF` softkey.
3. Use the (⇑) or (⇓) keys to select the timing delay between readings.
4. Use the RPG to select the timing delay between readings.
5. Use the number keys to enter the timing delay between readings.

External Trigger Level

For external triggering the HP 70110A digital multimeter can be configured to trigger on either the positive or negative edge of a TTL signal. The default condition is for the HP 70110A digital multimeter to externally trigger on a negative, or low going, TTL signal.

To change the polarity of the external triggering event:

1. Press the `Trigger` softkey.

2. Press the `EXT TRG POS NEG` softkey.

   Successive key presses of this last key will toggle the external trigger event from positive to negative. The present condition of this parameter will be shown by underlining either POS or NEG.

Math Operations

The HP 70110A digital multimeter's math operations manipulate or modify a measured reading before it is displayed, stored, or placed in the output buffer. In addition, there are two math operations (statistics and limit testing) that do not directly alter the reading, but store information pertaining to it.

The selected math operation is performed on every reading. If you change a measurement function, (for example, DCV to ACV), the math operations will be automatically turned off. However, other changes in settings will not affect the status of the math operation.

The HP 70110A digital multimeter allows multiple math operations to be in effect simultaneously. However, two limitations exist on the use of math operations. The first limitation is that only one math operation with units, (%, dB, dBm, °C), may be used at one time. If a math operation with units is enabled and another math operation with units is requested the first operation is turned off and the second activated. The second limitation is that dBm requires that a voltage measurement mode be active. Math operations are carried out in the order in which they are activated. The order in which the operations are being performed is shown, on screen, in parenthesis to the far right of each individual math operation.

Null

The Null operation subtracts a value from each subsequent measurement. The equation is:

Result = Reading − Offset

where:

Reading is any measurement after Null is turned on. **Offset** is a value selected by the user.

A possible application of the Null operation is in making more accurate 2-wire ohms measurements. To do this, select 2-wire ohms (see the section *Resistance* in this chapter) and short the ends of the test leads together. Now enable the Null operation. The first reading taken (the lead resistance) is stored in the Offset register. Connect the test leads to the unknown resistance to be measured. The multimeter subtracts the test lead resistance from each resistance measurement, thus the effects of the test lead resistance are eliminated.

To activate the null math operation:

1. Press the Math softkey.
2. Press the NULL ON OFF softkey.
3. Use the (⇑) or (⇓) keys to select the offset.
4. Use the RPG to select the offset.
5. Use the number keys to enter the offset.

Scale

The Scale operation modifies readings by multiplying by a scale factor. The equation is:

Result = Reading × Scale

where:

Reading is any measured value. **Scale** is a value selected by the user.

To activate the scale math operation:

1. Press the Math softkey.
2. Press the SCALE ON OFF softkey.
3. Use the (⇑) or (⇓) keys to select the scale factor.
4. Use the RPG to select the scale factor.
5. Use the number keys to enter the scale factor.

To perform a division:

1. Enter the reciprocal of the divisor (1/divisor).

    The equation becomes:

    Result = Reading × (1 ÷ Scale)

    For example, suppose you want to divide by 2. The reciprocal of 2 is 1/2 = 0.5. enter the value 0.5 as your scale value.

Percent

The percent math operation determines the difference, in percent, between a measured reading and the value in the Percent register. The equation is

Result = [(Reading − Reference) ÷ Reference] × 100

where:

Reading is any measure value. **Reference** is a value selected by the user.

To determine the difference (in percent) between an ideal value and the measured value:

1. Activate the percent math operation.
2. Enter the ideal value (10) in the Percent register.
3. Measure the dc voltage.

    If the measurement is exactly 10 Vdc, the HP 70110A digital multimeter displays a 0. If the measurement is, for example, 10.1 Vdc, the result becomes:

Result = [(10.1 -10) ÷ 10] × 100 = 0.01 × 100 = 1

The HP 70110A digital multimeter display shows 1, indicating the measured value is 1% higher than the ideal value.

This example uses the percent math operation to determine the percent error of a 10 Vdc voltage measurement.

To activate the percent math operation:

1. Press the Math softkey.
2.
          PERCENT

   Press the ON OFF softkey.
3. Use the ⬆ or ⬇ keys to select the percent value.
4. Use the RPG to select the percent value.
5. Use the number keys to enter the percent value.

dB

The dB math operation calculates a ratio in decibels. The equation is:

Result = 20 × $\log_{10}$(**Reading** ÷ **Reference**)

where:

Reading is any measured value. **Reference** is the value selected by the user.

To determine an amplifier's voltage gain:

1. Measure the input voltage to the amplifier and store that value.
2. Enable the dB math operation.
3. Measure the amplifier's output voltage.

   The gain of the amplifier is calculated and displayed in dB. For example, if the input voltage is 0.1 V and the output voltage is 10 V, the gain is:

   $20 \times \log_{10}(10/0.1) = 20 \times \log_{10}100 = 40$ dB

To activate the dB math operation:

1. Press the Math softkey.
2.
          dB

   Press the ON OFF softkey.
3. Use the ⬆ or ⬇ keys to select the reference value.
4. Use the RPG to select the reference value.
5. Use the number keys to enter the reference value.

dBm

The dBm math operation calculates the power delivered to a resistance, referenced to 1 mW. The equation is:

Result $= 10 \times \log_{10}(\text{Reading}^2/\text{Resistance}/1\ \text{mW})$

where:

Reading is any measure value. **Resistance** is the resistance value entered by the user.

To determine the input power to a loudspeaker:

1. Enter the speaker's impedance (for this example, assume 8 Ω).
2. Enable the dBm operation.
3. Measure the input voltage to the speaker.

   The HP 70110A digital multimeter calculates and displays the input power. For example, if the input voltage is 10 V, the power is:

   $10 \times \log_{10}(10^2/8/1\ \text{mW}) = 40.97\ \text{dBm}$

To activate the dBm math operation:

1. Press the Math softkey.
2.
   dBm
   Press the ON OFF softkey.
3. Use the (⬆) or (⬇) keys to select the resistor value.
4. Use the RPG to select the resistor value.
5. Use the number keys to enter the resistor value.

Note The dBm math operation function will only activate when the measurement mode is volts. Thus, if ON OFF (dBm) is pressed and the multimeter is not in a voltage mode then a menu showing the softkeys DCV , ACV , and ACV+DC will be displayed for the user to chose a mode of measurement. After a selection is made the previous menu will be shown and the user can activate the dBm operation by pressing ON OFF (dBm). Once the dBm math operation has been activated, if the measurement mode is changed from volts, then the dBm math operation will automatically be turned OFF.

Temperature

The HP 70110A digital multimeter can measure temperature using either a thermistor or an Resistance Temperature Detector (RTD). You can make thermistor and RTD measurements using either a 2-wire or 4-wire configuration. See *HP Application Note 290* for practical temperature measurement information. The following thermistor types are supported by the HP 70110A digital multimeter: (2252 Ω, 5 kΩ, and 10 kΩ). For RTD measurements the following RTD types are supported: (0.00385 $\Omega/\Omega/°C$ and 0.00392 $\Omega/\Omega/°C$). Figure 2-3 shows the proper way to configure 4-wire thermistor and RTD temperature measurements.
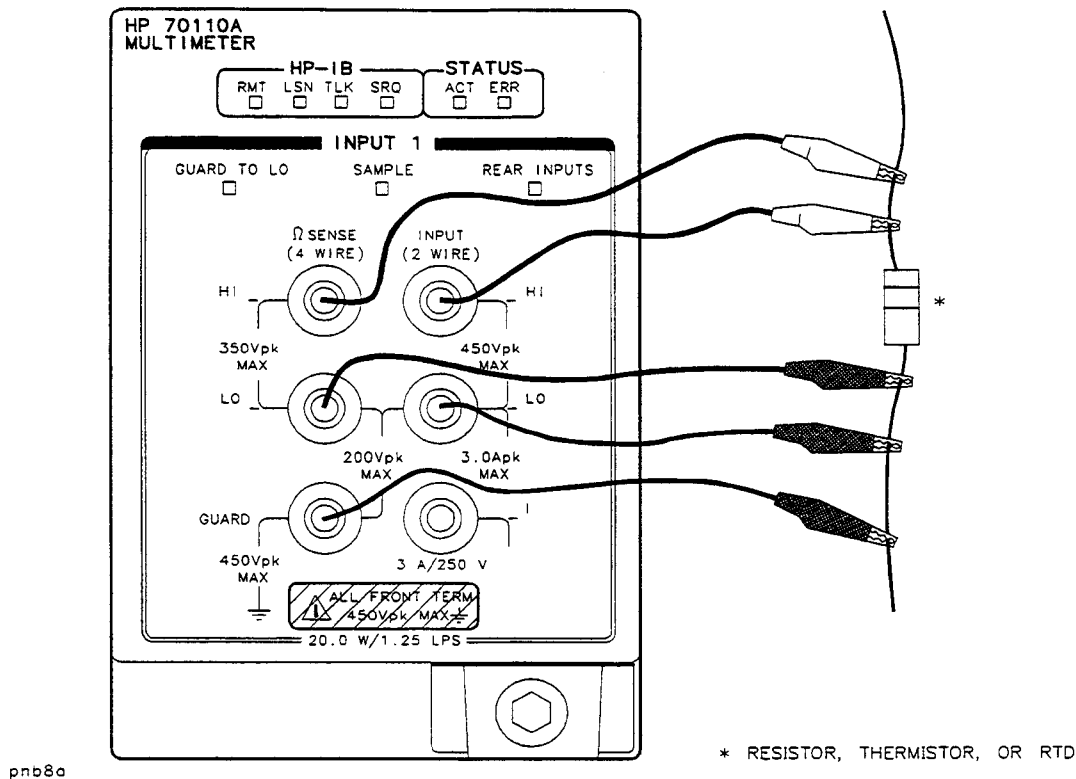
Figure 2-3. 4-Wire Thermistor or RTD Temperature Measurement

To activate the temperature measurement math operation:

1. Press the Math softkey.

2. Press the more 1 of 2 softkey.

3. Press the TEMP softkey.

4. Choose the appropriate temperature probe from among the right-hand menu choices.

Note	The temperature measurement math functions will only activate when the measurement mode is OHMS. Thus, if the measurement mode is not OHMS, when the TEMP ON OFF softkey is pressed, a submenu showing the two softkeys OHMS 2-WIRE and OHMS 4-WIRE will be activated. Now, choose one of these measurement modes and the previous menu will appear and the appropriate temperature probe can be chosen. Once temperature has been activated, if the measurement mode is changed from OHMS, then the temperature measurement will automatically be turned OFF.

Math On/Off

The HP 70110A digital multimeter allows the front panel user to turn on and off all of the math operations which manipulate or modify a measured value with a single math menu key.
The `MATH ON OFF` key does not alter the on and off conditions of the individual math operations. It turns off the entire sequence without altering the setup. This allows the math setup to be saved. For example, if a measurement function is changed, (which automatically turns math off), you can reinstate the previous math setup by merely turning math back on.

To turn math on and off:

1. Press the `Math` softkey.
2. Press the `MATH ON OFF` softkey.

Note

If a math mode has not previously been on, then pressing `MATH ON OFF` will have no effect on the multimeter. If the dBm math operation (measurement mode in volts) or the temperature math operation (measurement mode in ohms) have been on but then the measurement mode is changed to a noncompatible mode then the math operation (dBm or temperature) has been turned OFF and pressing `MATH ON OFF` will have no effect.

Statistics

The `STAT` math operation performs five running calculations on the present series of measurements and stores the results. The calculations are: standard deviation, average, number of readings, maximum reading (largest magnitude), and minimum reading (lowest magnitude). Any change in measurement mode or instrument setting that changes the resolution of the readings will automatically turn this function OFF.

To illuminate statistics:

1. Press the `Math` softkey.
2. Press the `more 1 of 2` softkey.
3. Press the `STAT ON OFF` softkey.

The statistics values will be shown in the lower-right of the screen as:
   StdDv:
   Avrge:
   #Rdgs:
   Max :
   Min :

Limit Testing

Limit testing allows measured values to be tested against user supplied maximum and minimum acceptable limits. If a result is outside the user specified bounds a "Fail" warning is shown on screen along with numerical value of the failure. A change in measurement mode will turn this feature off. The current state of this function is shown by underlining of either ON or OFF.

To activate limit testing:

1. Press the `Math` softkey.
2. Press the `more 1 of 2` softkey.
3. Press the `LIM TST ON OFF` softkey.

To select the limit values for testing:

1. Press the `SET HGH LIMIT` or `SET LOW LIMIT` softkey.
2. Use the (⇑) or (⇓) keys to select the limit.
3. Use the RPG to select the limit.
4. Use the number keys to enter the limit. When one of the number keys is pressed then a menu showing the keys 10^9, 10^6, 10^3, `ENTER`, 10^{-3}, 10^{-6}, and 10^{-9} will appear for use in entering the user's chosen values.

   Pressing the `CLEAR FAILED` softkey clears the fail notification for limit testing.

State

The State menus allow the user to save or recall configurations for up to ten different configurations. The current instrument firmware revision can be identified. A complete instrument self test or a complete automatic calibration routine may be run. The display feature may be turned on and off.

To save the current configuration:

1. Press the `State` softkey.
2. Press the `save state` softkey.

   This brings up a submenu of softkeys `SAVE STATE N` that allows up to ten states, 0 through 9, to be saved.

To recall a previously saved configuration:

1. Press the `State` softkey.

2. Press the `recall state` softkey.

This brings up a submenu of softkeys `RECALL STATE N` that allows any of the ten states, 0 through 9, to be active.

To display the current instrument firmware revision on screen:

1. Press the `State` softkey.
2. Press the `ROM VERSION` softkey.

The revision information is displayed for approximately eight seconds and then blanks out.

To run the complete instrument self-test:

1. Press the `State` softkey.
2. Press the `SELF TEST` softkey.

This routine typically takes less than 15 seconds to run. At the completion of instrument self test the user is provided with either a passed or failed on screen message of the test outcome.

To run the complete instrument automatic calibration routine:

1. Press the `State` softkey.
2. Press the `AUTO CAL` softkey.

This routine typically takes less than 40 seconds to run. At the completion of the instrument self calibration the user is provided with either a passed or failed on screen message of the test outcome.

To turn the display feature of the HP 70110A digital multimeter on and off:

1. Press the `State` softkey.
2. Press the `DISPLAY ON OFF` softkey.

This feature is useful if a remote program has left the instrument in the display off mode and a local user desires access.

3

Remote Programming Tasks

This chapter is divided into three principal sections.

Using the Multimeter   This section uses typical examples to show how to use the multimeter. Refer to Chapter 9, *Configuring and Addressing* for information on connecting input signals to the multimeter. Table 3-1 lists the commands used in this section.

This section contains the following subsections:

- Programming Overview
- Making a Single Measurement
- Making a Burst of Measurements
- Making Multiple Burst Measurements
- Making Externally Triggered Measurements
- Maximizing Measurement Accuracy
- Maximizing Measurement Speed
- Synchronizing the Multimeter with the Computer
- Checking for Errors
- Additional Measurement Functions

Understanding the Multimeter   "Using the Multimeter" shows you how to make measurements using the MEASure and CONFigure commands without much detail about the parameters involved. This section describes the individual measurement parameters (range, resolution, integration time, and so forth) used to configure the multimeter for measurements and optimize its performance. You will also learn how to program the multimeter's trigger system and save entire multimeter configurations in memory.

This section is divided into the following subsections:

- Using MEASure and CONFigure
- Measurement Functions
- Multimeter Parameters
- Triggering the Multimeter
- Saving Multimeter Configurations

Using the Multiplexer Option   This section shows how to connect external wiring to the multiplexer option and how to program it. This section is divided into the following subsections:

- Connecting File (user) Wiring
- Making Scanning Multimeter Measurements
- Measuring from a Multiplexer Channel
- Scanning a Channel List
- Making Multiple Scans
- Making Multiple Paced Scans
- Making an Externally Triggered Scan
- Independent Multiplexer Operation

■ Multimeter Measurements using the Multiplexer

■ Using the Multiplexer

Note

Throughout this chapter, optional command parameters are shown enclosed in square brackets ([]). For additional information on any TMSL command discussed in this chapter, refer to Chapter 8.

Using the Multimeter

Table 3-1. Multimeter Commands

Command	Description
CALibration:ZERO:AUTO OFF|0|ON|1|ONCE	Enable/disable autozero mode.
CONFigure :<function> [<max.input>[,<resolution>]]	Configure multimeter for selected function, but do not initiate or make measurement.
FETCh?	Place stored readings in output buffer.
INITiate [:IMMediate]	Place multimeter in wait-for trigger state.
MEASure :<function>? [<max.input>[,<resolution>]]	Configure multimeter for selected function, initiate the measurement, and send reading to output buffer.
READ?	Place multimeter in wait-for trigger state; place readings in output buffer.
SAMPle :COUNt 1-16,777,215|MIN|MAX	Set number of readings/trigger.
SAMPle :SOURce IMM|TIM	Set pacing source.
SAMPle :TIMer 680 μs-2100s|MIN|MAX	Define period between readings.
SYSTem :ERRor?	Read error queue.
TRIGger :COUNt 1-16,777,215|MIN|MAX	Set number of triggers or scans.
TRIGger :DELay 1 μs-2100s|MIN|MAX	Set delay between trigger and start of measurement.
TRIGger :SOURce BUS|EXT|HOLD|IMM	Specify trigger source.

Programming Overview

The easiest way to make measurements is to use the MEASure or CONFigure command. All you have to do is specify a function, expected value, and resolution. Other measurement parameters (aperture time, integration time, trigger count, and so forth) are automatically set to default values for you. The example programs in this chapter use MEASure or CONFigure to make measurements.

Executing MEASure or CONFigure is equivalent to configuring the multimeter with a series of "low-level" commands. When using CONFigure, you can change the multimeter's default configuration by executing the low-level commands. Refer to "Understanding the Multimeter" for more information.

The example programs in this chapter are written in the HP BASIC program language using SCPI commands. The example programs assume that the multimeter is controlled from an HP 9000 Series 200/300 controller computer over the HP-IB (IEEE STd 488).

When using HP BASIC as the controller language, use the OUTPUT statement to send commands from the computer to the multimeter:

OUTPUT 722; "MEAS:VOLT:DC?"

The address specified (722) represents the HP-IB interface select code (7) plus the HP-IB address of the multimeter (22).

Use the ENTER statement to enter data from the multimeter into the computer:

ENTER 722; Rdg

Note	For simplicity, all example programs in this chapter use dc voltage as the measurement function.
	To select a different measurement function, simply replace the function parameter in the MEASure or CONFigure command. Refer to the last section in this chapter, *Additional Measurement Functions*, for additional information.

Making a Single Measurement

This example makes one dc voltage measurement using MEASure and sends the reading to the output buffer.

```
10 OUTPUT 722; "*RST"              Reset multimeter to its power on state.
20 OUTPUT 722; "MEAS:VOLT:DC?"     Configured multimeter and made dc voltage
                                   measurement; sent reading to output buffer.
30 ENTER 722; Rdg                  Enter reading into computer.
40 PRINT Rdg                       Display reading on computer.
50 END
```

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: Autorange (default).

Integration Time Selected: 1 power line cycle (default).

Resolution Selected: Based on function and range selected.

Making a Burst of Measurements

This example makes 100 dc voltage measurements using CONFigure and stores the readings in multimeter memory.

10 DIM Rdgs(1:100)	*Dimension computer array to store readings.*
20 OUTPUT 722; "*RST"	*Reset multimeter to its power on state.*
30 OUTPUT 722; "CONF:VOLT:DC"	*Configure multimeter for dc voltage measurements.*
40 OUTPUT 722; "SAMP:COUN 100"	*Specify 100 readings per trigger.*
50 OUTPUT 722; "INIT"	*place multimeter in wait-for-trigger state; store readings in multimeter memory when trigger is received.*
60 OUTPUT 722;"FETC?"	*place readings in output buffer.*
70 ENTER 722; Rdgs(*)	*Enter readings into computer.*
80 PRINT Rdgs(1), Rdgs(50)	*Display selected readings on computer.*
90 END	

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: Autorange (default).

Integration Time Selected: 1 power line cycle (default).

Resolution Selected: Based on function and range selected.

Setting the Sample Count: The CONFigure command automatically sets the sample count (for example, the number of readings per trigger) to

1. The SAMPle:COUNt command sets the sample count to 100 in this example. You can specify up to 16,777,215 measurements per trigger using SAMPle:COUNt.

Using Multimeter Memory: When the INITiate command follows CONFigure, readings are stored in multimeter memory. The FETCh? command retrieves the readings from memory and places them in the output buffer. You can replace INITiate and FETCh? with the READ? command to place the readings directly in the output buffer (readings aren't stored in multimeter memory). However, when measurement speed is critical, store readings in multimeter memory using INITiate and FETCh?.

Multimeter Memory Capacity: The multimeter module has enough memory to store 16,384 readings. Each reading stored is eight bytes long.

Making Multiple Burst Measurements

This example makes three burst measurements and each burst consists of 10 readings. All readings are stored in multimeter memory (INITiate command). For this example, the maximum expected value of the input signal is specified as 8.25 Vdc. Based on this value, the multimeter automatically selects the 30 Vdc range.

`10 DIM Rdgs(1:30)`	*Dimension computer array to store readings.*
`20 OUTPUT 722; "*RST"`	*Reset multimeter to its power-on state.*
`30 OUTPUT 722; "CONF:VOLT:DC 8.25"`	*Configure multimeter for dc voltage measurements; specify fixed range.*
`40 OUTPUT 722; "TRIG:SOUR EXT"`	*Trigger source is external BNC on multimeter rear panel.*
`50 OUTPUT 722; "TRIG:COUN 3"`	*Multimeter will accept three external triggers (10 readings are taken per trigger).*
`60 OUTPUT 722; "SAMP:COUN 10"`	*Specify 10 readings per trigger.*
`70 OUTPUT 722; "INIT"`	*place multimeter in wait-for-trigger state; store readings in multimeter memory when trigger is received.*
`80 OUTPUT 722; "FETC?"`	*place readings in output buffer.*
`90 ENTER 722; Rdgs(*)`	*Enter readings into computer.*
`100 PRINT Rdgs(10), Rdgs(20)`	*Display selected readings on computer.*
`110 END`	

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: 30 Vdc

Integration Time Selected: 1 power line cycle (default).

Resolution Selected: 10 μV (default based on 1 PLC integration time).

Setting the Sample Count: The CONFigure command sets the sample count (for example, the number of readings per trigger) to 1. The SAMPle:COUNt command sets the sample count to 10 in this example. You can specify up to 16,777,215 measurements per trigger using SAMPle:COUNt.

Trigger Source: The MEASure and CONFigure commands automatically set the trigger source to the multimeter's internal trigger. For this example, the trigger source is set to external (EXT).

Trigger Count: The TRIGger:COUNt command sets the number of triggers the multimeter will accept before returning to the idle state. In this example, the multimeter will accept three external triggers. The maximum trigger count is 16,777,215.

Making Externally Triggered Measurements

This example makes 10 dc voltage measurements when the multimeter's external trigger BNC connector is pulsed low. This examples uses CONFigure with the READ? command to send the readings directly to the output buffer.

10	DIM Rdgs(1:10)	*Dimension computer array to store readings.*
20	OUTPUT 722; "*RST"	*Reset multimeter to its power-on state.*
30	OUTPUT 722; "CONF:VOLT:DC"	*Configure multimeter for dc voltage measurements.*
40	OUTPUT 722; "TRIG:SOUR EXT"	*Trigger source is external BNC on multimeter front panel.*
50	OUTPUT 722; "SAMP:COUN 10"	*Specify 10 readings per trigger.*
60	OUTPUT 722; "READ?"	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
70	ENTER 722; Rdgs(*)	*Enter readings into computer.*
80	PRINT Rdgs(*)	*Display readings on computer.*
90	END	

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: Autorange (default).

Integration Time Selected: 1 power line cycle (default).

Resolution Selected: Based on function and range selected.

Trigger Source: The MEASure and CONFigure commands automatically set the trigger source to the multimeter's internal trigger. For this example, the trigger source is set to external (EXT). **Trigger Slope:** The TRIGger:SLOPe command determines which edge (rising or falling) of a signal input to the external trigger BNC connector will trigger the multimeter. At power-on or after a *RST (reset) command, the multimeter is triggered on the falling edge (NEG). The MEASure and CONFigure commands automatically set the trigger slope to NEG.

Setting the Sample Count: The CONFigure command sets the sample count (for example, the number of readings per trigger) to 1. The SAMPle:COUNt command sets the sample count to 10 in this example. You can specify up to 16,777,215 measurements per trigger using SAMPle:COUNt.

Output Buffer Capacity: The output buffer capacity is 1024 bytes. Therefore, 52 readings over HP-IB and 13 over HP-MSIB can be transferred to the output buffer at a time.

Maximizing Measurement Accuracy

This example shows the multimeter configuration required to make measurements with the greatest possible accuracy (this program takes approximately five seconds to return the reading to the computer).

10 OUTPUT 722; "*RST"	*Reset multimeter to its power-on state.*
20 OUTPUT 722; "CONF:VOLT:DC AUTO,MIN"	*Configure multimeter for dc voltage measurements; enable autoranging; request the best possible resolution (integration time is 1 PLC).*
30 OUTPUT 722; "SENS:VOLT:NPLC MAX"	*Set integration time to 100 PLCs.*
40 OUTPUT 722; "READ?"	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
50 ENTER 722; Rdg	*Enter reading into computer.*
60 PRINT Rdg	*Display reading on computer.*
70 END	

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: Autorange is specified.

Integration Time Selected: 100 power line cycles. The MIN parameter in the CONFigure command selects the best possible resolution for the range selected by autorange (this sets the integration time to 1 PLC). The SENSe:VOLTage:NPLC MAX command selects the best integration time available (100 PLCs).

Resolution Selected: Based on function and range selected (the MIN parameter selects the best possible resolution for the range selected by autorange).

Offset Compensation: When making resistance measurements (including RTD and thermistor measurements), you can often increase accuracy by enabling offset compensation.

Maximizing Measurement Speed

This example shows the multimeter configuration required to make measurements at the fastest possible rate (1,450 readings per second).

10 DIM Rdgs(1:500)	*Dimension computer array to store readings.*
20 OUTPUT 722; "*RST"	*Reset multimeter to its power-on state.*
30 OUTPUT 722; "CONF:VOLT:DC 8.25,MAX"	*Configure multimeter for dc voltage measurements; specify fixed range with the worst resolution.*
40 OUTPUT 722; "CAL:ZERO:AUTO OFF"	*Disable autozero.*
50 OUTPUT 722; "SAMP:COUN 500"	*Specify 500 readings per trigger.*
60 OUTPUT 722; "SAMP:SOUR TIM"	*Sample source is SAMPle:TIMer command.*

```
70 OUTPUT 722; "SAMP:TIM MIN"          Set minimum sample rate.
80 OUTPUT 722; "INIT"                  place multimeter in wait-for-trigger
                                       state; store readings in multimeter
                                       memory when trigger is received.

90 OUTPUT 722; "FETC?"                 place readings in output buffer.
100 ENTER 722; Rdgs(*)                 Enter readings into computer.
110 PRINT Rdgs(1), Rdgs(250)           Display selected readings on computer.
120 END
```

Comments

Measurement Function: dc voltage is the default function selected by MEASure and CONFigure.

Range Selected: 30 Vdc

Integration Time Selected: 0.0005 (default).

Resolution Selected: 10 mV. By specifying MAX resolution in the CONFigure command, the multimeter selects the worst resolution for the selected range.

Setting the Sample Count: The CONFigure command sets the sample count (for example, the number of readings per trigger) to 1. The SAMPle:COUNt command sets the sample count to 500 in this example. You can specify up to 16,777,215 measurements per trigger using SAMPle:COUNt.

Autozero: The CALibration:ZERO:AUTO command enables or disables the autozero mode. When autozero is ON, the multimeter makes a zero measurement (measurement with input disabled) following every measured reading and subtracts the zero measurement from the reading. This doubles the time required per reading. When autozero is OFF, the multimeter makes one zero measurement and subtracts this from all subsequent measurements. A new zero measurement is made whenever the function is changed.

Sample Rate: The SAMPle:TIMer command defines the period between readings in a burst when SAMPle:COUNt is greater than 1 and the SAMPle:SOURce is TIMer. By specifying MIN for SAMPle:TIMer, the multimeter uses 680 μs.

Using Multimeter Memory: When the INITiate command follows CONFigure, readings are stored in multimeter memory. The FETCh? command retrieves the readings from memory and places them in the output buffer. You can replace INITiate and FETCh? with the READ? command to place the readings directly in the output buffer (readings aren't stored in multimeter memory). However, when measurement speed is critical, store readings in multimeter memory using INITiate and FETCh?.

Multimeter Memory Capacity: The multimeter module has enough memory to store 16,384 readings. Each reading stored is eight bytes long.

Aperture Time: 10 μs (default). For maximizing measurement rate at different aperture time setting. See Table 8-5 fpr aperture settings and sample time intervals.

Synchronizing the Multimeter with the Computer

This example shows how an HP 9000 Series 200/300 controller computer can monitor the multimeter to determine when data is available. This allows the computer to perform other functions while the multimeter is making measurements. When the readings are available to be read, the computer stops its present task and enters the data.

10 DIM Rdgs(1:15)	*Dimension computer array to store readings*
20 OUTPUT 722; "*CLS"	*Clear all status registers.*
30 OUTPUT 722; "*SRE 16"	*Unmask the Message Available bit (bit 4) in the Status Byte Register,*
40 OUTPUT 722; "CONF:VOLT:DC"	*Configure multimeter for dc voltage measurements.*
50 OUTPUT 722; "TRIG:COUN 15"	*Multimeter will accept 15 internal triggers (one reading is taken per trigger).*
60 OUTPUT 722; "TRIG:DEL 1"	*Wait 1 second between each trigger and measurement.*
70 OUTPUT 722; "INIT"	*place multimeter in wait-for-trigger state; store readings in multimeter memory.*
80 OUTPUT 722; "FETC?"	*place readings in output buffer.*

While the multimeter is making measurements, the computer is monitoring the Message Available bit. The computer displays a message while it waits for the bit to be set.

90 WHILE NOT BIT(SPOLL(722),4)	*Monitor Message Available bit.*
100 DISP "Waiting for Data..."	*Display message.*
110 WAIT .5	*Display message for 0.5 seconds.*
120 DISP " "	*Clear display.*
130 WAIT 0.5	*Wait 0.5 seconds.*
140 END WHILE	*Enter readings into computer.*
150 ENTER 722; Rdgs(*)	
160 FOR I = 1 TO 15	*Display readings on computer.*
170 PRINT Rdgs(I)	
180 NEXT I	
190 END	

Comments

Using Multimeter Memory: When the INITiate command follows CONFigure, readings are stored in multimeter memory. The FETCh? command retrieves the readings from memory and places them in the output buffer. You can replace INITiate and FETCh? with the READ? command to place the

readings directly in the output buffer (readings aren't stored in multimeter memory). However, when measurement speed is critical, store readings in multimeter memory using INITiate and FETCh?.

Multimeter Memory Capacity: The multimeter module has enough memory to store 16,384 readings. Each reading stored is eight bytes long.

Trigger Count: The TRIGger:COUNt command sets the number of triggers the multimeter will accept before returning to the idle state. In this example, the multimeter will accept 15 internal triggers. The maximum trigger count is 16,777,215.

Trigger Delay: The TRIGger:DELay command sets the delay period between receipt of the trigger and the start of the measurements. You can set the delay to values between 1 μs and 2100 seconds.

Retrieving Readings from Memory: Readings are not retrieved from multimeter memory until all measurements are completed. The Message Available bit in the Status Byte Register is set when the first reading is retrieved from memory and is placed in the output buffer.

The data from only one command can be placed in the output buffer or in multimeter memory. Synchronizing the computer with the multimeter as shown in this example ensures that data is entered and printed before it is replaced by data from another command.

Checking for Errors

This example shows a way to check for errors as you program the multimeter. The program monitors the multimeter's Standard Event Status Register for an error condition. If no errors occur, the multimeter operates as programmed. If errors do occur, the multimeter interrupts the computer and the error codes and messages are read from the multimeter's error queue.

Configure multimeter and computer to send/receive error interrupt:

10 OUTPUT 722; "*CLS"	*Clear all status registers and the error queue.*
20 OUTPUT 722; "*SRE 32"	*Unmask the Event Status bit (bit 5) in the multimeter's Status Byte Register.*
30 OUTPUT 722; "*ESE 60"	*Unmask the multimeter error conditions in the multimeter's Standard Event Status Register (unmask bits 2, 3, 4, and 5).*
40 OUTPUT 722; "*ESR?"	*Read and clear Standard Event Status Register.*
50 ENTER 722; Esr	*Enter result.*
60 ON INTR 7 CALL Errmsg	*Call subprogram if error occurs.*
70 ENABLE INTR 7;2	*Enable computer to respond to service request interrupt.*

At this point, send commands for your specific application. In this example, we will make a measurement using the MEASure command:

80 OUTPUT 722; "MEAS:VOLT:DC?"	*Configure multimeter and make dc voltage measurement; send reading to output buffer.*

Monitor "Message Available" bit (bit 4) and "Standard Event Status Register" summary bit (bit 5) in the Status Byte Register:

90 REPEAT	*Reading Serial Poll (SPOLL) can*
100 Spoll_val = SPOLL(722)	*occasionally clear the interrupt be-*
110 UNTIL BINAND(Spoll_val,48)	*fore the computer can respond.*
120 IF BIT(Spoll_val,5) THEN CALL Errmsg	

Enter results from MEASure command:

130 ENTER 722; Reading	*Enter measurement result if no errors occur.*
140 PRINT Reading	*Display result on computer.*
150 END	

The following subprogram is executed if an error occurs while the multimeter is being configured or during the measurement:

```
500 SUB Errmsg              Dimension computer string array to
510   DIM Message$[256]     store error messages.
520   CLEAR 722             Clear multimeter to regain control.
530   B = SPOLL(722)        Execute a serial poll to clear the Service
                            Request bit in the Status Byte Register.
540   REPEAT                Read all error messages in the multi-
                            meter's error queue.
550     OUTPUT 722; "SYST:ERR?"   Read error queue.
560     ENTER 722; Code,Message$  Enter error code and message.
570     PRINT Code,Message$       print results.
580   UNTIL Code = 0        Clear all bits in the multimeter's Stan-
590   OUTPUT 722; "*CLS"    dard Event Status Register.
600   STOP
610 SUBEND
```

Comments

The Error Queue: As multimeter errors are detected, they are placed in its error queue. The error queue is first-in, first-out. This means that if several error messages are waiting in the queue,

each SYST:ERR? command will return the oldest error message, and that message will be deleted from the queue.

If the error queues fills to 12 entries, the last error in the queue is replaced with −350, "Too many errors". No additional errors are accepted by the queue until space becomes available using SYST:ERR?, or the queue is cleared using the *CLS command. When SYST:ERR? is sent while the error queue is empty, the multimeter responds with 0, "No error".

Overload Condition: An overload condition (for example, 9.9000000E+37) sets the Device Dependent Error bit in the Standard Event Status Register. In this example, an overload condition will interrupt the computer and execute the error subprogram. However, an overload does not generate an error message and 0, "No error" is displayed (if no other errors are in the error queue).

Additional Measurement Functions

For simplicity, all example programs in this chapter use dc voltage as the measurement function.

To select a different measurement function, simply replace the *function* parameter in the CONFigure or MEASure command. Table 3-2 lists the syntax statements for the MEASure and CONFigure commands.

Note	For additional information on the MEASure and CONFigure commands and their parameters, refer to Chapter 8.

Table 3-2. CONFigure and MEASure Syntax Statements

Command	Description
CONFigure[:SCALar]	
:CURRent	
:AC [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for ac current.
:ACDC [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for ac+dc current.
[:DC] [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for dc current.
:FRESistance [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for 4-wire ohms.
:RESistance [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for 2-wire ohms.
:TEMPerature <*transducer*>, <*type*>[,<*chan lst*>]	Configure multimeter for temperature.
[:VOLTage]	
:AC [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for ac voltage.
:ACDC [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for ac+dc voltage.
[:DC] [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for dc voltage.
:FREQuency [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for frequency.
:PERiod [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Configure multimeter for period.
CONFigure?	Query multimeter configuration.
MEASure[:SCALar]	
:CURRent	
:AC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make ac current measurement.
:ACDC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make ac+dc current measurement.
[:DC]? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make dc current measurement.
:FRESistance? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make 4-wire ohms measurement.
:RESistance? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make 2-wire ohms measurement.
:TEMPerature? <*transducer*>, <*type*>[,<*chan lst*>]	Make temperature measurement.
[:VOLTage]	
:AC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make ac voltage measurement.
:ACDC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make ac+dc voltage measurement.
[:DC]? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make dc voltage measurement.
:FREQuency? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make frequency measurement.
:PERiod? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]	Make period measurement.

Understanding the Multimeter

Using MEASure and CONFigure

The easiest way to make measurements is to use the MEASure or CONFigure command. All you have to do is specify a function, expected value, and resolution. Other measurement parameters (aperture time, integration time, trigger count, and so forth) are automatically set to default values for you.

Executing the MEASure or CONFigure command is equivalent to configuring the multimeter with the "low-level" commands shown in Table 3-3. When using CONFigure, you can change the multimeter's default configuration by executing the low-level commands. Refer to *Multimeter Parameters* and *Triggering the Multimeter*, later in this chapter, for more information on using the low-level commands.

Table 3-3. Default Configuration Using CONFigure or MEASure

Parameter	Command	Description
Function	[SENSe:]FUNCtion[:ON] "CURRent:AC" [SENSe:]FUNCtion[:ON] "CURRent:DC" [SENSe:]FUNCtion[:ON] "FREQuency" [SENSe:]FUNCtion[:ON] "FRESistance" [SENSe:]FUNCtion[:ON] "PERiod" [SENSe:]FUNCtion[:ON] "RESistance" [SENSe:]FUNCtion[:ON] "VOLTage:AC" [SENSe:]FUNCtion[:ON] "VOLTage:DC"	As specified by CONFigure.
Range	[SENSe:]CURRent:AC:RANGe [SENSe:]CURRent:[DC]:RANGe [SENSe:]RESistance:RANGE [SENSe:]VOLTage:AC:RANGe [SENSe:]VOLTage:[DC]:RANGe	As specified, or autorange.
Autozero	CALibration:ZERO:AUTO	ON (performs autozero after each measurement).
Input State	INPut:[STATe]	ON (connects input source).
Input Coupling	INPut:COUPling	ac voltage.
Integration Time	[SENSe:]CURRent:AC:NPLCycles [SENSe:]CURRent:[DC:]NPLCycles [SENSe:]RESistance:NPLCycles [SENSe:]VOLTage:AC:NPLCycles [SENSe:]VOLTage:[DC:]NPLCycles	1 Power Line Cycle (PLC), or based on specified resolution.
Aperture Time	[SENSe:]VOLTage:AC:APERture [SENSe:]VOLTage:[DC:]APERture [SENSe:]RESistance:APERture [SENSe:]VOLTage:AC:APERture [SENSe:]VOLTage:[DC:]APERture	16.7 ms (60 Hz) or 20 ms (50 Hz), or based on specified resolution.
Offset Compensation	[SENSe:]RESistance:OCOMpensated	OFF (useful for resistance measurements only).
Input Impedance	INPut:IMPedance:AUTO	ON (useful for dc voltage measurements only).
AC Bandwidth	[SENSe:]DETector:BANDwidth	Selects slow measurement mode (useful for ac voltage, frequency, and period measurements only).
Readings per Trigger	SAMPle:COUNt	1 reading.
Terminals	ROUTe:TERMinals	FRONT if no channel list specified. REAR if no channel list specified.
Trigger Source	TRIGger:SOURce	IMMediate (trigger signal is always true).
Trigger Count	TRIGger:COUNt	1 trigger.
Trigger Delay	TRIGger:DELay	Default (see Table 3-12)

Making Measurements Using MEASure

The MEASure command configures the multimeter to perform the specified measurement. However, unlike the CONFigure command, MEASure immediately makes the measurement and sends the readings to the output buffer. The only measurement parameters that you can control when using MEASure are function, range, and resolution (for example, the low-level commands cannot be used with MEASure).

You can configure the multimeter for the following functions: frequency, 4-wire resistance, period, temperature, 2-wire resistance, ac current, ac+dc current, dc current, ac voltage, ac+dc voltage, and dc voltage. The MEASure subsystem syntax follows.

```
MEASure[:SCALar]
    :CURRent
        :AC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :ACDC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        [:DC]? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
    :FRESistance? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
    :RESistance? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
    :TEMPerature? <transducer>,<type>[,<channel list>]
    [:VOLTage]
        :AC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :ACDC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        [:DC]? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :FREQuency? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :PERiod? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
```

The *expected value* parameter specifies the expected value of the input signal. The multimeter then selects the correct range. By

not specifying a value for the *expected value* parameter, or by substituting "AUTO" or "DEF", the multimeter selects the autorange mode.

By substituting "MIN" for the *expected value* parameter, the multimeter selects the minimum range available for that function. By substituting "MAX" for the *expected value* parameter, the multimeter selects the maximum range.

The *resolution* parameter specifies the desired resolution for the measurement. By not specifying a value for the *resolution* parameter, or by substituting "DEF", the multimeter selects a resolution of 1 power line cycle (PLC).

By substituting "MIN" for the *resolution* parameter, the multimeter selects the minimum resolution available for that function. By substituting "MAX" for the *resolution* parameter, the multimeter selects the maximum resolution.

Then *channel list* parameter specifies which multiplexer inputs are to be scanned for a measurement. The basic form of a channel list is (@101,102,104) where 101 refers to card 1, channel 1.

For temperature measurements, the *transducer* parameter specifies the transducer (RTD or thermistor) and *type* specifies the transducer type (5 kΩ thermistor, type 85 RTD, and so forth). Range and resolution parameters are not available for temperature measurements.

Note	For a complete listing of range and resolution values available for each function, refer to *Measurement Functions* later in this chapter.

Example: Making Measurements Using MEASure. The following program configures the multimeter to make a dc voltage measurement on the 30 V range with 1 mV resolution. The measurement is taken and the reading is sent to the output buffer as soon as the MEASure command is executed.

`MEAS:VOLT:DC? 8.25,1.0E-3`	*Function: dc voltage; range selected: 30 V; resolution selected: 1 mV; trigger source is immediate by default.*
`enter statement`	*Enter reading into computer.*

Making Measurements Using CONFigure

The CONFigure command configures the multimeter to perform the specified measurement but *does not* automatically make the measurement. Therefore, after initially configuring the multimeter, you can change the individual measurement parameters using low-level commands (Table 3-3).

You can configure the multimeter for the following functions: frequency, 4-wire resistance, period, temperature, 2-wire resistance, ac current, ac+dc current, DC current, ac voltage, ac+dc voltage, and dc voltage. The CONFigure subsystem syntax follows.

```
CONFigure[:SCALar]
    :CURRent
        :AC [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
        :ACDC [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
        [:DC] [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
    :FRESistance [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
    :RESistance [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
    :TEMPerature <transducer>,<type>[,<channel list>]
    [:VOLTage]
        :AC [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
        :ACDC [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
        [:DC] [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
        :FREQuency [<expected value>[,<resolution>]] [,<channel list>]] | [<channel list>]
        :PERiod [<expected value>[,<resolution>] [,<channel list>]] | [<channel list>]
```

The *expected value* parameter specifies the expected value of the input signal. The multimeter then selects the correct range. By not specifying a value for the *expected value* parameter, or by substituting "AUTO" or "DEF", the multimeter selects the autorange mode.

By substituting "MIN" for the *expected value* parameter, the multimeter selects the minimum range available for that function. By substituting "MAX" for the *expected value* parameter, the multimeter selects the maximum range.

The *resolution* parameter specifies the desired resolution for the measurement. By not specifying a value for the *resolution* parameter, or by substituting "DEF", the multimeter selects a resolution of 1 power line cycle (PLC).

By substituting "MIN" for the *resolution* parameter, the multimeter selects the minimum resolution available for that function. By substituting "MAX" for the *resolution* parameter, the multimeter selects the maximum resolution.

Then *channel list* parameter specifies which multiplexer inputs are to be scanned for a measurement. The basic form of a channel list is (@101,102,104) where 101 refers to card 1, channel 1.

For temperature measurements, the *transducer* parameter specifies the transducer (RTD or thermistor) and *type* specifies the transducer type (5 kΩ thermistor, type 85 RTD, and so forth). Range and resolution parameters are not available for temperature measurements.

Note	For a complete listing of range and resolution values available for each function, refer to *Measurement Functions* later in this chapter.

Making the Measurement. After the multimeter is configured with CONFigure, use the READ? command to place the multimeter in the wait-for-trigger state and send the readings to the output buffer when the trigger occurs. Or, use the INITiate[:IMMediate] command to place the multimeter in the wait-for-trigger state and store readings in multimeter memory when the trigger occurs.

The READ? and INITiate commands will make the measurement when executed if the trigger source is TRIGger:SOURce IMMediate. If the trigger source is changed after CONFigure is executed, the READ? and INITiate commands place the multimeter in the wait-for-trigger state. However, a measurement is not made until the trigger is received from the specified source. For more information on triggering, refer to *Triggering the Multimeter*.

Example: Making Measurements Using CONFigure. The following program makes eight 4-wire resistance measurements with the best possible resolution. The trigger source for the measurement is the multimeter's external trigger BNC connector. The expected value for each reading is approximately 2.5 kΩ. The readings are sent to the output buffer.

dimension array	*Dimension computer array.*
CONF:FRES 2.5E+3,MIN	*Function: 4-wire Ω range selected: 3 kΩ MIN resolution: 1 mΩ*
TRIG:SOUR EXT	*Trigger source is external trigger BNC connector on multimeter front panel.*
TRIG:COUN 8	*Multimeter will accept eight external triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Storing Readings in Memory

As described earlier, the INITiate command places the multimeter in the wait-for-trigger state and stores readings in multimeter memory. The multimeter has enough memory available to store up to 16,384 readings. Readings stored in memory from previous commands are replaced by the new readings.

Storing readings in multimeter memory using the INITiate command is

faster than sending readings to the output buffer using the READ? command. Storing readings in memory also ensures that the period between readings is constant.

Example: Storing Readings in Memory. The following program makes eight dc voltage measurements. The trigger source for the measurement is the multimeter's external trigger BNC connector. The expected value for each reading is approximately 25 volts. The readings are stored in multimeter memory.

dimension array	*Dimension computer array.*
CONF:VOLT:DC 25,MAX	*Function: dc voltage; range selected: 30 V; MAX resolution: 10 mV (for fastest measurements).*
TRIG:SOUR EXT	*Trigger source is external trigger BNC connector on multimeter front panel.*
TRIG:COUN 8	*Multimeter will accept 8 external triggers (one measurement is taken per trigger).*
INIT	*place multimeter in wait-for-trigger state; store readings in memory when trigger is received.*

Retrieving Readings From Memory

The FETCh? command retrieves readings stored in multimeter memory by the most recent INITiate command and places them in the output buffer. The following program shows how to use the FETCh? command.

dimension array	*Dimension computer array.*
CONF:VOLT:DC 25,MAX	*Function: dc voltage; range selected: 30 V; MAX resolution: 10 mV (for fastest measurements).*
TRIG:SOUR EXT	*Trigger source is external trigger BNC connector on multimeter front panel.*
TRIG:COUN 8	*Multimeter will accept 8 external triggers (one measurement is taken per trigger).*
INIT	*place multimeter in wait-for-trigger state; store readings in memory when trigger is received.*
FETC?	*place readings in output buffer.*
enter statement	*Enter readings into computer.*

Measurement Data Format

Each reading sent to the output buffer consists of 17 bytes (characters) in Real ASCII format:

±1.23456789E ±123 LF

If multiple readings are returned by a command, the readings are separated by commas. A Line Feed (LF) and the HP-IB End-or-Identify (EOI) signal follow the last reading returned.

Overload Indication

The multimeter indicates an overload condition (input greater than the present range can measure) by sending 9.9000000E+37 to the output buffer instead of a reading. An overload condition sets the Device Dependent Error bit (bit 3) in the Standard Event Status Register. An overload condition also sets the appropriate bits in the Questionable Data/Signal Register:

Voltage Overrange - bit 0
Current Overrange - bit 1

Period Overrange - bit 2
Temperature Overrange - bit 4
Frequency Overrange - bit 5
Resistance Overrange - bit 9

An overload condition does not generate an error message. If no other errors are present in the error queue at the time of the overload, the multimeter responds with +0, "No error".

Note	If the inguard A/D converter does not respond to the multimeter's outguard, a reading of 9.9100000E+37 is returned. This reading, which is very similar to the overload indication, is sent to the output buffer after the multimeter's internal timeout occurs. This condition sets the Device Dependent Error bit (bit 3) in the Standard Event Status Register and places +1102, "A/D timeout" in the error queue.

The Output Buffer

The multimeter's output buffer capacity is 1024 bytes. The multimeter remains "busy" until you begin removing readings from the output buffer using your computer's enter statement. New data sent to the output buffer overwrites data sent from previous commands.

Measurement Functions

This section describes the measurement functions (ac voltage, 2-wire ohms, frequency, and so forth) and shows the ranges and resolution available for each. You can use the CONFigure, MEASure, and SENSe commands to select the measurement function. This section gives the complete command syntax statements for each function. Refer to Chapter 8 for detailed information on each command.

Voltage Measurements

The multimeter can make dc voltage, ac voltage, and ac+dc voltage measurements. Table 3-4 shows the voltage ranges and the resolution available for the various aperture times or integration times.

Table 3-4.
DC, AC, or AC+DC Voltage: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
30 mV	30.30000 mV	10 nV	10 nV	10 nV	100 nV	1 μV	10 μV
300 mV	303.0000 mV	100 nV	100 nV	100 nV	1 μV	10 μV	100 μV
3 V	3.030000 V	1 μV	1 μV	1 μV	10 μV	100 μV	1 mV
30 V	30.30000 V	10 μV	10 μV	10 μV	100 μV	1 mV	10 mV
300 V	303.0000 V	100 μV	100 μV	100 μV	1 mV	10 mV	100 mV

1 In 10 and 100 NPLC, more digits may be returned.
2 50 Hz aperture times are enclosed in parentheses.

DC Voltage Measurements. The multimeter can measure dc voltage from 30 mV to 300 V with resolution from 10 nV to 100 μV depending on aperture or integration time selected. dc voltage is the multimeter's power-on function.

Each of the following commands selects the dc voltage function:

```
MEASure[:VOLTage][:DC]? [<expected value>[,<resolution>][,<channel list>]]
CONFigure[:VOLTage][:DC] [<expected value>[,<resolution>][,<channel list>]]
[SENSe:]FUNCtion "VOLTage:DC"
```

AC and AC+DC Voltage Measurements. The multimeter can measure ac or ac+dc voltages in a bandwidth of 20 Hz to 1 MHz for all ranges. The multimeter uses a true RMS-to-dc converter for ac and ac+dc voltage measurements. It can measure the true RMS value of signals that are noisy, non-periodic, or non-sinusoidal such as sawtooth, triangle, and square waveforms. It also measures the true RMS value of low repetition rate, high crest factor (ratio of peak to RMS) pulse trains. In addition, the RMS-to-dc converter can measure any of these waveforms riding on a dc voltage level and can either include the dc level in the RMS value (ac+dc voltage measurements) or block the dc component (ac voltage measurements).

Each of the following commands selects the ac voltage function:

```
MEASure[:VOLTage]:AC? [<expected value>[,<resolution>][,<channel list>]]
CONFigure[:VOLTage]:AC [<expected value>[,<resolution>][,<channel list>]]
INPut:COUPling AC;[SENSe:]FUNCtion "VOLTage:AC"
```

Each of the following commands selects the ac+dc voltage function:

```
MEASure:VOLTage:ACDC? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:VOLTage:ACDC [<expected value>[,<resolution>][,<channel list>]]
INPut:COUPling DC;[SENSe:]FUNCtion "VOLTage:AC"
```

Current Measurements

The multimeter can make dc current, ac current, and ac+dc current measurements. Table 3-5 shows the current ranges and the resolution available for the various aperture times or integration times.

Table 3-5.
DC, AC, or AC+DC Current: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
300 μA[3]	303.0000 μa	100 pA	100 pA	100 pA	1 nA	10 nA	100 nA
3 mA[3]	3.030000 ma	1 nA	1 nA	1 nA	10 nA	100 nA	1 μA
30 mA	30.30000 ma	10 nA	10 nA	10 nA	100 nA	1 μA	10 μA
300 mA	303.0000 mA	100 nA	100 nA	100 nA	1 μA	10 μA	100 μA
3 A[4]	3.030000 A	1 μA	1 μA	1 μA	10 μA	100 μA	1 mA

1 In 10 and 100 NPLC, more digits may be returned.

2 50 Hz aperture times are enclosed in parentheses.

3 This range applies to dc current only.

4 Limited by internal fuse, 2 A rating.

DC Current Measurements. The multimeter can measure dc current from 300 μA to 2 A with resolution from 100 pA to 1 nA depending on aperture or integration time selected.

each of the following commands selects the dc current function:

```
MEASure:CURRent:DC? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:CURRent:DC [<expected value>[,<resolution>][,<channel list>]]
[SENSe:]FUNCtion "CURRent:DC"
```

AC and AC+DC Current Measurements. The multimeter can measure ac or ac+dc currents in a bandwidth of 20 Hz to 1 MHz for all ranges. The multimeter uses a true RMS-to-dc converter for ac and ac+dc current measurements. It can measure the true RMS value of signals that are noisy, non-periodic, or non-sinusoidal such as sawtooth, triangle, and square waveforms. It also measures the true RMS value of low repetition rate, high crest factor (ratio of peak to RMS) pulse trains. In addition, the RMS-to-dc converter can measure any of these waveforms riding on a dc current level and can either include the dc level in the RMS value (ac+dc current measurements) or block the dc component (ac current measurements).

Each of the following commands selects the ac current function:

```
MEASure:CURRent:AC? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:CURRent:AC [<expected value>[,<resolution>][,<channel list>]]
INPut:COUPling AC;[SENSe:]FUNCtion "CURRent:AC"
```

Each of the following commands selects the ac+dc current function:

```
MEASure:CURRent:ACDC? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:CURRent:ACDC [<expected value>[,<resolution>][,<channel list>]]
INPut:COUPling DC;[SENSe:]FUNCtion "CURRent:AC"
```

Resistance Measurements

The multimeter can make 2-wire and 4-wire resistance measurements. Table 3-6 shows the resistance ranges and the resolution available for the various aperture times or integration times.

Table 3-6.
2-Wire or 4-Wire Ohms: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 µs (100 µs) .005 PLCs	10 µs (10 µs) 0.0005 PLCs
30 Ω	30.30000 Ω	10 µΩ	10 µΩ	10 µΩ	100 µΩ	1 mΩ	10 mΩ
300 Ω	303.0000 Ω	100 µΩ	100 µΩ	100 µΩ	1 mΩ	10 mΩ	100 mΩ
3 kΩ	3.030000 kΩ	1 mΩ	1 mΩ	1 mΩ	10 mΩ	100 mΩ	1 Ω
30 kΩ	30.30000 kΩ	10 mΩ	10 mΩ	10 mΩ	100 mΩ	1 Ω	10 Ω
300 kΩ	303.0000 kΩ	100 mΩ	100 mΩ	100 mΩ	1 Ω	10 Ω	100 Ω
3 MΩ	3.030000 MΩ	1 Ω	1 Ω	1 Ω	10 Ω	100 Ω	1 kΩ
30 MΩ	30.30000 MΩ	10 Ω	10 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ
300 MΩ	303.0000 MΩ	100 Ω	100 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
3 GΩ	3.030000 GΩ	1 kΩ	1 kΩ	1 kΩ	10 kΩ	100 kΩ	1 MΩ

1 In 10 and 100 NPLC, more digits may be returned.

2 50 Hz aperture times are enclosed in parentheses.

The multimeter measures resistance by sourcing a known current through the unknown resistance being measured. The current passing through the resistance generates a voltage across the resistance. The multimeter measures this voltage and calculates the unknown resistance (*resistance = voltage/current*). Table 3-7 shows the nominal current sourced on each range for both 2-wire and 4-wire measurements.

Note

The offset compensation function prevents small external offset voltages from affecting 2-wire and 4-wire resistance measurements. Refer to *Offset Compensation*, later in this chapter, for more information.

Table 3-7. Resistance Range versus Current Sourced

Range	Current Sourced
30 Ω	1 mA
300 Ω	1 mA
3 kΩ	1 mA
30 kΩ	100 µA
300 kΩ	10 µA
3 MΩ	1 µA
30 MΩ	100 nA
300 MΩ	100 nA[1]
3 GΩ	100 nA[1]

1 Current source is in parallel with 10 MΩ resistor.

2-Wire Resistance Measurements. Use the 2-wire resistance function in applications where the test lead resistance is not critical. Since the multimeter measures the total resistance between its terminals, lead resistance that is large relative to the unknown resistance will

cause inaccurate measurements. Therefore, for all resistance measurements and especially those on the lower ranges, make the test leads as short as possible.

Each of the following commands selects the 2-wire resistance function:

```
MEASure:RESistance? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:RESistance [<expected value>[,<resolution>][,<channel list>]]
[SENSe:]FUNCtion "RESistance"
```

4-Wire Resistance Measurements. The 4-wire resistance function eliminates the measurement error caused by test lead resistance. In the 2-wire mode, the voltage measurement is made across the combined resistance of the test wiring and the unknown resistance. In the 4-wire mode, the voltage is measured across the unknown resistance only, not the combined resistance. The 4-wire resistance function is essential when the greatest accuracy is required, especially when the test lead resistance is high in comparison to the resistance being measured.

Each of the following commands selects the 4-wire resistance function:

```
MEASure:FRESistance? [<expected value>[,<resolution>][,<channel list>]]
CONFigure:FRESistance [<expected value>[,<resolution>][,<channel list>]]
[SENSe:]FUNCtion "FRESistance"
```

Frequency and Period Measurements

The multimeter's frequency and period counter accepts ac voltage or ac+dc voltage as inputs. You must specify whether the input is ac-coupled or dc-coupled using the INPut:COUPling command. The multimeter can make frequency measurements from 10 Hz to 1.5 MHz or period measurements from 100 ms to 667 ns.

Each of the following commands selects the frequency function (ac-coupled):

```
MEASure[:VOLTage]:FREQuency? [<expected value>[,<resolution>][,<channel list>]]
CONFigure[:VOLTage]:FREQuency [<expected value>[,<resolution>][,<channel list>]];INPut:COUPling AC
INPut:COUPling AC;[SENSe:]FUNCtion "FREQuency"
```

Each of the following commands selects the frequency function (dc-coupled):

```
CONFigure[:VOLTage]:FREQuency [<expected value>[,<resolution>][,<channel list>]];INPut:COUPling DC
INPut:COUPling DC;[SENSe:]FUNCtion "FREQuency"
```

Each of the following commands selects the period function (ac-coupled):

```
MEASure[:VOLTage]:PERiod? [<expected value>[,<resolution>][,<channel list>]]
CONFigure[:VOLTage]:PERiod [<expected value>[,<resolution>][,<channel list>]];INPut:COUPling AC
INPut:Coupling AC;[SENSe:]FUNCtion "PERiod"
```

Each of the following commands selects the period function (dc-coupled):

```
CONFigure[:VOLTage]:PERiod [<expected value>[,<resolution>][,<channel list>]];INPut:COUPling DC
INPut:COUPliing DC;[SENSe:]FUNCtion "PERiod"
```

Temperature Measurements

The multimeter can measure temperature using either thermistors or RTDs. The MEASure and CONFigure commands return all temperature measurements in degrees Celsius.

Thermistor Measurements. The following thermistor types are supported by the MEASure and CONFigure commands: 2252 Ω, 5 kΩ, and 10 kΩ. You can make thermistor measurements using either a 2-wire or 4-wire configuration.

Each of the following commands selects the 2-wire thermistor function (specify *type* as 2252, 5000, or 10000):

> MEASure:TEMPerature? THERmistor,<*type*>[,<*channel list*>]
> CONFigure:TEMPerature THERmistor,<*type*>[,<*channel list*>]

Each of the following commands selects the 4-wire thermistor function (specify *type* as 2252, 5000, or 10000):

> MEASure:TEMPerature? FTHermistor,<*type*>[,<*channel list*>]
> CONFigure:TEMPerature FTHermistor,<*type*>[,<*channel list*>]

RTD Measurements. The following RTD types are supported by the MEASure and CONFigure commands: 85 (0.00385 Ω/Ω/°C) and 92 (0.00392 Ω/Ω/°C). You can make RTD measurements using either a 2-wire or 4-wire configuration.

Each of the following commands selects the 2-wire RTD function (specify *type* as 85 or 92):

> MEASure:TEMPerature? RTD,<*type*>[,<*channel list*>]
> CONFigure:TEMPerature RTD,<*type*>[,<*channel list*>]

Each of the following commands selects the 4-wire RTD function (specify *type* as 85 or 92):

> MEASure:TEMPerature? FRTD,<*type*>[,<*channel list*>]
> CONFigure:TEMPerature FRTD,<*type*>[,<*channel list*>]

Multimeter Parameters

As described earlier in this chapter (Table 3-3), executing the MEASure or CONFigure command is equivalent to configuring the multimeter with a series of low-level commands. In addition to selecting a function, range, and resolution, these low-level commands configure the multimeter's analog-to-digital (A/D) converter and other portions of its measurement circuitry.

This section describes the low-level commands and the multimeter parameters that these commands control (for example, input terminals, ac bandwidth, frequency source, aperture and integration time, offset compensation, and so forth). Refer to Chapter 8 for detailed information on each low-level command discussed in this section.

Note	The low-level commands are most commonly used with the CONFigure and SENSe commands to change specific measurement parameters without completely reconfiguring the multimeter. Remember that the only parameters that can be changed when using MEASure are function, range, and resolution.

Enabling/Disabling the Input Terminals

The INPut:STATe <*mode*> command enables or disables the multimeter's input terminals. The input terminals are either connected (enabled) or open (disabled).

To enable the input terminals (this is the power-on state) send:

> INPut:STATe ON

To disconnect the HI, LO, Ω SENSE HI, and Ω SENSE LO terminals, send the following command. (The Guard, External Trigger, and Voltmeter Complete terminals are not affected by this command.)

    INPut:STATe OFF

Checking the Input Terminal State

The INPut:STATe? command returns a number to show whether the input terminals are connected or open: "1" = ON (connected), "0" = OFF (open). The number is sent to the output buffer.

Selecting Front or Rear Terminals

The ROUTe:TERMinals <mode> command selects which terminals are connected to the multimeter. Substituting "FRON" for the mode parameter connects only the front terminals to the multimeter and substituting "REAR" for the mode parameter connects only the rear panel option to the multimeter. This command has no effect on the INPut:STATe command which also must be "ON" to make a measurement with the multimeter.

Specifying the AC Bandwidth

For any type of ac measurement (ACV, ACDCV, ACI, ACDCI, FREQ, and PER), you should specify the ac fast or slow measurement mode. The slow mode is for frequencies below 400 Hz. In the slow mode, a longer time constant is used for the input filter in ACV and ACDCV and a longer settling time (delay) is used (compared to the fast mode) for ACV, ACDCV, ACI, ACDCI, FREQ, and PER. The fast mode is for signals above 400 Hz and uses a shorter time constant and delay time. Table 3-12 (later in this chapter in the *Default Delays* section) shows the measurement speeds used in the fast and slow modes. Table 3-8 shows the measurement speeds for ac measurements made in the fast or slow mode for the various integration times or aperture times.

Table 3-8. AC FAST versus Slow Mode (ACV or ACDCV)

Aperture Time[1]	Power Line Cycles	Readings per Second			
		Slow Mode		Fast Mode	
		60 Hz	50 Hz	60 Hz	50 Hz
10 μs (10 μs)	0.0005	1	1	9.5	9.5
100 μs (100 μs)	0.005	1	1	9.5	9.5
1.67 ms (2.0 ms)	0.1	1	1	9.25	9.2
16.7 ms (20.0 ms)	1	1	1	7.25	6.9
167 ms (200 ms)	10	0.7	0.65	2.0	1.7
1.67s (2.0s)	100	0.2	0.17	0.25	0.2

1 50 Hz aperture times are enclosed in parentheses.

The [SENSe:]DETector:BANDwidth <frequency> command selects the ac fast or slow mode. You specify *frequency* as the expected frequency of the input signal. The multimeter selects the slow mode (20 Hz is used) or fast mode (400 Hz is used) based on the frequency you specify. At power-on or after a *RST (reset), the slow mode is selected. (The MEASure and CONFigure commands automatically select the slow mode.)

If you specify a frequency value greater than or equal to 400 Hz, the multimeter selects the fast mode. If you specify a value less than 400 Hz, the multimeter selects the slow mode. For example, the following program statement selects the fast mode.

    SENSe:DETector:BANDwidth 5000

Note	If you are unsure of the input frequency, or if the frequency may dip below 400 Hz, use the slow mode. This takes slightly more time per measurement, but ensures accurate measurements.

Checking the AC Bandwidth

The SENSe:DETector:BANDwidth? [MINimum|MAXimum] command returns one of the following numbers to the output buffer:

- The present bandwidth (in hertz) selected by the multimeter (either 20 or 400) if MIN or MAX is not specified.

- The minimum bandwidth available (20) if MIN is specified.

- The maximum bandwidth available (400) if MAX is specified.

Specifying the AC Input Coupling Source

The INPut:COUPling <source> command selects the ac input coupling source for ac voltage, frequency, and period measurements.

To select ac voltage as the input coupling source (this is the power-on configuration), send:

    INPut:COUPling AC

To select ac+dc voltage as the input coupling source, send:

    INPut:COUPling DC

Note	To make ac+dc voltage or current measurements using the SENSe command, send the following command sequences: INPut:COUPling DC;SENSe:FUNCtion "VOLTage:AC" INPut:COUPling DC;SENSe:FUNCtion "CURRent:AC"

Checking the AC Input Coupling Source

The INPut:COUPling? command returns "AC" or "DC" to show the present ac input coupling source. The string is sent to the output buffer.

Autorange

When the autorange mode is enabled, the multimeter samples the input signal before each measurement and selects the appropriate range. At power-on, the autorange mode is enabled. Therefore, if you are measuring a fairly stable input signal, you can allow autorange to select the correct range and then disable autorange. This allows you to get the automatic range selection advantage of autorange and also the speed advantage of readings made with autorange disabled.

Each of the following commands enables or disables the autorange function for resistance, current, or voltage measurements:

    SENSe:RESistance:RANGe:AUTO <mode>
    SENSe:CURRent:AC:RANGe:AUTO <mode>
    SENSe:CURRent[:DC]:RANGe:AUTO <mode>
    SENSe:VOLTage:AC:RANGe:AUTO <mode>
    SENSe:VOLTage[:DC]:RANGe:AUTO <mode>

Substituting "OFF" for the *mode* parameter disables autoranging. Substituting "ON" for the *mode* parameter enables autoranging.

You have several ways to control the autorange mode when using the MEASure or CONFigure commands. Autorange is enabled if you substitute "AUTO" or "DEF" for the *expected value* parameter (or default the parameter). Autoranging is disabled if you specify a numeric value for the *expected value* parameter.

Checking the Autorange Setting

Each of the following commands returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

    SENSe:RESistance:RANGe:AUTO?
    SENSe:CURRent:AC:RANGe:AUTO?
    SENSe:CURRent[:DC]:RANGe:AUTO?
    SENSe:VOLTage:AC:RANGe:AUTO?
    SENSe:VOLTage[:DC]:RANGe:AUTO?

Specifying the Range

To specify a range without reconfiguring the multimeter by sending MEASure or CONFigure, you can use one of the commands shown below. For a complete listing of the range and resolution values available, see Table 3-4 and Table 3-6 earlier in this chapter.

    SENSe:RESistance:RANGe <expected value>
    SENSe:CURRent:AC:RANGe <expected value>
    SENSe:CURRent[:DC]:RANGe <expected value>
    SENSe:VOLTage:AC:RANGe <expected value>
    SENSe:VOLTage[:DC]:RANGe <expected value>

The *expected value* parameter specifies the expected value of the input signal. The multimeter then selects the correct range.

By substituting "MIN" for the *expected value* parameter, the multimeter selects the minimum range available for that function. By substituting "MAX" for the *expected value* parameter, the multimeter selects the maximum range.

Note   The multimeter indicates an overload condition (input greater than the present range can measure) by sending 9.9000000E+37 to the output buffer instead of a reading.

Checking the Range

You can use one of the following low-level commands to check the measurement range on the specified function.

```
SENSe:RESistance:RANGe? [MINimum|MAXimum]
SENSe:CURRent:AC:RANGe? [MINimum|MAXimum]
SENSe:CURRent[:DC]:RANGe? [MINimum|MAXimum]
SENSe:VOLTage:AC:RANGe? [MINimum|MAXimum]
SENSe:VOLTage[:DC]:RANGe? [MINimum|MAXimum]
```

These commands return one of the following numbers to the output buffer:

- The present range selected for the specified function if MIN or MAX is not specified.

- The minimum range available for the specified function if MIN is specified.

- The maximum range available for the specified function if MAX is specified.

Specifying the Resolution

To specify a resolution without reconfiguring the multimeter by sending MEASure or CONFigure, you can use one of the following commands. For a complete listing of the range and resolution values available, see Table 3-4 and Table 3-6 earlier in this chapter.

```
SENSe:RESistance:RESolution <resolution>
SENSe:CURRent:AC:RESolution <resolution>
SENSe:CURRent[:DC]:RESolution <resolution>
SENSe:VOLTage:AC:RESolution <resolution>
SENSe:VOLTage[:DC]:RESolution <resolution>
```

The *resolution* parameter specifies the desired resolution for the measurement. By substituting "MIN" for the *resolution* parameter, the multimeter selects the minimum resolution available for that function. By substituting "MAX" for the *resolution* parameter, the multimeter selects the maximum resolution.

Specify a resolution only when making measurements on a fixed range. Otherwise, the resolution will change to correspond to the range selected during autorange. Resolution also affects the reading rate. The better the resolution, the slower the reading rate.

Setting the resolution also sets the aperture time and integration time. Of these three parameters (resolution, aperture time, and integration time), the settings of the other two are based on the one most recently set. For example, specifying a resolution of 10 μV on the 3 V range (Table 3-4), sets a 1.67 ms aperture time and a 0.1 PLC integration time.

Checking the Resolution

You can use one of the following low-level commands to check the measurement resolution on the specified function.

```
SENSe:RESistance:RESolution? [MINimum|MAXimum]
SENSe:CURRent:AC:RESolution? [MINimum|MAXimum]
SENSe:CURRent[:DC]:RESolution? [MINimum|MAXimum]
SENSe:VOLTage:AC:RESolution? [MINimum|MAXimum]
SENSe:VOLTage[:DC]:RESolution? [MINimum|MAXimum]
```

These commands return one of the following numbers to the output buffer:

- The present resolution selected for the specified function and range if MIN or MAX is not specified.

- The minimum resolution available for the specified function and range if MIN is specified.

- The maximum resolution available for the specified function and range if MAX is specified.

Aperture and Integration Times

The multimeter samples the input signal being measured for a period of time (aperture time or integration time) based on the power line frequency. Aperture time is expressed in seconds and integration time is expressed in power line cycles (PLCs).

The integration time determines the measurement speed, accuracy, maximum digits of resolution, and the amount of normal-mode noise rejection (ability to reject noise at multiples of the power line frequency from the measurements). With longer integration times, the measurement resolution, accuracy, and normal-mode noise rejection increase, but measurement speed decreases.

Table 3-9 shows the relationship between the integration time in PLCs to the aperture time; the maximum number of digits; the reading rate; the ac normal-mode noise rejection (AC NMR); the ac effective common-mode noise rejection (AC ECMR); and the dc common-mode noise rejection (dc CMR) for dc measurements. Refer to Chapter 4 for accuracy specifications on each measurement function.

Table 3-9. A/D Converter Relationships

Aperture Time[1]	Power Line Cycles	Maximum Number of Digits[2]	Maximum Reading Rate[3]		Noise Rejection(dB)[4]		
			60 Hz	50 Hz	AC NMR	AC ECMR	DC CMR
10 μs (10 μs)	0.0005	3.5	1450	1450	0 dB	86	140
100 μs (100 μs)	0.005	4.5	1250	1250	0 dB	86	140
1.67 ms (2.0 ms)	0.1	5.5	360	312	0 dB	86	140
16.7 ms (20.0 ms)	1	6.5	56	47	60 dB	146	140
167 ms (200 ms)	10	6.5	4.9	4.0	80 dB	160	140
1.67s (2.0s)	100	6.5	0.49	0.4	90 dB	160	140

1 50 Hz aperture times are enclosed in parentheses.

2 Aperture times of 167 ms, 200 ms, 1.67s, and 2s may return extra digits of resolution.

3 Autozero off, autorange off, offset compensation off, fixed range, delay = 0.

4 With 1 kΩ imbalance in the LO lead and a power line frequency of 50 or 60 Hz (±0.08%).

Setting the aperture time or integration time also sets the resolution. Of these three parameters (aperture time, integration time, and resolution), the settings of the other two are based on the one most recently set. For example, specifying an aperture time of 1.67 ms sets the integration to 0.1 PLCs (the resolution selected is based on the present range). The MEASure and CONFigure commands set the integration time to 1 PLC and the aperture time to 16.7 ms (60 Hz) or 20 ms (50 Hz).

Note	Use the SYSTem:LFRequency command to select the line frequency reference (see Chapter 9).

Each of the following commands sets the aperture time (in seconds) for resistance, current, or voltage measurements.

    SENSe:RESistance:APERture <time>
    SENSe:CURRent:AC:APERture <time>
    SENSe:CURRent[:DC]:APERture <time>
    SENSe:VOLTage:AC:APERture <time>
    SENSe:VOLTage[:DC]:APERture <time>

By substituting "MIN" for the *time* parameter, the multimeter sets the aperture time to 10 μs. By substituting "MAX" for the *time* parameter, the multimeter sets the aperture time to 2.0 seconds.

Each of the following commands set the integration time (in PLCs) for resistance, current, or voltage measurements.

    SENSe:RESistance:NPLCycles <number>
    SENSe:CURRent:AC:NPLCycles <number>
    SENSe:CURRent[:DC]:NPLCycles <number>
    SENSe:VOLTage:AC:NPLCycles <number>
    SENSe:VOLTage[:DC]:NPLCycles <number>

By substituting "MIN" for the *number* parameter, the multimeter sets the integration time to 0.0005 PLCs. By substituting "MAX" for the *number* parameter, the multimeter sets the integration time to 100 PLCs.

To set the integration time for the fastest measurements (with the lowest accuracy, lowest resolution, and no normal-mode noise rejection), send:

    SENSe:VOLTage:DC:NPLCycles 0.0005

To specify the most accuracy, highest resolution, and 90 dB of normal-mode noise rejection (with the slowest measurement speed), send:

    SENSe:VOLTage:DC:NPLCycles 100

The remaining four settings (0.005, 0.1, 1, and 10 PLCs) provide flexibility in the selection of measurement speed, accuracy, resolution, and normal-mode noise rejection. Typically, you should select the integration time that provides adequate speed while maintaining an acceptable amount of accuracy, resolution, and normal-mode noise rejection.

Checking the Aperture and Integration Times

You can use the following commands to check the aperture time setting for resistance, current, or voltage measurements.

    SENSe:RESistance:APERture? [MINimum|MAXimum]
    SENSe:CURRent:AC:APERture? [MINimum|MAXimum]
    SENSe:CURRent[:DC]:APERture? [MINimum|MAXimum]
    SENSe:VOLTage:AC:APERture? [MINimum|MAXimum]
    SENSe:VOLTage[:DC]:APERture? [MINimum|MAXimum]

These commands return one of the following numbers to the output buffer:

- The present aperture time in seconds if MIN or MAX is not specified.

- The minimum aperture time available (10 μs) if MIN is specified.

- The maximum aperture time available (2.0 seconds) if MAX is specified.

You can use the following commands to check the integration time setting for resistance, current, or voltage measurements.

```
SENSe:RESistance:NPLCycles? [MINimum|MAXimum]
SENSe:CURRent:AC:NPLCycles? [MINimum|MAXimum]
SENSe:CURRent[:DC]:NPLCycles? [MINimum|MAXimum]
SENSe:VOLTage:AC:NPLCycles? [MINimum|MAXimum]
SENSe:VOLTage[:DC]:NPLCycles? [MINimum|MAXimum]
```

These commands return one of the following numbers to the output buffer:

- The present integration time in PLCs if MIN or MAX is not specified.

- The minimum integration time available (0.0005) if MIN is specified.

- The maximum integration time available (100) if MAX is specified.

The Autozero Function

The autozero function ensures that any offset errors *internal* to the multimeter are nulled from subsequent measurements. You can control the autozero function using the CALibration:ZERO:AUTO <*mode*> command. With autozero enabled, the multimeter internally disconnects the input signal and makes a zero reading following every measurement. It then subtracts the zero reading from the preceding measurement. This prevents offset voltages on the multimeter's internal circuitry from affecting measurements.

With autozero disabled, a new zero measurement is taken whenever you change the function, range, number of PLCs, input coupling source, or offset compensation mode. At power-on, the autozero function is enabled (CAL:ZERO:AUTO ON). The MEASure and CONFigure commands automatically enable autozero.

To disable the autozero function, send:

```
CALibration:ZERO:AUTO OFF or CALibration:ZERO:AUTO ONCE
```

Checking the Autozero Function

The CALibration:ZERO:AUTO? command returns a number to show whether the autozero mode is enabled or disabled: "1" = ON, "0" = OFF or ONCE. The number is sent to the output buffer.

Offset Compensation

You can use offset compensation for both 2-wire and 4-wire resistance measurements. Offset compensation allows the multimeter to make accurate resistance measurements in the presence of small *external* offset voltages on the 30Ω, 300Ω, and 3 kΩ ranges. Offset compensation does not function on the 30 kΩ through 3 GΩ ranges.

With offset compensation enabled, the multimeter measures the offset voltage prior to each resistance reading. Next, it sources a known current and measures the combination of induced voltage and offset voltage. The multimeter subtracts the offset voltage from the combined

voltage leaving only the induced voltage. The multimeter then uses this induced voltage to determine the resistance (*resistance = voltage/current*). Table 3-10 shows the maximum combined voltages that can be present for each range.

Table 3-10. Maximum Combined Voltages

Range	Maximum Offset for Full Scale Measurements	Maximum Combined Voltage
30 Ω	0.001 V	0.0303 V
300 Ω	0.01 V	0.303 V
3 kΩ	0.1 V	3.03 V

To enable offset compensation, send:

    SENSe:RESistance:OCOMpensated ON

To disable offset compensation (this is the power-on configuration), send:

    SENSe:RESistance:OCOMpensated OFF

Checking the Offset Compensation Setting

The SENSe:RESistance:OCOMpensated? command returns a number to show whether offset compensation is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Fixed Input Impedance

When making dc voltage measurements, you can fix the multimeter's input resistance using the INPut:IMPedance:AUTO <*mode*> command. This is useful to prevent a change in input impedance (caused by changing ranges) from affecting the measurements. Table 3-11 shows the input impedance values for the dc voltage ranges with fixed input impedance enabled (AUTO ON) and disabled (AUTO OFF).

Table 3-11. Input Impedances

mode Parameter	30 mV, 300 mV, 3 V DCV ranges	30 V, 300 V DCV ranges
OFF or 0	10 GΩ	10 MΩ
ON or 1	10 MΩ	10 MΩ

To enable the automatic input impedance mode (this is the power-on configuration), send:

    INPut:IMPedance:AUTO ON

With the fixed input impedance mode enabled, the multimeter's input impedance is 10 GΩ on the 30 mV, 300 mV, and 3 V ranges.

To disable the automatic input impedance mode, send:

    INPut:IMPedance:AUTO OFF

With the fixed input impedance mode disabled, the multimeter maintains its input impedance of 10 MΩ on all dc voltage ranges.

The automatic input impedance mode remains disabled (AUTO OFF) after you change from dc voltage measurements to 2-wire or 4-wire resistance measurements. This can affect the resistance measurements since the 10 MΩ resistance remains connected in parallel with the input terminals. Enable the automatic input impedance mode (AUTO ON) before selecting resistance measurements.

The automatic input impedance mode is temporarily enabled (AUTO ON) when you change from dc voltage measurements to ac voltage, ac+dc voltage, frequency, or period measurements. When you return the measurement function to dc voltages, automatic input impedance is again disabled (AUTO OFF).

Checking the Fixed Input Impedance Mode

The INPut:IMPedance:AUTO? command returns a number to show whether the automatic input impedance mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Triggering the Multimeter

This section discusses the multimeter's trigger system and outlines the different triggering configurations and programming methods used to control the trigger system. Keep in mind that you do not have to program the trigger system to make measurements. By using the default trigger configuration set by MEASure and CONFigure, you can avoid having to learn the information in this chapter. However, to take advantage of the flexibility of the multimeter's trigger system when using the CONFigure command, this chapter is the place to find that information.

The multimeter's trigger system synchronizes measurements with specified internal or external events. These events include software trigger commands and positive or negative edges on the multimeter's external trigger BNC connector. The trigger system also allows you to specify the number of triggers that will be accepted, the number of readings per trigger, and the delay between the trigger and the first reading.

Figure 3-1 summarizes the multimeter's trigger system and the programming commands that control the trigger system. Notice that the multimeter operates in one of two trigger states. When you are configuring the multimeter for measurements, the multimeter must be in the *idle* state. After configuring the multimeter, the multimeter must be placed in the *wait-for-trigger* state.
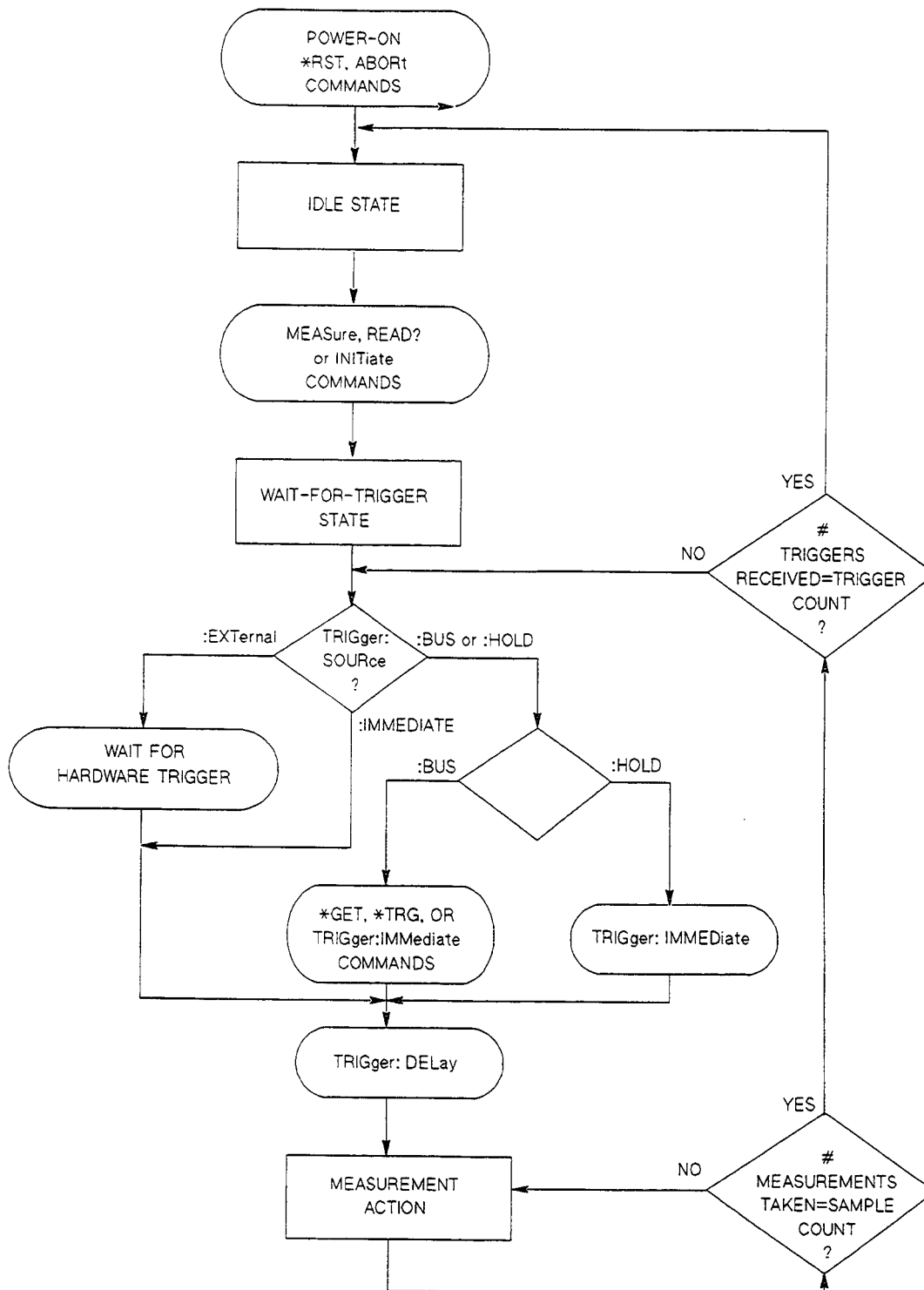
Figure 3-1. The Multimeter Trigger System

The Trigger Source

The TRIGger:SOURce <*source*> command configures the multimeter's trigger system to respond to the specified source. The following trigger sources are available:

- **BUS:** Trigger source is the HP-IB Group Execute Trigger (GET) or the * TRG common command. Within the HP 75000 Series C mainframes, the instrument whose trigger source is "BUS" and was the last instrument addressed to listen will respond to the HP-IB Group Execute Trigger. The * TRG is sent to a specific instrument (for example, OUTPUT 722; " * TRG").

- **EXTernal:** Trigger source is the multimeter's external trigger BNC connector. At power-on or after a * RST command, the falling (negative-going) edge of the input signal triggers the multimeter. Use the TRIGger:SLOPe command to change the trigger slope (see "The Trigger Slope" for more information).

- **HOLD:** Suspend triggering. After executing TRIGger:SOURce HOLD, only the TRIGger[:IMMediate] command will trigger the multimeter.

- **IMMediate:** Internal trigger is always present. If the multimeter is in the wait-for-trigger state (INITiate), TRIGger:SOURce IMMediate sends the trigger. The MEASure and CONFigure commands automatically set the trigger source to IMM. For example, the following program statement selects the external trigger BNC connector as the trigger source.

      TRIGger:SOURce EXTernal

You can change the trigger source only when the multimeter is in the idle state. Attempting to change the trigger source while the multimeter is in the wait-for-trigger state will generate the "Settings conflict" error.

Note	Do not confuse the levels of triggering commands containing the IMMediate parameter. The TRIGger:SOURce IMMediate command bypasses the trigger system so that the multimeter is triggered immediately if it is in the wait-for-trigger state. The TRIGger[:IMMediate] command (see *Sending a Single Trigger* later in this section) initiates a single trigger cycle after the trigger system has been disabled (the trigger source must be TRIGger:SOURce BUS or TRIGger:SOURce HOLD).

Checking the Trigger Source

The TRIGger:SOURce? command returns "BUS", "EXT", "HOLD", or "IMM" to show the present trigger source. The string is sent to the output buffer.

The Trigger Slope

The TRIGger:SLOPe <*edge*> command determines which edge (rising or falling) of a signal input to the external trigger BNC connector will trigger the multimeter. TRIGger:SLOPe POSitive selects the rising edge and TRIGger:SLOPe NEGative selects the falling edge (NEG is the power-on setting).

Checking the Trigger Slope

The TRIGger:SLOPe? command returns "NEG" or "POS" to show the present trigger slope. The string is sent to the output buffer.

The Trigger Count

The TRIGger:COUNt <*number*> command sets the number of triggers the multimeter will accept in the wait-for-trigger state before returning to the idle state. Use the *number* parameter to set the trigger count to a value between 1 and 16,777,215. The MEASure and CONFigure commands set the trigger count to 1.

Substituting MIN for the *number* parameter sets the trigger count to 1. Substituting MAX for the *number* parameter sets the trigger count to 16,777,215.

Example: Setting the Trigger Count. In the following example, one dc voltage measurement is made each time the multimeter's external trigger BNC connector is pulsed low (the default trigger slope is NEG). After 10 external triggers are received, the multimeter returns to the idle state.

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
TRIG:COUN 10	*Multimeter will accept 10 external triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Checking the Trigger Count

The TRIGger:COUNt? [MINimum|MAXimum] command returns one of the following numbers to the output buffer:

■ The present trigger count (1 through 16,777,215) if MIN or MAX are not specified.

■ The minimum trigger count available (1) if MIN is specified.

■ The maximum trigger count available (16,777,215) if MAX is specified.

Inserting a Trigger Delay

The TRIGger:DELay <*period*> command inserts a delay between the trigger and the first reading (Figure 3-2). After that, only the sample time interval (SAMPle:TIMer command) occurs between readings. The *period* parameter sets the delay to a value between 1 μs and 2100 seconds (with 1 μs resolution).

Substituting MIN for the *period* parameter sets the trigger delay to 1 μs. Substituting MAX for the *period* parameter sets the trigger delay to 2100 seconds.
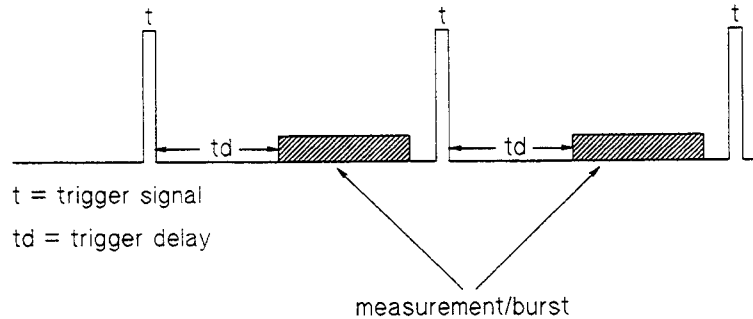
Figure 3-2. Inserting a Trigger Delay

Example: Inserting a Trigger Delay. In the following example, the multimeter will accept 5 triggers from the external trigger BNC connector. One measurement is taken per trigger (this is the default sample count) and the trigger delay is 2 seconds.

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
TRIG:COUN 5	*Multimeter will accept 5 external triggers (one measurement is taken per trigger).*
TRIG:DEL 2	*Wait 2 seconds between trigger and start of each measurement.*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Default Delays

If you do not specify a trigger delay, the multimeter automatically determines a delay time (default delay) based on the present measurement function, range, resolution, and ac bandwidth setting. The delay time is actually the settling time allowed before measurements which ensures accurate measurements. The default delay time is automatically updated whenever you change the function or range. Once you specify a delay time value, however, the value does not change until you specify another value or reset the multimeter. Table 3-12 shows the default delay times for all functions.

Note	You can specify a shorter delay time than the default values shown. However, the resulting settling time may not produce accurate measurements.

The values shown in Table 3-12 (for ac measurement functions) assume the range and function have been selected for at least one reading.

Whenever the range changes on an ac measurement function, the first reading after the change has an additional delay added to the default delay. This is shown in Table 3-13 Whenever you select an ac measurement function, an additional delay is added to the default delay before the first reading. This delay is shown in Table 3-14.

Table 3-12. Default Delay Times

Function	AC Bandwidth[1]	Range	Default Delay versus Aperture Time (seconds) or Integration Time (PLCs)[2]					
			1.67s (2.0s) 100 PLCs	167 ms (200 ms) 10 PLCs	16.7s (20.0s) 1 PLC	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
DCV		30 mV	0.56 ms	0.56 ms	0.56 ms	0.46 ms	0.39 ms	0.32 ms
DCV		300 mV– 300 V	0.35 ms	0.35 ms	0.35 ms	0.3 ms	0.25 ms	0.2 ms
DCI		Any	0.35 ms	0.35 ms	0.35 ms	0.3 ms	0.25 ms	0.2 ms
ACV	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
ACI	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
ACV	<400	Any	1s	1s	1s	1s	1s	1s
ACI	<400	Any	1s	1s	1s	1s	1s	1s
ACDCV	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
ACDCI	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
ACDCV	<400	Any	1 s	1 s	1 s	1 s	1 s	1 s
ACDCI	<400	Any	1 s	1 s	1 s	1 s	1 s	1 s
RES|FRES		30Ω	0.56 ms	0.56 ms	0.56	0.46 ms	0.39 ms	0.32 ms
RES|FRES		300Ω–30 kΩ	0.35 ms	0.35 ms	0.35 ms	0.3 ms	0.25 ms	0.2 ms
RES|FRES		300 kΩ	2.4 ms	2.4 ms	2.4 ms	2.0 ms	1.7 ms	1.3 ms
RES|FRES		3 MΩ	24 ms	24 ms	24 ms	20 ms	17 ms	13 ms
RES|FRES		30 MΩ–3 GΩ	240 ms	240 ms	240 ms	200 ms	170 ms	130 ms
FREQ	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
FREQ	<400	Any	1s	1s	1s	1s	1s	1s
PER	≥400	Any	100 ms	100 ms	100 ms	100 ms	100 ms	100 ms
PER	<400	Any	1 s	1 s	1 s	1 s	1 s	1 s

1 SENse:BANDwidth:DETector command.

2 50 Hz aperture times are enclosed in parentheses.

Table 3-13. Added Delay for Range Change

Function	AC Bandwidth[1]	Change to Range	Added Delay
ACV	≥ 400	30 mV	900 ms
ACV	≥ 400	300 mV	700 ms
ACV	≥ 400	Others	0 ms
ACV	< 400	30 mV	500 ms
ACV	< 400	Others	100 ms
ACDCV	≥ 400	Any	0 ms
ACDCV	< 400	Any	100 ms

1 SENSe:BANDwidth:DETector command.

Table 3-14. Added Delay for Function Change

Change to Function	AC Bandwidth[1]	Range	Delay
ACV	$\geq$ 400	30 mV	1000 ms
ACV	$\geq$ 400	300 mV	800 ms
ACV	$\geq$ 400	Others	100 ms
ACV	< 400	30 mV	800 ms
ACV	< 400	Others	400 ms
ACDCV	$\geq$ 400	Any	100 ms
ACDCV	< 400	Any	400 ms

1 SENSe:BANDwidth:DETector command.

Checking the Delay Time

The TRIGger:DELay? [MINimum|MAXimum] command returns one of the following numbers to the output buffer:

■ The present trigger delay (1 μs through 2100 seconds) if MIN or MAX is not specified.

■ The minimum trigger delay available (1 μs) if MIN is specified.

■ The maximum trigger delay available (2100 seconds) if MAX is specified.

The Sample Count

The SAMPle:COUNt <*number*> command designates the number of readings per trigger. The *number* parameter sets the number of readings to a value between 1 and 16,777,215. Substituting MIN for the *number* parameter sets the number of readings per trigger to 1. Substituting MAX for the *number* parameter sets the number of readings per trigger to 16,777,215.

Example: Setting the Sample Count. In the following example, 10 dc voltage measurements are made when the multimeter's external trigger BNC connector is pulsed low (the default trigger slope is NEG). After the 10 readings are taken, the multimeter returns to the idle state.

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
SAMP:COUN 10	*Specify 10 readings per trigger.*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Checking the Sample Count

The SAMPle:COUNt? [MINimum|MAXimum] command returns one of the following numbers to the output buffer:

■ The present sample count (1 through 16,777,215) if MIN or MAX are not specified.

■ The minimum sample count available (1) if MIN is specified.

■ The maximum sample count available (16,777,215) if MAX is specified.

The Sample Rate

When you set the sample count greater than 1 (for example, SAMPle:COUNt 10), the multimeter allows you to set the period between readings (sample rate). The SAMPle:SOURce <source> command selects the source which sets sample rate. The following sources are available:

- **IMMediate:** Initiate reading whenever multimeter is not busy. The MEASure and CONFigure commands automatically set SAMPle:SOURce to IMM.

- **TIMer:** Specify sample rate using the SAMPle:TIMer <period> command. The *period* parameter sets the sample rate to a value between 680 μs and 2100 seconds (with 1 μs resolution). Substituting MIN for the *period* parameter sets the sample rate to 680 μs. Substituting MAX for the *period* parameter sets the sample rate to 2100 seconds.

Note	To achieve the fastest sample rate, you must disable autoranging and autozero. Also, the sample rate will not be exact if autoranging is enabled.

The specified sample rate must be longer than the specified aperture time. Table 3-15 shows the minimum sample rates for each available aperture time setting.

Table 3-15. Aperture Times and Minimum Sample Rates

Aperture Time[1]	Minimum Sample Rate (SAMPle:TIMer)	Maximum Reading Rate (Readings/Second)
2.0 s	2.5 s	0.4
1.67s	2.04 s	0.49
200 ms	250 ms	4.0
167 ms	204 ms	4.9
20 ms	21.2 ms	47
1.67 ms	17.8 ms	56
2.0 ms	3.2 ms	312
1.67 ms	2.7 ms	360
100 μs	800 μs	1250
10 μs	680 μs	1450

1 Autozero off, fixed range.

Note	If the aperture time is longer than the sample rate, 2602 "Timer too fast" is stored in the error queue when the multimeter attempts to make the measurement.

Example: Setting the Sample Rate. In the following example, 10 readings are taken when the READ? command is executed (the trigger source is IMM by default). The aperture time is set to 2 ms to allow a sample rate of 10 ms (the 10 ms delay is inserted between each of the 10 readings).

dimension array	*Dimension computer array.*
CONF:VOLT:DC 8.25	*Function: ac volts; range selected: 30 V; default resolution: 10 μV.*

VOLT:APER 0.002	*Set aperture time to 2.0 ms.*
SAMP:COUN 10	*Specify 10 readings per trigger; trigger source is IMM by default.*
SAMP:SOUR TIM	*Sample source is SAMPle:TIMer command.*
SAMP:TIM 0.01	*Set 10 ms sample rate.*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Checking the Sample Source

The SAMPle:SOURce? command returns "IMM" or "TIM" to show the present sample source. The string is sent to the output buffer.

Checking the Sample Rate

The SAMPle:TIMer? [MINimum|MAXimum] command returns one of the following numbers to the output buffer:

■ The present sample rate (680 μs through 2100 seconds) if MIN or MAX are not specified.

■ The minimum sample rate available (680 μs) if MIN is specified.

■ The maximum sample rate available (2100 seconds) if MAX is specified.

The Wait-For-Trigger State

Before the multimeter will respond to a trigger signal, it must be moved from the idle state to the wait-for-trigger state. You can place the multimeter in the wait-for-trigger state using one of three methods:

1. Use the INITiate command explicitly.

2. Use the READ? command, which executes INITiate implicitly.

3. Use the MEASure command, which executes INITiate implicitly.

Note	The multimeter returns to the idle state following each trigger cycle or after the number of triggers specified by TRIGger:COUNt have occurred.

Example: Using INITiate Explicitly. In the following example, the CONFigure command configures the multimeter for dc voltage measurements. The trigger source is the multimeter's external trigger BNC connector (TRIGger:SOURce EXTernal). The INIT command places the multimeter in the wait-for-trigger state. When the external trigger occurs, the measurement is taken and the reading is stored in multimeter memory. The FETCh? command transfers the reading from memory to the output buffer.

CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
INIT	*place multimeter in wait-for-trigger state; store reading in multimeter memory when trigger is received.*
FETC?	*place reading in output buffer.*
enter statement	*Enter reading into computer.*

Example: Using INITiate Implicitly (READ?). In the following example, the CONFigure command configures the multimeter for dc voltage measurements. The trigger source is the multimeter's external trigger BNC connector (TRIGger:SOURce EXTernal). The READ? command places the multimeter in the wait-for-trigger state. When the external trigger occurs, the measurement is taken and the reading is sent to the output buffer.

`CONF:VOLT:DC`	*Function: dc voltage.*
`TRIG:SOUR EXT`	*Trigger source is external BNC on multimeter front panel.*
`READ?`	*place multimeter in wait-for-trigger state; make measurement when external trigger is received; send reading to output buffer.*
`enter statement`	*Enter reading into computer.*

Example: Using INITiate Implicitly (MEASure). In the following example, INITiate is executed by the MEASure command after configuring the multimeter for dc voltage measurements. The trigger source is IMM by default for the MEASure command. When MEASure is executed, the multimeter is placed in the wait-for-trigger state, the measurement is taken, and the reading is sent to the output buffer.

`MEAS:VOLT:DC?`	*Function: dc voltage; trigger source is IMM by default.*
`enter statement`	*Enter reading into computer.*

Sending a Single Trigger

The TRIGger[:IMMediate] command sends an immediate internal trigger if the multimeter is in the wait-for-trigger state. The readings are stored in multimeter memory following the trigger. The trigger source must be BUS or HOLD (see *The Trigger Source*).

Note	Do not confuse the levels of triggering commands containing the IMMediate parameter. The TRIGger:SOURce IMMediate command bypasses the trigger system so that the multimeter is triggered immediately if it is in the wait-for-trigger state. The TRIGger[:IMMediate] command initiates a single trigger cycle after the trigger system has been disabled.

Example: Sending a Single Trigger. In the following example, the CONFigure command configures the multimeter for dc voltage measurements. The trigger source is HOLD and the sample count is 10. When the TRIG command is executed the multimeter makes 10 dc voltage measurements and stores them in multimeter memory.

`dimension array`	*Dimension computer array.*
`CONF:VOLT:DC`	*Function: dc voltage.*
`TRIG:SOUR HOLD`	*Suspend triggering.*
`SAMP:COUN 10`	*Specify 10 readings per trigger.*
`INIT`	*place multimeter in wait-for-trigger state; store readings in memory when trigger is received.*
`TRIG`	*Trigger the multimeter.*
`FETC?`	*place readings in output buffer.*
`enter statement`	*Enter readings into computer.*

Trigger Buffering

The TRIGger:BUFFered <*mode*> command enables or disables the multimeter's trigger buffer and corrects for a "Trigger ignored" error. With trigger buffering disabled, any external trigger occurring during a reading generates a "Trigger ignored" error and the triggers are ignored.

To enable trigger buffering, send:

    TRIGger:BUFFered ON

With trigger buffering enabled, the first external trigger occurring during a reading is stored and no error is generated. After the reading is complete, the stored trigger satisfies the EXTernal trigger event if the multimeter is so programmed. However, a second trigger occurring during a reading does generate the "Trigger ignored" error.

To disable trigger buffering (this is the power-on state), send:

    TRIGger:BUFFered OFF

Checking the Trigger Buffer State

The TRIGger:BUFFered? command returns a number to show whether trigger buffering is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Aborting a Measurement

The ABORt command removes the multimeter from the wait-for-trigger state and places it in the idle state. ABORt can only be use with the following trigger sources: TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

If TRIGger:SOURce BUS is selected as the trigger source, ABORt returns the multimeter to the idle state. When a Group Execute Trigger (GET) bus command or *TRG common command is executed, the "Trigger ignored" error is generated.

If TRIGger:SOURce HOLD is selected as the trigger source, ABORt returns the multimeter to the idle state. All subsequent single triggers sent using TRIGger:IMMediate are ignored and the "Trigger ignored" error is generated.

Note	If TRIGger:SOURce EXT is selected as the trigger source and the multimeter is waiting for an external trigger, send the HP-IB CLEAR command to return to the idle state.

The multimeter generates a *voltmeter complete* signal after it has sampled the input for each reading. The *voltmeter complete* signal is always routed to the multimeter's rear panel "VM" BNC connector.

Saving Multimeter Configurations

You can store up to 10 different configurations in multimeter memory for later recall. The information stored includes:

Measurement Parameters:

- Function
- Range
- Autozero
- Input Terminals State
- Multiplexer Channels
- Integration Time
- Aperture Time
- Offset Compensation
- Input Impedance
- Input Coupling
- AC Bandwidth

Trigger Parameters:

- Trigger Source
- Trigger Count
- Trigger Delay
- Trigger Slope
- Trigger Buffering
- Sample Count
- Sample Source
- Sample Timer

The *SAV <*state number*> common command stores the present configuration in a numbered memory location (0 through 9). The stored configurations remain in memory until power is removed. The *RCL <*state number*> common command recalls the specified configuration from memory.

Example: Saving and Recalling a Configuration

The following example saves a configuration in memory location 2. The *RST command resets the multimeter to its power-on configuration. The stored configuration is then recalled using the *RCL command.

dimension array	*Dimension computer array.*
CONF:VOLT:DC 8.25	*Function: dc voltage; range selected: 30 V.*
VOLT:APER 1.67E-01	*Aperture time is 167 ms.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
TRIG:COUN 10	*Multimeter will accept 10 external triggers (one measurement is taken per trigger).*
*SAV 2	*Save configuration in memory location 2.*
*RST	*Reset multimeter.*
*RCL 2	*Recall configuration in memory location 2.*

READ?   *place multimeter in wait-for-trigger state; make measure-*
           ments when external trigger is received; send readings to
           output buffer.

enter statement   *Enter readings into computer.*

Using the Multiplexer Option

Connecting Field (user) Wiring

There is a wiring diagram in the middle of the rear panel of the multimeter. This diagram explains the rear terminal wiring for the connector at the right on the rear panel. (See Figure 3-3.)

pnb9a
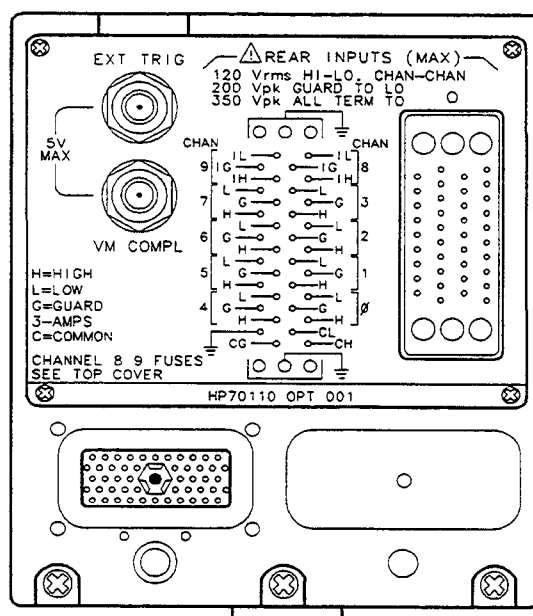
Figure 3-3. Rear Terminal Wiring for Option 001

In the 2-wire resistance function mode, the voltage measurement is made across the combined resistance of the test wiring and the unknown resistance (see Figure 3-4).
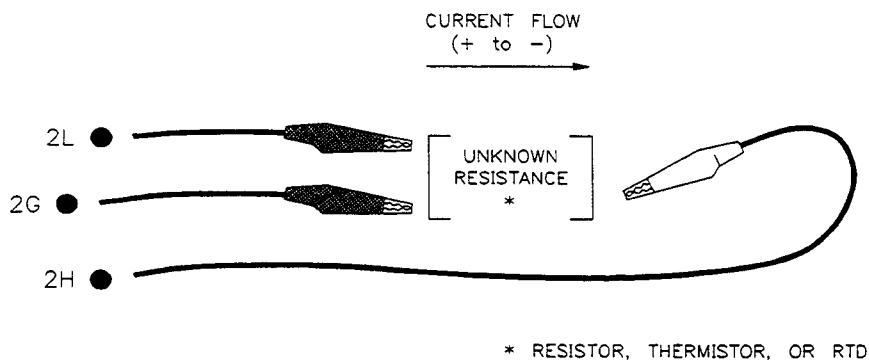
pnb10a

Figure 3-4. 2-Wire Connection Example for Channel 2

The 4-wire resistance function eliminates the measurement error caused by test lead resistance. In the 4-wire mode, the voltage is measured across the unknown resistance only, not the combined resistance. In 4-wire resistance mode the wiring terminals 4–7 are paired with the 0–3 terminals (see Figure 3-5).
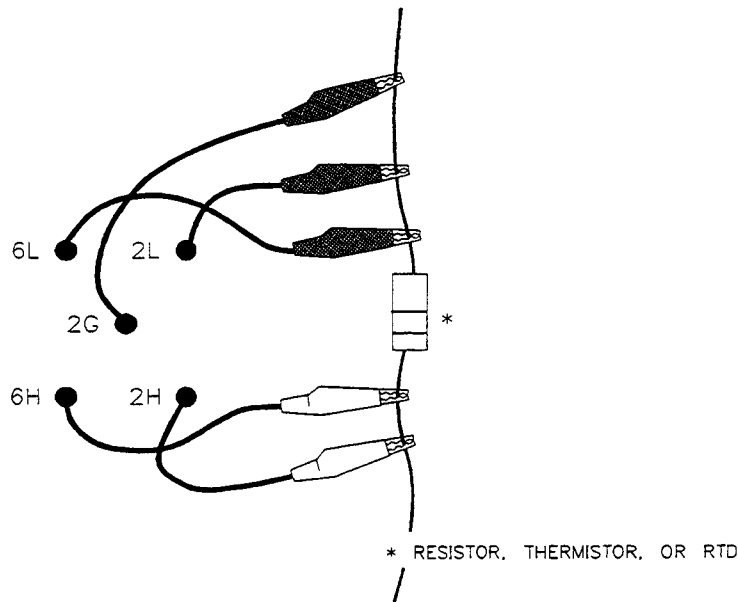
pnb11a

Figure 3-5. 4-Wire Connection Example for Channels 2 and 6

Making Scanning Multimeter Measurements

When a multiplexer option is installed, a channel list may be supplied with the CONFigure or MEASure command to select a particular channel or scan a range of channels. Depending on the option, channels may be used to specify a particular input connection as shown below.

Channels	Designations for Scanning Multiplexer
Option 001 (Relay/Actuator Card):	
0–7	Volts, 2-wire ohm
8–9	Current
10–13	4-wire resistance
Option 002 (Reed Relay Multiplexer):	
0–9	Volts, 2-wire ohm
10–14	4-wire resistance

Note

To open all channels regardless of current state use, ROUT:OPEN (@100:115) command for Option 001 and use ROUT:OPEN (@100:114) for Option 002.

Measuring from a Multiplexer Channel

This program measures dc voltage from a source connected to multiplexer channel 102.

```
CLEAR 722                          Clear the multimeter.
OUTPUT 722;"*RST"                  Reset the multimeter.
OUTPUT 722;"ROUT:TERM REAR"        Select the rear panel multiplexer.
OUTPUT 722;"MEAS:VOLT:DC? (@102)"  Configure the multimeter and make dc
                                   voltage measurement on channel 102.
ENTER 722;Rdg                      Enter and
PRINT Rdg                          display the reading on the computer
END
```

Scanning a Channel List

This program scans a channel list one time using the multimeter configuration set by the MEASure command.

```
DIM Rdgs(1:18)                        Dimension a computer array to store
                                      the readings.
CLEAR 722                             Clear the multimeter.
OUTPUT 722;"*RST"                     Reset the multimeter.
OUTPUT 722;"ROUT:TERM REAR"           Select the rear panel multiplexer.
OUTPUT 722;"MEAS:VOLT:DC? (@100:107)" Configure the multimeter and make dc
                                      voltage measurements on channels 100
                                      through 107.
ENTER 722;Rdgs(*)                     Enter and
FOR I=1 to 18                         display the readings
  PRINT Rdgs(I)                       on the computer.
NEXT I
END
```

Comments

■ The multimeter output buffer can hold 52 readings if the data is being transmitted over HP-IB or 13 readings if the data is being transmitted over HP-MSIB. When the buffer fills, measurements are suspended until readings are read from the buffer (by the computer) to make space available.

Making Multiple Scans

This program scans a channel list multiple times.

```
DIM Rdgs(1:20)                        Dimension a computer array to store
                                      the readings.
CLEAR 722                             Clear the multimeter.
OUTPUT 722;"*RST"                     Reset the multimeter.
OUTPUT 722;"ROUT:TERM REAR"           Select the rear panel multiplexer.
OUTPUT 722;"CONF:VOLT:DC (@100:103)"  Configure the multimeter for dc voltage
                                      measurements.
OUTPUT 722;" TRIG:COUN 5"             Scan the channel list five times.
```

```
OUTPUT 722:"READ?"                              Enter and
ENTER 722;Rdgs(*)
FOR I=1 to 20 STEP 4                            display the readings
  PRINT Rdgs(I),Rdgs(I+1),                      on the computer.
 Rdgs(I+2),Rdgs(I+3)
NEXT I
END
```

Comments

- For the scanning multimeter, CONFigure sets one scan (pass) through the channel list. The TRIGger:COUNt command can specify up to 16,777,215 scans.

- The multimeter makes one measurement per channel per scan.

- The multimeter output buffer can hold 52 readings if the data is being transmitted over HP-IB and 13 readings if the data is being transmitted over HP-MSIB. When the buffer fills, measurements are suspended until readings are read from the buffer (by the computer) to make space available.

Making Multiple Paced Scans

This program makes multiple scans through a channel list with the scans occurring at specified intervals.

```
DIM Rdgs(1:20)                          Dimension a computer array to store
                                        the readings.
CLEAR 722                               Clear the multimeter.
OUTPUT 722;"*RST"                       Reset the multimeter.
OUTPUT 722;"ROUT:TERM REAR"             Select the rear panel multiplexer.
OUTPUT 722;"CONF:VOLT:DC (@100:103)"    Configure the multimeter for dc voltage
                                        measurements.
OUTPUT 722;"TRIG:COUN 5"                Scan the channel list five times,
OUTPUT 722;"TRIG:DEL 2"                 with a two second delay between scans.
OUTPUT 722;"INIT"                       Store the readings in mainframe memory.
OUTPUT 722;"FETCH?"                     place readings in output buffer.
ENTER 722;Rdgs(*)                       Enter and
FOR I=1 to 20 STEP 4                    display the readings
  PRINT Rdgs(I),Rdgs(I+1),              on the computer.
 Rdgs(I+2),Rdgs(I+3)
NEXT I
END
```

Comments

- For the scanning multimeter, CONFigure sets one scan (pass) through the channel list. The TRIGger:COUNt command can specify up to 16,777,215 scans.

- The delay between scans is the delay between the trigger signal and the first channel in the list. There is no programmable delay between subsequent channels in the list. The trigger delay set by CONFigure is 0 seconds for the dc voltage function. The TRIGger:DELay command is used to set delays up to 16.7 seconds.

- When INIT follow CONFigure, the readings are stored in memory. FETCH? retrieves the readings and places them in the output buffer once all measurements are taken. Replace INIT and FETCH? with READ? returns the readings directly to the output buffer.

Making an Externally Triggered Scan

This example makes one scan through a channel list when the multimeter receives an external trigger.

`DIM Rdgs(1:18)`	*Dimension a computer array to store the readings.*
`CLEAR 722`	*Clear the multimeter.*
`OUTPUT 722;"*RST"`	*Reset the multimeter.*
`OUTPUT 722;"ROUT:TERM REAR"`	*Select the rear panel multiplexer.*
`OUTPUT 722;"CONF:VOLT:DC (@100:107)"`	*Configure the multimeter for dc voltage measurements.*
`OUTPUT 722;"TRIG:SOUR EXT`	*Set the trigger source to an external trigger.*
`OUTPUT 722;"READ?"`	*Scan the channel list one time when the trigger is received.*
`ENTER 722;Rdgs(*)`	*Enter and*
`FOR I=1 to 18`	*display the readings*
`  PRINT Rdgs(I)`	*on the computer.*
`NEXT I`	
`END`	

Comments

- The multimeter is triggered when a high-to-low TTL signal is applied to the External Trigger port.

- CONFigure sets the trigger source to the multimeter's internal trigger. The trigger source is changed with the TRIGger:SOURce command. The sources available are:

> IMM   immediate (internal) trigger
> EXT   external trigger
> BUS   triggered by * TRG or HP-IB group execute trigger
> HOLD   suspend trigger

- If programmed for multiple scans, multiple external triggers must occur since each scan requires a trigger.

Independent Multiplexer Operation

A multiplexer option can be controlled independently or in conjunction with the multimeter. The ROUTe:OPEN and ROUTe:CLOSe commands provide direct access to the multiplexer. The following channels may be used in conjunction with the ROUTe:OPEN and ROUTe:CLOSe commands:

Channels	Designations for Scanning Multiplexer
Option 001 (Relay/Actuator Card):	
0–7	Volts, 2-wire ohm
8–9	Current
10–13	4-wire resistance
14–15	Actuator control
Option 002 (Reed Relay Multiplexer):	
0–9	Volts, 2-wire ohm
10–14	4-wire resistance

The multiplexer can be used independently from the multimeter when the rear terminals are disconnected using the ROUTe:TERMinal command. When ROUTe:TERMinal is set to REAR the multiplexer is connected through to the multimeter. Measurements can be made by selecting the proper ROUTe:OPEN as an alternative to using a channel list with the MEASure or CONFigure commands. For Option 001, only one of the channels 0–13 may be selected at a time. Channels 14–15 are never connected to the common bus. For Option 002, only one channel can be closed at a time.

Note	To open all channels regardless of current state use ROUT:OPEN (@100:115) command for Option 001 and use ROUT:OPEN (@100:114) for Option 002.

Multimeter Measurements Using the Multiplexer

This program selects a channel and makes a single measurement using the multimeter configuration set by the MEASure command.

CLEAR 722	*Clear the multimeter.*
OUTPUT 722;"*RST"	*Reset the multimeter.*
OUTPUT 722;"ROUT:TERM REAR"	*Select the multiplexer channel.*
OUTPUT 722;"ROUT:OPEN (@100:113)	*Disconnect all other ports.*
OUTPUT 722;"ROUT:CLOS (@102)"	*Configure the multimeter and make dc*
OUTPUT 722;"CONF:VOLT:DC?"	*voltage measurement on channel 2.*
ENTER 722;Rdg	*Enter and display the*
PRINT Rdgs(I)	*reading on the computer.*
END	

Using the Multiplexer

This program selects a multiplexer channel which is being used to route a signal to the external common multiplexer port.

OUTPUT 722;"ROUT:TERM FRONT"	*Disconnect the rear multiplexer.*
OUTPUT 722;"ROUT:OPEN (@100:113)	*Disconnect all other ports.*
OUTPUT 722;"ROUT:CLOS (@101)"	*Connect the multiplexer port.*

Maximizing Multiple Channel Measurement Speed.

This example shows the multimeter configuration required to make measurements to maximize the channel switching rate. The switching rate is 34 channels per second for Option 001 (Relay/Actuator) and 318 channels per second for Option 002 (Reed Relay).

```
DIM Rdgs(1:800)                              Dimension computer array
                                             to store readings.
OUTPUT 722; "*RST"                           Reset multimeter to its power-
                                             on state.
OUTPUT 722; "CONF:VOLT:DC 8.25,MAX,(@100:107)"   Configure multimeter for dc
                                             volts, fixed range, worst res-
                                             olution and scanner mode
                                             with a channel list.
OUTPUT 722; "CAL:ZERO:AUTO OFF"              Disable auto zero.
OUTPUT 722; "SAMP:COUN 800"                  Specify 800 readings - mul-
                                             tiple of number of channels
                                             in scanlist.
OUTPUT 722; "INIT"                           place multimeter in wait-
                                             for-trigger state; store read-
                                             ings in multimeter memory
                                             when trigger is received.
OUTPUT 722; "FETC?"                          place readings in output buffer.
ENTER 722; Rdgs(*)                           Enter readings into computer.
PRINT Rdgs(1), Rdgs(650)                     Display selected readings.
```

Specifications and Characteristics

This chapter contains the specifications and characteristics for the HP 70110A digital multimeter.

These are the performance standards, or limits against which the instrument may be tested including typical characteristics as additional information for the user. (Only specifications are warranted.)

Table 4-1. Specifications and Characteristics

STANDARD TERMINAL SPECIFICATIONS*			
DC Voltage			
Maximum Non-Destructive Input			
Terminals	DC	AC RMS	AC Peak
HI to LO	450 V	300 V	450 V
HI to Guard	450 V	300 V	450 V
HI to Chassis	450 V	300 V	450 V
LO to Guard	200 V	140 V	200 V
LO to Chassis	450 V	300 V	450 V
Guard to Chassis	450 V	300 V	450 V
Maximum Reading	Range	Reading	
	30 mV	30.30000 mV	
	300 mV	303.0000 mV	
	3 V	3.030000 V	
	30 V	30.30000 V	
	300 V	303.0000 V	
Input Resistance†	Range	Resistance Reading	
	30 mV	>10 GΩ	
	300 mV	>10 GΩ	
	3 V	>10 GΩ	
	30 V	10 MΩ ±1%	
	300 V	10 MΩ ±1%	

* Standard Terminals refer to front or rear panel banana jack inputs.
† With INPut:IMPedance:AUTO ON. If INPut:IMPedance:AUTO is OFF, the input resistance is 10 MΩ on all ranges.

STANDARD TERMINAL SPECIFICATIONS

DC Voltage (continued)

Resolution[*]

Range	Aperture			
	$\geq$ 16.7 ms	2 ms/1.67 ms	100 μs	10 μs
30 mV	10 nV	100 nV	1 μV	10 μV
300 mV	100 nV	1 μV	10 μV	100 μV
3 V	1 μV	10 μV	100 μV	1 mV
30 V	10 μV	100 μV	1 mV	10 mV
300 V	100 μV	1 mV	10 mV	100 mV

DC Voltage Accuracy Conditions

Autozero on (CALibration:ZERO:AUTO ON). After one-hour warm-up.

Tcal is the temperature of calibration from 18 °C to 28 °C.

24-Hour Accuracy[†‡]

Range	Aperture		
	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
30 mV	0.0012%+2.2 μV	0.0012%+2.4 μV	0.0012%+3.5 μV
300 mV	0.0005%+2.4 μV	0.0005%+2.5 μV	0.0005%+3.5 μV
3V	0.00035%+5.0 μV	0.00035%+6.0 μV	0.00035%+6.0 μV
30 V	0.00065%+90 μV	0.00065%+100 μV	0.00065%+200 μV
300 V	0.0025%+500 μV	0.0025%+600 μV	0.0025%+600 μV

Range	2 ms/1.67 ms	100 μs	10 μs
30 mV	0.0012%+5.5 μV	0.0012%+17 μV	0.0012%+60 μV
300 mV	0.0005%+7.0 μV	0.0005%+40 μV	0.0005%+400 μV
3V	0.00035%+40 μV	0.00035%+400 μV	0.00035%+4 mV
30 V	0.00065%+600 μV	0.00065%+4.0 mV	0.00065%+40 mV
300 V	0.0025%+4.0 mV	0.0025%+40 mV	0.0025%+400 mV

90-Day Accuracy[†§]

Range	Aperture		
	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
30 mV	0.0040%+3.7 μV	0.0040%+3.9 μV	0.0040%+5.0 μV
300 mV	0.0025%+3.9 μV	0.0025%+4.0 μV	0.0025%+5.0 μV
3 V	0.0017%+6.0 μV	0.0017%+7.0 μV	0.0017%+7.0 μV
30 V	0.0035%+190 μV	0.0035%+200 μV	0.0035%+300 μV
300 V	0.0050%+600 μV	0.0050%+700 μV	0.0050%+700 μV

Range	2 ms/1.67 ms	100 μs	10 μs
30 mV	0.0040%+7.0 μV	0.0040%+19 μV	0.0040%+60 μV
300 mV	0.0025%+9.0 μV	0.0025%+40 μV	0.0025%+400 μV
3 V	0.0017%+40 μV	0.0017%+400 μV	0.0017%+4.0 μV
30 V	0.0035%+700 μV	0.0035%+4.0 mV	0.0035%+40 mV
300 V	0.0050%+4.0 mV	0.0050%+40 mV	0.0050%+400 mV

[*] Useful Resolution. In some instances, the multimeter may give additional digits.

[†] $\pm$(% of reading + volts)

[‡] Tcal $\pm$1 °C. Accuracy is relative to calibration standard. The module should be calibrated as used.

[§] Tcal $\pm$5 °C. Accuracy relative to calibration standard. See the Factory Calibration adders at the end of this appendix. The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used.

STANDARD TERMINAL SPECIFICATIONS			
DC Voltage (continued)			
1-Year Accuracy[*][†]		Aperture	
Range	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
30 mV	0.0045%+3.7 μV	0.0045%+3.9 μV	0.0045%+5.0 μV
300 mV	0.0035%+3.9 μV	0.0035%+4.0 μV	0.0035%+5.0 μV
3 V	0.0025%+6.0 μV	0.0025%+7.0 μV	0.0025%+7.0 μV
30 V	0.0040%+190 μV	0.0040%+200 μV	0.0040%+300 μV
300 V	0.0055%+600 μV	0.0055%+700 μV	0.0055%+700 μV
Range	2 ms/1.67 ms	100 μs	10 μs
30 mV	0.0045%+7.0 μV	0.0045%+19 μV	0.0045%+60 μV
300 mV	0.0035%+9.0 μV	0.0035%+40 μV	0.0035%+400 μV
3 V	0.0025%+40 μV	0.0025%+400 μV	0.0025%+4.0 mV
30 V	0.0040%+700 μV	0.0040%+4.0 mV	0.0040%+40 mV
300 V	0.0055%+4.0 mV	0.0055%+40 mV	0.0055%+400 mV

Temperature Coefficient[‡][§]	Range	Coefficient Range
	30 mV	0.0005%+0.3 μV
	300 mV	0.0005%+0.3 μV
	3 V	0.0005%+0.3 μV
	30 V	0.0005%+3 μV
	300 V	0.0005%+30 μV
Autozero OFF Offset Error[**]	Range	Additional Offset Error
	30 mV	100 nV
	300 mV	1 μV
	3 V	10 μV
	30 V	100 μV
	300 V	1 mV

Range-to-Range Response Error — For default settling times, add 0.0005% of input voltage step to the first reading following a range change.

Noise Rejection[††]

NPLC	AC NMR	AC ECMR Guarded	AC ECMR Guard to LO	DC ECMR
<1	0	90	76	140
1	60	150	136	140
10	80	170	156	140
100	90	180	166	140

[*] ±(% of reading + volts)

[†] Tcal ±5 °C. Accuracy relative to calibration standard. See the Factory Calibration adders at the end of this appendix. The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used.

[‡] ±(% of reading + volts)/ °C

[§] To determine the additional error for operation outside the temperature ranges shown in the accuracy specifications, multiply the temperature coefficient by the difference between the operating temperature and Tcal.

[**] Add additional offset error if autozero is off (CALibration:ZERO:AUTO OFF). Assumes stable environment, ±1 °C over 10 minutes.

[††] With 1 kΩ in the LO lead and line frequency ±.08%

STANDARD TERMINAL SPECIFICATIONS

Resistance (Two- and Four-Wire)

Input Protection

Terminals	DC	AC RMS	AC Peak
HI to LO	450 V	300 V	450 V
HI Sense to LO Sense	350 V	350 V	350 V
HI Sense/LO Sense to LO	350 V	250 V	350 V
HI/Hi Sense to Guard	450 V	450 V	450 V
HI/HI Sense to Chassis	450 V	450 V	450 V
LO/LO Sense to Guard	200 V	140 V	200 V
LO/LO Sense to Chassis	450 V	300 V	450 V
Guard to Chassis	450 V	300 V	450 V

Maximum Reading

Range	Reading
30 Ω	30.30000 Ω
300 Ω	303.0000 Ω
3 kΩ	3.030000 kΩ
30 kΩ	30.30000 kΩ
300 kΩ	303.0000 kΩ
3 MΩ	3.030000 MΩ
30 MΩ	30.30000 MΩ
300 MΩ	303.0000 MΩ
3 GΩ	3.030000 GΩ

Measurement Characteristics*

Range	Source Current	Maximum Open Circuit Voltage	Maximum Allowable Current Source Lead Resistance	Maximum Allowable Offset Voltage for Offset Compensated Oh ms	Default Measurement Settling Time
30 Ω	1 mA	12 V	1 Ω	1 mV	560 μs
300 Ω	1 mA	12 V	10 Ω	10 mV	350 μs
3 kΩ	1 mA	12 V	100 Ω	100 mV	350 μs
30 kΩ	100 μA	12 V	1 kΩ	N/A	350 μs
300 kΩ	10 μA	12 V	10 kΩ	N/A	2.4 ms
3 MΩ	1 μA	12 V	100 kΩ	N/A	24 ms
30 MΩ	100 nA	8.5 V	1 MΩ	N/A	240 ms
300 MΩ	100 nA	8.5 V	N/A	N/A	2.4 s
3 GΩ	100 nA	8.5 V	N/A	N/A	2.5 s

* The first reading meets accuracy specification with preprogrammed settling times and < 200 pF circuit capacitance. An additional delay of 0.1 seconds is necessary after a range or function change to meet rated accuracy. On the 300 MΩ and 3 GΩ ranges, the current source is in parallel with 10 MΩ.

STANDARD TERMINAL SPECIFICATIONS

Resistance (2- and 4-Wire) cont'd

Noise Rejection

See the DC Voltage Noise Rejection specifications.

Resolution*

Range	≥ 16.7 ms	2 ms/1.67 ms	100 μs	10 μs
		Aperture		
30 Ω	10 μΩ	100 μΩ	1 mΩ	10 mΩ
300 Ω	100 μΩ	1 mΩ	10 mΩ	100 mΩ
3 kΩ	1 mΩ	10 mΩ	100 mΩ	1 Ω
30 kΩ	10 mΩ	100 mΩ	1 Ω	10 Ω
300 kΩ	100 mΩ	1 Ω	10 Ω	100 Ω
3 MΩ	1 Ω	10 Ω	100 Ω	1 kΩ
30 MΩ	10 Ω	100 Ω	1 kΩ	10 kΩ
300 MΩ	100 Ω	1 kΩ	10 kΩ	100 kΩ
3 GΩ	1 k Ω	10 kΩ	100 kΩ	1 MΩ

Resistance Accuracy Conditions

Autozero on (CALibration:ZERO:AUTO ON). After one-hour warm-up.

Offset compensation on (SENSe:RESistance:OCOMpensated).

Tcal is the temperature of calibration from 18 °C to 28 °C.

24-Hour Four-Wire Accuracy[†‡]

Range	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
	Aperture		
30 Ω	0.003%+2.2 mΩ	0.003%+2.4 mΩ	0.003%+3.5 mΩ
300 Ω	0.0015%+2.4 mΩ	0.0015%+2.5 mΩ	0.0015%+3.5 mΩ
3 kΩ	0.001%+5 mΩ	0.001%+6 mΩ	0.001%+6 mΩ
30 kΩ	0.001%+50 mΩ	0.001%+60 mΩ	0.001%+60 mΩ
300 kΩ	0.001%+600 mΩ	0.001%+700 mΩ	0.001%+800 mΩ
3 MΩ	0.003%+12 Ω	0.003%+14 Ω	0.003%+16 Ω
30 MΩ	0.02%+800 Ω	0.02%+830 Ω	0.02%+930 Ω
300 MΩ	Only specified for two-wire Ω.		
3 GΩ	Only specified for two-wire Ω.		

Range	2 ms/1.67 ms	100 μs	10 μs
30 Ω	0.003%+5.5 mΩ	0.003%+17 mΩ	0.003%+60 mΩ
300 Ω	0.0015%+6 mΩ	0.0015%+40 mΩ	0.0015%+400 mΩ
3 kΩ	0.001%+40 mΩ	0.001%+400 mΩ	0.001%+4 Ω
30 kΩ	0.001%+400 mΩ	0.001%+4 Ω	0.001%+40 Ω
300 kΩ	0.001%+4 Ω	0.001%+40 Ω	0.001%+400 Ω
3 MΩ	0.003%+70 Ω	0.003%+500 Ω	0.003%+5 kΩ
30 MΩ	0.02%+1.4 kΩ	0.02%+6 kΩ	0.02%+40 kΩ
300 MΩ	Only specified for two-wire Ω		
3 GΩ	Only specified for two-wire Ω		

*Userful resolution. In some instances, the multimeter may give additional digits.

[†] ±(% of reading + oh ms)

[‡] Tcal ±1 °C. Accuracy is relative to calibration standard. The module should be calibrated as used.

STANDARD TERMINAL SPECIFICATIONS

Resistance (2- and 4-Wire) cont'd

90-Day Four-Wire Accuracy[*][†]

Range	Aperture		
	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
30 Ω	0.0065%+3.2 mΩ	0.0065%+3.4 mΩ	0.0065%+4.5 mΩ
300 Ω	0.0045%+3.4 mΩ	0.0045%+3.5 mΩ	0.0045%+4.5 mΩ
3 kΩ	0.0035%+6 mΩ	0.0035%+7 mΩ	0.0035%+7 mΩ
30 kΩ	0.0035%+60 mΩ	0.0035%+70 mΩ	0.0035%+70 mΩ
300 kΩ	0.0040%+700 mΩ	0.0040%+800 mΩ	0.0040%+900 mΩ
3 MΩ	0.0055%+12 Ω	0.0055%+14 Ω	0.0055%+16 Ω
30 MΩ	0.0250%+800 Ω	0.0250%+830 Ω	0.0250%+930 Ω
300 MΩ/3 GΩ	Only specified for two-wire Ω.		
Range	2 ms/1.67 ms	100 μs	10 μs
30 Ω	0.0065%+6.5 mΩ	0.0065%+18 mΩ	0.0065%+60 mΩ
300 Ω	0.0045%+8 mΩ	0.0045%+40 mΩ	0.0045%+400 mΩ
3 kΩ	0.0035%+40 mΩ	0.0035%+400 mΩ	0.0035%+4Ω
30 kΩ	0.0035%+400 mΩ	0.0035%+4 Ω	0.0035%+40 Ω
300 kΩ	0.0040%+4 Ω	0.0040%+40 Ω	0.0040%+400 Ω
3 MΩ	0.0055%+70 Ω	0.0055%+500 Ω	0.0055%+5 kΩ
30 MΩ	0.0250%+1.4 kΩ	0.0250%+6 kΩ	0.0250+50 kΩ
300 MΩ/3 GΩ	Only specified for two-wire Ω		

1-Year Four-Wire Accuracy[*][†]

Range	Aperture		
	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
30 Ω	0.0075%+3.2 mΩ	0.0075%+3.4 mΩ	0.0075%+4.5 mΩ
300 Ω	0.0055%+3.4 mΩ	0.0055%+3.5 mΩ	0.0055%+4.5 mΩ
3 kΩ	0.0050%+6 mΩ	0.0050%+7 mΩ	0.0050%+7 mΩ
30 kΩ	0.0050%+60 mΩ	0.0050%+70 mΩ	0.0050%+70 mΩ
300 kΩ	0.0050%+700 mΩ	0.0050%+800 mΩ	0.0050%+900 mΩ
3 MΩ	0.0065%+12 Ω	0.0065%+14 Ω	0.0065%+16 Ω
30 MΩ	0.0400%+800 Ω	0.0400%+830 Ω	0.0400%+930 Ω
300 MΩ/3 GΩ	Only specified for two-wire Ω.		
Range	2 ms/1.67 ms	100 μs	10 μs
30 Ω	0.0075%+6.5 mΩ	0.0075%+18 mΩ	0.0075%+60 mΩ
300 Ω	0.0055%+8 mΩ	0.0055%+40 mΩ	0.0055%+400 mΩ
3 kΩ	0.0050%+40 mΩ	0.0050%+400 mΩ	0.0050%+4 Ω
30 kΩ	0.0050%+400 mΩ	0.0050%+4 Ω	0.0050%+40 Ω
300 kΩ	0.0050%+4 Ω	0.0050%+40 Ω	0.0050%+400 Ω
3 MΩ	0.0065%+70 Ω	0.0065%+500 Ω	0.0065%+5 kΩ
30 MΩ	0.0400%+1.4 kΩ	0.0400%+6 kΩ	0.0400%+50 kΩ
300 MΩ/3 GΩ	Only specified for two-wire Ω		

[*] ±(% of reading + ohms)

[†] Tcal ±5 °C. Accuracy relative to calibration standard. See the Factory Calibration adders at the end of this appendix. The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used.

STANDARD TERMINAL SPECIFICATIONS

Resistance (2- and 4-Wire) cont'd

24-Hour Two-Wire Accuracy[*†]

Aperture

Add ±200 mΩ to all four-wire specifications except those on the 300 MΩ and 3 GΩ ranges (see below).

Range	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
300 MΩ	0.6%+100 kΩ	0.6%+100 kΩ	0.6%+100 kΩ
3 GΩ	6.0%+1 MΩ	6.0%+1 MΩ	6.0%+1 MΩ
Range	2 ms/1.67 ms	100 μs	10 μs
300 MΩ/3 GΩ	Not specified for aperture times less than 16.7 ms		

90-Day and 1-Year Two-Wire Accuracy[*‡]

Aperture

Add ±200 mΩ to all four-wire specifications except those on the 300 MΩ and 3 GΩ ranges (see below).

Range	2 s/1.67 s	200 ms/167 ms	20 ms/16.7 ms
300 MΩ	1.6%+100 kΩ	1.6%+100 kΩ	1.6%+100 kΩ
3 GΩ	16%+1 MΩ	16%+1 MΩ	16%+1 MΩ
Range	2 ms/1.67 ms	100 μs	10 μs
300 MΩ/3 GΩ	Not specified for aperture times less than 16.7 ms		

Temperature Coefficient[§**]

Range	Temperature Coefficient
30 Ω	0.0005%+.5 mΩ
300 Ω	0.0005%+.5 mΩ
3 kΩ	0.0005%+.5 mΩ
30 kΩ	0.0005%+5 mΩ
300 kΩ	0.0008%+50 mΩ
3 MΩ	0.0010%+500 mΩ
30 MΩ	0.0025%+5 Ω
300 MΩ	0.3500%+0 Ω
3 GΩ	3.5000%+0 Ω

Autozero OFF Offset Error[††]

Range	Additional Offset Error
30 Ω	100 μΩ
300 Ω	1 mΩ
3 kΩ	10 mΩ
30 kΩ	100 mΩ
300 kΩ	1 Ω
3 MΩ	10 Ω
30 MΩ	100 Ω
300 MΩ	1 kΩ
3 GΩ	10 kΩ

[*] ±(% of reading + oh ms)

[†] Inputs > 10% of full scale only, for stable conditions (±1 °C) and within 24 hours of autocalibration (CALibration:INTernal? RES).

[‡] Inputs > 10% of full scale only. For stable conditions (±1 °C) and within 24 hours of autocalibration (CALibration:INTernal? RES), use the 24-hour specifications.

[§] ±(% of reading + oh ms)/ °C

[**] To determine the additional error for operation outside the temperature ranges shown in the accuracy specifications above, multiply the temperature coefficient by the difference between the operating temperature and Tcal.

[††] Add additional offset error if autozero is off (CALibration:ZERO:AUTO OFF). Assumes stable environment ±1 °C over 10 minutes. With autozero off, changes in the four-wire oh ms LO lead resistance are not corrected.

STANDARD TERMINAL SPECIFICATIONS			

True RMS AC Voltage	(AC- & DC-Coupled)		

Maximum Non-Destructive Input

Terminals	DC	AC RMS	AC Peak
HI to LO	450 V	300 V	450 V
HI to Guard	450 V	300 V	450 V
HI to Chassis	450 V	300 V	450 V
LO to Guard	200 V	140 V	200 V
LO to Chassis	450 V	300 V	450 V
Guard to Chassis	450 V	300 V	450 V

Maximum Reading

Range	Reading
30 mV	32.50000 mV
300 mV	325.0000 mV
3 V	3.250000 V
30 V	32.50000 V
300 V	303.00000 V

Input Impedance*

Range	Impedance
30 mV	1 MΩ ±1%, <90 pF
300 mV	1 MΩ ±1%, <90 pF
3 V	1 MΩ ±1%, <90 pF
30 V	1 MΩ ±1%, <90 pF
300 V	1 MΩ ±1%, <90 pF

Crest Factor	100% Full Scale	3.5

Noise Rejection[†]

Noise Configuration — DC to 60 Hz Common Mode Rejection (CMR)

Rejection — > 90 dB (Guarded)   > 76 dB (Guard to LO)

Resolution[‡]

	Aperture			
Range	16.7 ms	2/1.67 ms	100 μs	10 μs
30 mV	10 nV	100 nV	1 μV	10 μV
300 mV	100 nV	1 μV	10 μV	100 μV
3 V	1 μV	10 μV	100 μV	1 mV
30 V	10 μV	100 μV	1 mV	10 mV
300 V	100 μV	1 mV	10 mV	100 mV

AC-Coupled Accuracy Conditions — AC voltage accuracy specified for sinewave inputs >10% of range. DC component <10% of AC component. AC slow filter on (SENSe:BANDwidth:DETector 20). After one-hour warm-up. Autozero on (CALibration:ZERO:AUTO ON). With preprogrammed settling times, add an additional error of 0.1% of the input voltage step to the first reading. Tcal is the temperature of calibration from 18 °C to 28 °C.

* Oh ms ±%, shunt capacitance.
† 1 kΩ imbalance in LO lead.
‡ Userful resoltuion. In some instances, the multimeter may give additional digits.

STANDARD TERMINAL SPECIFICATIONS

ae RMS AC Voltage cont'd 24-Hour AC-Coupled Accuracy[*†]	(AC- & DC-Coupled) Aperture		
Range	**Frequency**	**≥ 16.7 ms**	**20 ms/1.67 ms**
30 mV to 30 V	20 Hz–45 Hz	0.5%+0.03%	0.5%+0.03%
	45 Hz–100 Hz	0.15%+0.03%	0.15%+0.03%
	100 Hz–20 kHz	0.07%+0.03%	0.07%+0.03%
	400 Hz–20 kHz[‡]	0.08%+0.03%	0.08%+0.17%
	20 kHz–100 kHz	0.6%+0.06%	0.6%+0.06%
	100 kHz–300 kHz	3.1%+0.3%	3.1%+0.3%
	300 kHz–1 MHz	10.1%+2.2%	10.1%+2.2%
Range	**Frequency**	**100 μs**	**10 μs**
30 mV to 30 V	20 Hz–45 Hz	0.5%+0.04%	0.5%+0.2%
	45 Hz–100 Hz	0.15%+0.04%	0.15%+0.2%
	100 Hz–20 kHz	0.07%+0.04%	0.07%+0.2%
	400 Hz–20 kHz[‡]	0.08%+0.18%	0.08%+0.33%
	20 kHz–100 kHz	0.6%+0.08%	0.6%+0.23%
	100 kHz–300 kHz	3.1%+0.33%	3.1%+0.47%
	300 kHz–1 MHz	10.1%+2.2%	10.1%+2.4%
Range	**Frequency**	**≥ 16.7 ms**	**20 ms/1.67 ms**
300 V	20 Hz–45 Hz	0.56%+0.03%	0.56%+0.03%
	45 Hz–100 Hz	0.21%+0.03%	0.21%+0.03%
	100 Hz–20 kHz	0.13%+0.03%	0.13%+0.03%
	400 Hz–20 kHz[‡]	0.14%+0.03%	0.14%+0.17%
	20 kHz–100 kHz	1.0%+0.11%	1.0%+0.11%
	100 kHz–300 kHz	not specified	not specified
Range	**Frequency**	**100 μs**	**10 μs**
300 V	20 Hz–45 Hz	not specified	not specified
	45 Hz–100 Hz	not specified	not specified
	100 Hz–20 kHz	not specified	not specified
	400 Hz–20 kHz[‡]	not specified	not specified
	20 kHz–100 kHz	not specified	not specified
	100 kHz–300 kHz	not specified	not specified
90-Day AC-Coupled Accuracy[§]	Add 0.06% reading + 0.013% of range to the 24-hour specifications above.		

[*] ±(% of reading + % of range)

[†] Tcal ±1 °C. Accuracy relative to calibration standard. The module should be calibrated as used.

[‡] Using AC fast filter (SENSe:BANDwidth:DETector 400) for frequencies above 400 Hz.

[§] Tcal ±5 °C. Within one week of autocal (CALibration:Internal? AC) and within ±5 °C of Tcal (Tcal is the temperature of autocal). The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used. Accuracy relative to calibration standard. See the Factory Calibration adders at end of this appendix. Stable conditions. If autocal is not used, add an additional 0.6% to the % of reading.

STANDARD TERMINAL SPECIFICATIONS		
True RMS AC Voltage cont'd	(AC- & DC-Coupled)	
1-Year AC-Coupled Accuracy*	Add 0.1% reading + 0.02% of range to the 24-hour specifications above.	
AC-Coupled Temperature Coefficient†‡		
Range	Frequency	Temperature Coefficient
All Ranges	20 Hz–100 kHz	0.01% + 0.005%
All Ranges	100 kHz–1 MHz	0.08% + 0.01%
DC-Coupled Accuracy Conditions	AC voltage accuracy specified for sinewave inputs >10% of range. DC component <10% of AC component. AC slow filter on (SENSe:BANDwidth:DETector 20). After one-hour warm-up. Autozero on (CALibration:AUTO:ZERO ON). With preprogrammed settling times, add an additional error of 0.1% of the input voltage step to the first reading. Tcal is the temperature of calibration from 18 °C to 28 °C. Source impedance <10 kΩ	

* Tcal ±5 °C. Within one week of autocal (CALibration:Internal? AC) and within ±5 °C of Tcal (Tcal is the temperature of autocal). The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used. Accuracy relative to calibration standard. See the Factory Calibration adders at end of this appendix. Stable conditions. If autocal is not used, add an additional 0.6% to the % of reading.

† ±(% of reading + % of range)/°C

‡ To determine the additional error for operation outside the temperature ranges shown in the accuracy specifications, multiply the temperature coefficient by the difference between the operating temperature and Tcal.

STANDARD TERMINAL SPECIFICATIONS			
True RMS AC Voltage cont'd	**(AC- & DC-Coupled)**		
24-Hour DC-Coupled Accuracy[*][†]		Aperture	
Range	**Frequency**	**$\geq$ 16.7 ms**	**20 ms/1.67 ms**
30 mV to 30 V	20 Hz–45 Hz	1.3%+0.05%	1.3%+0.05%
	45 Hz–100 Hz	0.1%+0.05%	0.1%+0.05%
	100 Hz–20 kHz	0.1%+0.05%	0.1%+0.05%
	400 Hz–20 kHz[‡]	0.38%+0.05%	0.38%+0.87%
	20 kHz–100 kHz	0.6%+0.08%	0.6%+0.09%
	100 kHz–300 kHz	3.1%+0.3%	3.1%+0.3%
	300 kHz–1 MHz	10.1%+2.3%	10.1%+2.3%
Range	**Frequency**	**100 μs**	**10 μs**
30 mV to 30 V	20 Hz–45 Hz	1.3%+0.07%	1.3%+0.2%
	45 Hz–100 Hz	0.1%+0.07%	0.1%+0.2%
	100 Hz–20 kHz	0.1%+0.07%	0.1%+0.2%
	400 Hz–20 kHz[‡]	0.38%+0.87%	0.38%+1.0%
	20 kHz–100 kHz	0.6%+0.1%	0.6%+0.23%
	100 kHz–300 kHz	3.1%+0.33%	3.1%+0.47%
	300 kHz–1 MHz	10.1%+2.3%	10.1%+2.4%
Range	**Frequency**	**$\geq$ 16.7 ms**	**20 ms/1.67 ms**
300 V	20 Hz–45 Hz	1.3%+0.05%	1.31%+0.066%
	45 Hz–100 Hz	0.17%+0.05%	0.18%+0.066%
	100 Hz–20 kHz	0.17%+0.05%	0.18%+0.066%
	400 Hz–20 kHz[‡]	0.44%+0.05%	0.45%+0.881%
	20 kHz–100 kHz	1.1%+0.14%	1.11%+0.161%
	> 100 kHz	not specified	not specified
Range	**Frequency**	**100 μs**	**10 μs**
300 V	20 Hz–45 Hz	not specified	not specified
	45 Hz–100 Hz	not specified	not specified
	100 Hz–20 kHz	not specified	not specified
	400 Hz–20 kHz[‡]	not specified	not specified
	20 kHz–100 kHz	not specified	not specified
	> 100 kHz	not specified	not specified

[*] ±(% of reading + % of range)

[†] Tcal ±1 °C. Accuracy relative to calibration standard. The module should be calibrated as used.

[‡] Using AC fast filter (SENSe:BANDwidth:DETector 400) for frequencies above 400 Hz.

STANDARD TERMINAL SPECIFICATIONS

True RMS AC Voltage cont'd	(AC- & DC-Coupled)
90-Day DC-Coupled Accuracy*	Add ±(0.06% reading + 0.07% of range) to the 24-hour specs.
1-Year DC-Coupled Accuracy*	Add ±(0.1% reading + 0.07% of range) to the 24-hour specs.
DC-Coupled Temperature Coefficient[†‡]	

Range	Frequency	Temperature Coefficient
30 mV, 3V	20 Hz–100 kHz	0.01% + 0.19%
30 mV, 3V	100 kHz–1 MHz	0.08% + 0.20%
300 mV, 30V, 300V	20 Hz–100 kHz	0.01% + 0.034%
300 mV, 30V, 300V	100 kHz–1 MHz	0.08% + 0.044%

DC-Coupled DC Componenet Error[§]	Add ±(0.14% of reading + 0.77% of range)
Frequency and Period[**]	
Input Impedance[††]	1 MΩ ±1%, < 90 pF
Maximum Input	Refer to AC Voltage specifications
Frequency Range	10 Hz to 1.5 MHz
Period Range	0.1 s to 667 ns
Trigger Level	Triggers and counts on zero crossings
Sensitivity	10 mV RMS (sinewave)
Accuracy	±(% of reading)

Frequency	Period	Accuracy
10 Hz–400 Hz	0.1 – 0.025 s	0.05%
400 Hz–1.5 MHz	0.025 s – 667 ns	0.01%

Memory	
Reading Storage into internal RAM	16,384 readings (all aperture times)
Multimeter State Memory	10 states (*SAV 0 to *SAV 9)

*Within one week of autocal (CALibration:Internal? AC) and within ±5 °C of Tcal (Tcal is the temperature of autocal from 18 °C to 28 °C). The Tcal specification is based on the ambient temperature when the calibration was performed. Factory calibration was performed in an HP 70001A mainframe with various other low-power modules. Variations due to different mainframes, modules, or module locations may cause variations in the module temperature. For highest accuracy, the module should be calibrated as used. Accuracy relative to calibration standard. See the Factory Calibration adders at end of this appendix. Stable conditions. If autocal is not used, add the following: ±(0.6% of reading + 0.2% of range).

[†] ±(% of reading + % of range)/°C

[‡] To determine the additional error for operation outside the temperature ranges shown in the accuracy specification, multiply the temperature coefficient by the difference between the operating temperature and Tcal.

[§] DC component > 10% of AC component

[**] Frequency and period of the AC componenet of the AC- or DC-coupled voltage input is measured. The counter uses a reciprocal counting technique to give constant resolution independent of the input frequency.

[††] resistance ±%, capacitance

STANDARD TERMINAL SPECIFICATIONS

Timer/Pacer*†	(SAMPle:SOUREce TIMer;:SAMPle:TIMer)
Timer Range	680 μs to 2100 s in 1 μs increments
Accuracy	0.02% of setting
Jitter	< 2 ns RMS
Programmable Delay	(TRIGger:DELay)
Input Range‡	0 to 2100 s in increments of 1 μs

DC Current

Resolution

Range	Maximum Reading 6.5 Digits	Aperture 2 s/1.67 s to 20 ms/16.7 ms	2 ms/1.67 ms
300 μA	303.0000 μA	100 pA	1 nA
3 mA	3.030000 mA	1 nA	10 nA
30 mA	30.30000 mA	10 nA	100 nA
300 mA	303.0000 mA	100 nA	1 μA
2A	2.00000 A	1 μA	10 μA

Range	Aperture 100 μs	10 μs	Shunt Resistance
300 μA	10 nA	100 nA	1000 Ω
3 mA	100 nA	1 μA	100 Ω
30 mA	1 μA	10 μA	10 Ω
300 mA	10 μA	100 μA	1 Ω
2 A	100 μA	1 mA	.1 Ω

Maximum Burden Voltage	Range	Voltage
	300 μA, 3 mA, 30 mA	0.35 V
	300 mA	0.6 V
	2 A	2 V

Temperature Coefficient   ±(% of Reading + Amps)/ °C

Range	Auto-Zero ON	Auto-Zero OFF
300 μA	.002 + 2 nA	.002 + 3 nA
3 mA	.002 + 20 nA	.002 + 30 nA
30 mA	.002 + 200 nA	.002 + 300 nA
300 mA	.007 + 2 μA	.007 + 3 μA
2A	.007 + 20 μA	.007 + 30 μA

Noise Rejection	See the DC Voltage Noise Rejection Specifications

*Allows the selection of the time between measurements cycles after the time set for TRIGger:DELay has past. Its primary purpose is to generate a precise internal timing pulse to pace the measurement cycles.

†Autozero off (CALibration:ZERO:AUTO OFF) and autorange off in DCV or Oh ms for aperture times of 10 μs or 100 μs.

‡Allows selection of the time between measurement cycles. It is provided to allow the selection of settling time and precise triggering of the measurement.

STANDARD TERMINAL SPECIFICATIONS

DC Current (cont'd)

24 Hour Accuracy[*][†]

Range	% Reading	2s/1.67 ms	Aperture 200 ms/167 ms	20 ms/16.7 ms
300 μA	0.0020	5.4 nA	5.4 nA	6.5 nA
3 mA	0.002	54 nA	54 nA	65 nA
30 mA	0.0020	540 nA	540 nA	650 nA
300 mA	0.03	15 μA	15 μA	17 μA
2A	0.03	500 μA	500 μA	500 μA
Range		2 ms/1.67 ms	100 μs	10 μs
300 μA		9 nA	50 nA	400 nA
3 mA		90 nA	500 nA	4 μA
30 mA		900 nA	5 μA	40 μA
300 mA		19 μA	60 μA	400 μA
2A		540 μA	900 μA	5 mA

90 Day Accuracy[*][‡]

Range	% Reading	2s/1.67 ms	Aperture 200 ms/167 ms	20 ms/16.7 ms
300 μA	0.020	10 nA	10 nA	12 nA
3 mA	0.020	100 nA	100 nA	120 nA
30 mA	0.020	1 μA	1 μA	1.2 μA
300 mA	0.070	20 μA	20 μA	22 μA
2A	0.070	600 μA	600 μA	620 μA
Range		2 ms/1.67 ms	100 μs	10 μs
300 μA		14 nA	50 nA	400 nA
3 mA		140 nA	500 nA	4 μA
30 mA		1.4 μA	5 μA	40 μA
300 mA		24 μA	60 μA	400 μA
2A		640 μA	1 mA	5 mA

1 Year Accuracy[*][‡]

Range	% Reading	2s/1.67 ms	Aperture 200 ms/167 ms	20 ms/16.7 ms
300 μA	0.04	10 nA	10 nA	12 nA
3 mA	0.04	100 nA	100 nA	120 nA
30 mA	0.04	1 μA	1 μA	1.2 μA
300 mA	0.08	20 μA	20 μA	22 μA
2A	0.08	600 μA	600 μA	620 μA
Range		2 ms/1.67 ms	100 μs	10 μs
300 μA		14 nA	50 nA	400 nA
3 mA		140 nA	500 nA	4 μA
30 mA		1.4 μA	5 μA	40 μA
300 mA		24 μA	60 μA	400 μA
2A		640 μA	1 mA	5 mA

[*]±(% of Reading + Amps)

[†]Tcal ±1 °C after two hour warm-up. Auto-zero ON. Accuracy relative to calibration standard.

[‡]Tcal ±5 °C after one hour warm-up. Auto-zero ON. Accuracy relative to calibration standard.

STANDARD TERMINAL SPECIFICATIONS

True RMS AC Current	AC and DC Coupled

True RMS AC Current

Resolution

			Aperture		
Range	Maximum Reading	≥20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
30 mA	32.50000 mA	10 nA	100 nA	1 μA	10 μA
300 mA	325.0000 mA	100 nA	1 μA	10 μA	100 μA
2 A	2.000000 A	1 μA	10 μA	100 μA	1 mA

Maximum Input[*] 3 Amps from 250 volt source. Input is fuse protected.

Maximum Burden Voltage 2 V r ms at 2A r ms input for frequencies < 20 kHz.

Crest Factor > 3.5 to 1 at full-scale.

AC-Coupled Accuracy Conditions After two hour warm-up. Since-wave inputs >10% of range. AC slow filter ON (SENSe:BANDwidth:DETector 20). Auto-zero ON. For preprogrammed settling times, error is <10% of input current step. Specifications apply within one week of AC auto-cal (CALibration:INTernal? AC) for stable temperature conditions. If AC auto-cal is not used, add 0.6 to the percent of reading figures.

24-Hour AC-Coupled Accuracy[†‡]

30 mA and 300 mA Range

Frequency	Aperture			
	≥20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
20Hz–45Hz	0.8% + 0.095%	0.8% + 0.095%	0.8% + 0.11%	0.8% + 0.23%
46Hz–100Hz	0.25% + 0.095%	0.25% + 0.095%	0.25% + 0.11%	0.25% + 0.23%
101Hz–20kHz	0.2% + 0.095%	0.2% + 0.095%	0.2% + 0.11%	0.2% + 0.23%
400Hz–20kHz[§]	0.2% + 0.095%	0.2% + 0.25%	0.2% + 0.27%	0.2% + 0.4%
21kHz–100kHz	0.9% + 0.13%	0.9% + 0.13%	0.9% + 0.14%	0.9% + 0.27%

2 A Range

Frequency	Aperture			
	≥20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
20Hz–45Hz	0.9% + 0.095%	0.9% + 0.095%	0.9% + 0.11%	0.9% + 0.23%
46Hz–100Hz	0.35% + 0.095%	0.35% + 0.095%	0.35% + 0.11%	0.35% + 0.23%
101Hz–20kHz	0.30% + 0.095%	0.30% + 0.095%	0.30% + 0.11%	0.30% + 0.23%
400Hz–20kHz[§]	0.30% + 0.095%	0.30% + 0.25%	0.30% + 0.27%	0.30% + 0.4%

90 Day AC Coupled Accuracy[**] Add 0.05 to the % of reading numbers in the above 24-Hour Specs.

1 Year AC Coupled Accuracy[**] Add 0.08 to the % of reading numbers in the above 24-Hour Specs.

[*]non-destructive
[†]±(% of Reading + % of Range)
[‡]Tcal ±1 °C. After 2 hour warm-up. Accuracy relative to calibration standard.
[§]Using AC fast filter (SENSe:BANDwidth:DETector 400) for frequencies above 400 Hz.
[**]All ranges.

STANDARD TERMINAL SPECIFICATIONS

True RMS AC Current (cont'd)

Temperature Coefficient-AC Coupled*

Frequency	Aperture			
	$\geq$20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
20Hz–100 kHz	0.017% + 0.005%	0.017% + 0.005%	0.017% + 0.005%	0.017% + 0.005%

DC-Coupled Accuracy Conditions

After two hour warm-up. Since-wave inputs >10% of range. AC slow filter ON (SENSe:BANDwidth:DETector 20). Auto-zero ON. For preprogrammed settling times, error is 0.1% of input current step.

24-Hour DC-Coupled Accuracy[†‡]

30 mA and 300 mA Range

Frequency	Aperture			
	$\geq$20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
20Hz–45Hz	1.5% + 0.53%	1.5% + 0.53%	1.5% + 0.55%	1.5% + 0.67%
46Hz–100Hz	0.35% + 0.53%	0.35% + 0.53%	0.35% + 0.55%	0.35% + 0.67%
101Hz–20kHz	0.25% + 0.53%	0.25% + 0.53%	0.25% + 0.55%	0.25% + 0.67%
400Hz–20kHz[§]	0.6% + 0.53%	0.6% + 1.25%	0.6% + 1.25%	0.6% + 1.4%
21kHz–100kHz	0.9% + 0.58%	0.9% + 0.58%	0.9% + 0.6%	0.9% + 0.73%

2 A Range[**]   Add 0.1 to the % of reading numbers in the above 24-Hour Specs.

90 Day DC Coupled Accuracy*   Add 0.05 to the % of reading numbers in the above 24-Hour Specs.

Temperature Coefficient-DC Coupled*

Frequency	Aperture			
	$\geq$20 ms/16.7 ms	2 ms/1.67 ms	100 μs	10 μs
20Hz–100 kHz	0.017% + 0.005%	0.017% + 0.005%	0.017% + 0.005%	0.017% + 0.005%

Maximum Reading Rates[††‡‡]

Aperture	AC Slow Response[§§]		AC Fast Response[§§]	
	60 Hz	50 Hz	60 Hz	50 Hz
10 μs	1.0	1.0	9.5	9.5
100 μs	1.0	1.0	9.5	9.5
2 ms/1.67 ms	1.0	1.0	9.25	9.2
20 ms/16.7 ms	1.0	1.0	7.25	6.9
200 ms/167 ms	0.7	0.65	2.0	1.7
2 s/1.67 s	0.2	0.17	0.25	0.2

*All ranges.

[†]±(% of Reading + % of Range)

[‡]Tcal ±1 °C. (ACDCI Function) After 2 hour warm-up. Accuracy relative to calibration standard.

[§]Using AC fast filter (SENSe:BANDwidth:DETector 400) for frequencies above 400 Hz.

[**]The 2A range is only specified up to 20 kHz and a maximum input of 2A r ms.

[††]Readings/Second

[‡‡]Reading Rates apply with Auto-zerto ON, fixed range, and preprogrammed settling times.

[§§]SENSe:BANDwidth:DETector set to <400 for AC slow response and set to >400 for AC fast response.

MULTIPLEXER INPUTS

Armature Relay Multiplexer	
Input Characteristics	Eight two-wire with guard, armature relay channels and two current/actuator channels, with guard.
Maximum Voltage	250 VDC or 250 VAC r ms HI-to-Lo or channel-to-channel. 200 V peak Guard-to-Lo. 350 V peak terminals to chassis.
Maximum Current*	2 A DC or AC r ms
Thermal Offset	$< 3 \ \mu V$
Relay Life	10^6 operations at maximum load (2 amps @ 250 VAC r ms).
Closed Channel Resistance[†]	$< 2 \ \Omega$
Max Switching and Meas. Speed	33 channels/second
Adjacent Channel Crosstalk[‡]	-70 dB @ 100 kHz
DC Isolation[§]	Channels 0–7 (40 °C, 95% Relative Humidity) $10^{10} \ \Omega$
	Channels 0–7 (40 °C, 60% Relative Humidity) $10^{11} \ \Omega$
	Channels 8 & 9 (40 °C, 95% Relative Humidity) $10^9 \ \Omega$
	Channels 8 & 9 (40 °C, 60% Relative Humidity) $10^{10} \ \Omega$
AC Isolation	Channels 0–7 Closed 150 pF
	Channels 0–7 Open 10 pF
Noise Rejection**	Refer to Noise Rejection specifications for each function.
Reed Relay Multiplexer	
Input Characteristics	Ten two-wire with guard, reed relay channels or five four-wire channels with guard.
Maximum Voltage	Terminal-to-Terminal or Terminal-to-chassis. 120 Vr ms, 120 Vdc, 170 Vpeak.
Thermal Offset	$< 3 \ \mu V$
Relay Life	10^7 operations at maximum load (125 VAC peak-to-peak).
Closed Channel Resistance[†]	$< 4 \ \Omega$
Max Switching and Meas. Speed	300 channels/second
Adjacent Channel Crosstalk[‡]	-70 dB @ 100 kHz
DC Isolation[§]	Channels 0–9 (40 °C, 95% Relative Humidity) $10^9 \ \Omega$
	Channels 0–9 (40 °C, 60% Relative Humidity) $10^{10} \ \Omega$
AC Isolation	Channels 0–9 Closed 200 pF
	Channels 0–9 Open 15 pF
Noise Rejection**	Refer to Noise Rejection specifications for each function.

*Per current/actuator channel.
[†]End of Relay Life.
[‡]Channels terminated into 50 Ω
[§]Channel-to-channel and Hi-to-Lo resistance.
**The Noise Rejection specifications can be degraded by a maximum of 10 dB if all channels are unguarded and connected to chassis ground.

GENERAL SPECIFICATIONS					
Reading Rates*†			Aperture		
Function	2s	1.67s	200 ms	167 ms	20 ms
DC Voltage, 2- and 4- Wire Ω, DCI	0.4	0.49	4	4.9	47
AC Voltage (fast response)	0.2	0.25	1.7	2.0	6.9
AC Voltage (slow response)	0.17	0.2	0.65	0.7	1.0
Function	16.7 ms	2 ms	1.67 ms	100 μs	10 μs
DC Voltage, 2- and 4- Wire Ω, DCI	56	312	360	1250	1450
AC Voltage (fast response)	7.2	9.2	9.2	9.5	9.5
AC Voltage (slow response)	1.0	1.0	1.0	1.0	1.0

A/D Resolution‡§		Aperture		
Units	≥16.7 ms	2m1/1.67 ms	100 μs	10 μs
Binary Bits	±21.5	±18.2	±14.9	±11.5
Decimal Digits	6.5	5.5	4.5	3.5

Factor Calibration Adders					
DCV					
Range	30 mV	300 mV	3V	30 V	300 V
Adder Value	33.3 PPM	7.1 PPM	5.5 PPM	9.7 PPM	10.5 PPM
ACV					
Range	30 mV	300 mV	3V	30 V	300 V
Adder Value	250 PPM	155 PPM	155 PPM	285 PPM	485 PPM
OHMS					
Range	30 Ω	300 Ω	3 kΩ	30 kΩ	300 kΩ
Adder Value	33.3 PPM	16.5 PPM	16.5 PPM	16.5 PPM	21.0 PPM
OHMS					
Range	3 MΩ	30 MΩ			
Adder Value	25.0 PPM	120.0 PPM			

Power Line Cycles	Aperture		
	50 Hz**	60 Hz**	PLCs
	2 s	1.67 s	100
	200 ms	167 ms	10
	20 ms	16.7 ms	1
	2 ms	1.67 ms	0.1
	100 μs	100 μs	0.005
	10 μs	10 μs	0.0005

*Readings/Second

†For DC voltage, 2- and 4-wire resistance: autozero, autrange, and offset compensation are OFF; fixed range (30 Ω to 3 kΩ range for resistance); delay set to 0 seconds; sample source time and sample count >1; For AC voltage: autozero OFF in fixed range with preprogrammed setting times; reading to internal memory. No backplane activity such as serial polls or query operations occurring.

‡bits/digits

§Useful resolution. In some instances, the multimeter may return additional digits.

**Power Line Frequency

5

Menu Maps and Softkey Descriptions

Menu Maps graphically represent all top-level softkeys and their associated lower-level softkeys. (The top-level softkeys are located along the left side of the display.)

This chapter lists all menu maps in the order they appear from top to bottom on the left side of the display. With each menu map, a short description of each of the lower-level softkeys is provided.

Measure Menu and Softkey Descriptions

```
Measure
         DCV
         ACV ─────────► AC ONLY|AC + DC
         OHMS ───────►2W|4W
         DCI
         ACI ─────────► AC ONLY|AC + DC
         ACV:FRQ
         ACV:PER
```
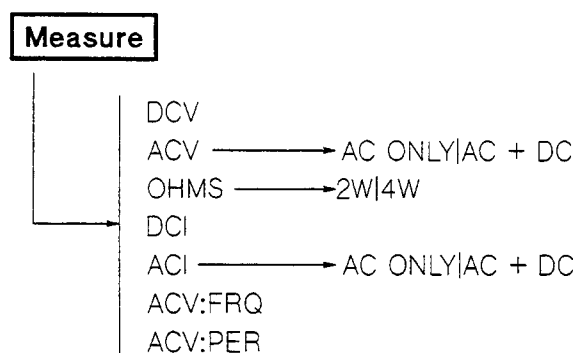
DCV

dc voltage measurement.

ACV

ac and ac+dc voltage measurements.

OHMS

2-wire and 4-wire resistance measurements.

DCI

dc current measurement.

ACI

ac and ac+dc current measurements.

ACV:FRQ

ac voltage frequency measurement.

ACV:PER

ac voltage period measurement.

Setup Menu and Softkey Descriptions

```
┌─────────────┐
│   Setup     │
└─────────────┘
    │
    │     INPUT, FR|REAR              100PLC, 1.67S|2S *
    │     CHANNEL, ADVANCE            10PLC, 167mS|200mS *
    │     RANGE, AUTO|MAN             1PLC, 16.7mS|20mS *
    └───▶ GUARD, OPEN|LO       ───▶   .1PLC, 1.67mS|2mS *
          nplcs, aperture ─────┘      .005PLC, 100 µS
          #digits, display ────┐      .0005, 10 µS
          more, 1 of 2 ──────┐ │      prev, menu
                             │ │
    ┌────────────────────────┘ │
    │     AC BNDW, FAST|SLO     │      6.5, DIGITS
    │     FIXED Z, ON|OFF       │      5.5, DIGITS
    │     ZEROING, AUTO|OFF     │      4.5, DIGITS
    └───▶ OFFCOMP, ON|OFF  ─────┘      3.5, DIGITS
          LF:60Hz,|50/400

          more, 2 of 2               prev, menu
```
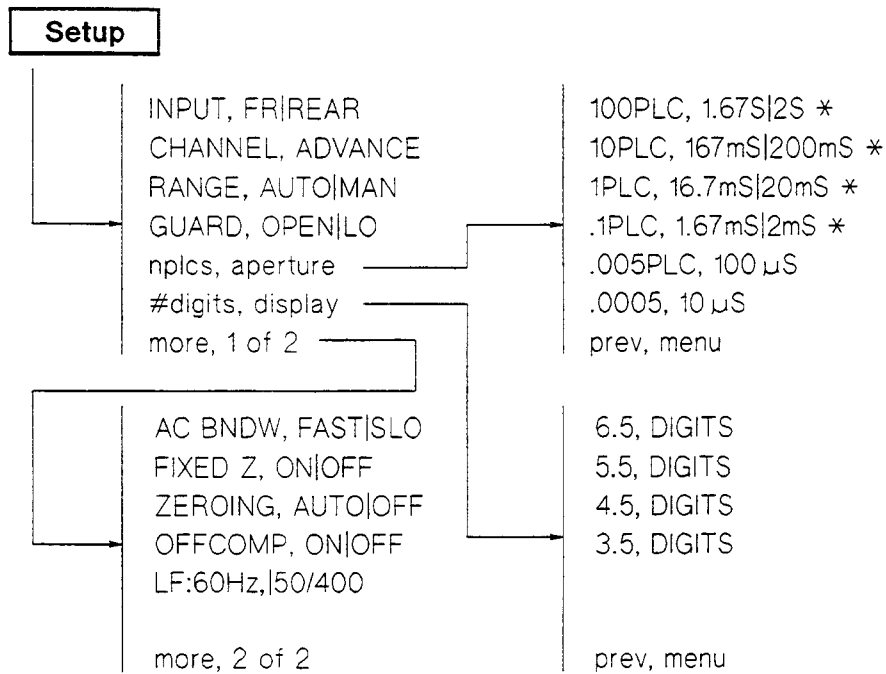
* depends on choice of LF:60Hz|50/400

INPUT
FR REAR

Toggles between front and rear measurement terminals. With a multiplexer option installed, (Option 001 or Option 002) REAR is replaced by SCAN.

CHANNEL
ADVANCE

This key is only present when a multiplexer option is installed, (Option 001 or Option 002). When the input selection is SCAN and this key is pressed the measurement channel is indexed by one. Successive pressing of this key allows the user to scroll though all of the active channels for each measurement function. The available channels with associated measurement functions are shown below.

Option 001 Armature Relay:

Channels 0-7: Voltage, 2-wire ohms, frequency/period.
Channels 8&9: Current
Channels 10-13: 4-wire ohms

Option 002 Reed Relay:

Channels 0-9: Voltage, 2-wire ohms, frequency/period.
Channels 10-14: 4-wire ohms

`RANGE`
`AUTOMAN`

The HP 70110A digital multimeter Auto-Range feature automatically selects the appropriate range based on the level of the input signal. The Auto-Range feature is disabled by selecting Manual Ranging. Manual ranging is available for all measurement functions except frequency and period. Different ranges exist for each type of measurement function. These are shown below:

Voltage: 30 mV, 300 mV, 3 V, 30 V, and 300 V.
Resistance: 30 Ω, 300 Ω, 3 kΩ, 30 kΩ, 300 kΩ, 3 MΩ, 30 MΩ, 300 MΩ, and 3 GΩ.
dc current: 300 μA, 3 mA, 30 mA, 300 mA, and 2 A.
ac current: 30 mA, 300 mA, and 2 A.

`GUARD`
`OPEN LO`

Internally connects the LO terminal to the GUARD terminal. For best results, the GUARD terminal of the HP 70110A digital multimeter should be connected so as to divert common mode currents away from the measurement. Some experimentation may be required to find the best guarding method for any particular measurement. For information on making guarded measurements, see *Application Note 123 Floating Measurements and Guarding.* Default for this function is for LO to be connected to GUARD. The reason for the default choice is that it is usually better to connect GUARD to LO than to incorrectly connect GUARD.

`nplcs`
`aprture`

Allows you to change the resolution of a measurement. Measurement resolution is changed by increasing or decreasing the integration time of the measurement. Increasing the integration time reduces measurement noise. Decreasing integration time permits faster readings. The integration time is dependent on the power line frequency and is expressed in number of power line cycles (NPLC). There are six integration times available and are chosen by selecting one of the softkeys in the NPLC's submenu. If the power line frequency is 60 Hz (see `LF:60` `50/400` below) then these keys are `100PLC` `1.67S`, `10PLC` `167mS`, `1PLC` `16.7mS`, `.1PLC` `1.67mS`, `.005PLC` `100μS`, and `.0005PLC` `10μS`. If the power line frequency is 50 Hz or 400 Hz, then these keys are `100PLC` `2S`, `10PLC` `200mS`, `1PLC` `20mS`, `.1PLC` `2mS`, `.005PLC` `100μS`, and `.0005PLC` `10μS`. The greater the PLC number, the quieter and more accurate the reading will be and the slower the measurement speed. The default is 1 PLC.

`#digits`
`display`

This key allows you to reduce or increase the number of digits displayed on screen. You can choose a display of $3\frac{1}{2}$, $4\frac{1}{2}$, $5\frac{1}{2}$, or $6\frac{1}{2}$ digits.

Note	The HP 70110A digital multimeter will only display the useful resolution of the measurement. For example, if you choose a short integration time which results in $3\frac{1}{2}$ digits of resolution the HP 70110A digital multimeter will display a maximum of $3\frac{1}{2}$ digits regardless of the number of digits that you have requested.

`AC BNDW`
`FASTSLO`

when making ac voltage, current, frequency, or period measurements, you can select either a slow or fast mode. The slow mode is for signals below 400 Hz. In the slow mode, a longer time constant is used for the input filter and a longer delay is used. The fast mode is for signals greater than or equal to 400 Hz and allows you to make a series of measurements in a shorter amount of time. Successive key presses of this key will toggle between the fast and slow ac modes.

`FIXED Z`
`ON OFF`

when making dc voltage measurements, you can fix the input impedance to 10 MΩ. This is useful to prevent a change in input impedance, (caused by a range change), from affecting the measurement. Table 2-1 shows the input impedances with fixed impedance on and fixed impedance off. Default is for fixed impedance to be off. Successive key presses of this key will toggle between the on and off conditions. The present condition of Fixed Impedance will be shown by underlining of either ON or OFF.

Note	Fixed Impedance is temporarily disabled when you change from dc voltage measurements to ac voltage, ac or dc current, frequency, or period measurements. Fixed Impedance remains enabled when you change from dc voltage to 2-wire or 4-wire resistance measurements. When Fixed Impedance is on and you are in a resistance measurement mode the HP 70110A digital multimeter measures the 10 MΩ (Fixed Impedance), resister.

ZEROING
AUTOOFF

This give the display user access to the HP 70110A digital multimeter Autozero function. With autozero on, the HP 70110A digital multimeter internally disconnects the input signal after each measurement and takes a zero reading. It then subtracts the zero reading from the preceding measurement. This minimizes the effects of offset voltages present on the HP 70110A digital multimeter's input circuitry from affecting measurements. The default is for autozero to be on. With autozero off, the HP 70110A digital multimeter takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time there is a function or range change. Turning autozero off results in faster readings and reduced measurement accuracy.

OFFCOMP
ON OFF

Used to turn offset compensation on or off. With offset compensation on, the HP 70110A digital multimeter compensates for small extraneous voltages on the 30 Ω through 3 kΩ ranges. Offset compensation does not function on the higher ranges, (30 kΩ through 3 GΩ). The HP 70110A digital multimeter compensates for offset by, first measuring the offset voltage. Next, it sources current and measures the combination of the induced and offset voltages. The HP 70110A digital multimeter then subtracts the offset voltage from the combined voltage leaving only the induced voltage. The induced voltage is then used to determine the resistance; resistance = voltage ÷ current. Table 2-3 shows the maximum offset voltage that can be present on offset compensated measurements for the various ranges. Also shown are the resulting combined voltages. You can use offset compensation for both 2-wire and 4-wire ohms measurements. Turning offset compensation on is crucial for measurement accuracy when the offset voltage is an appreciable percentage of the combined voltage. Leaving offset compensation off results in faster readings. The default is for offset compensation to be off. Successive key presses of this key will toggle offset compensation between the on and off conditions. The current state of offset compensation will be shown by underlining either ON or OFF.

LF:60Hz
50/400

This key allows the user to select the clock rate for the A/D converter within the HP 70110A digital multimeter. The HP 70110A digital multimeter measures an analog signal source by converting it to a digital value. Input signals are converted to digital values by the HP 70110A digital multimeter's A/D, (analog to digital), converter. The A/D converter is responsible for many of the HP 70110A digital multimeter's operating characteristics. One of these includes its ac line rejection. By integrating measurements over a harmonic of the

line frequency this type of unwanted noise is rejected from the final measurement value. Two settings are available. This first is for a power line frequency of 60 Hz. The second allows operation with either 50 or 400 Hz power line frequency.

Trigger Menu and Softkey Descriptions
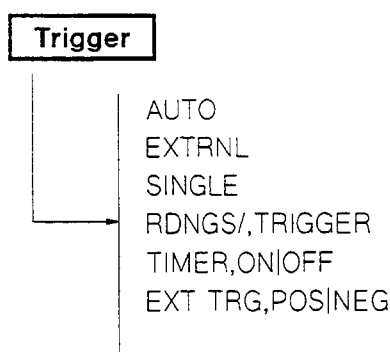
```
┌─────────────┐
│   Trigger   │
└─────────────┘
       │            AUTO
       │            EXTRNL
       │            SINGLE
       └──────────► RDNGS/,TRIGGER
                    TIMER,ON|OFF
                    EXT TRG,POS|NEG
```

The HP 70110A digital multimeter must be triggered by some event before it can make a measurement. The default triggering event for front panel operation is automatic triggering. (Refer to Chapter 8.)

AUTO

Selects automatic triggering, (auto trigger). This type of triggering causes the HP 70110A digital multimeter to make a measurement whenever it is not busy doing something else, (for example, performing a remotely generated task). Auto trigger is the power on default.

EXTRNL

External triggering allows the user to synchronize the HP 70110A measurement with other instruments or devices. The external trigger is achieved through the rear panel BNC connector, EXT TRIG, at TTL level trigger signals. The HP 70110A digital multimeter will take one measurement for each trigger received.

Single

Single triggering allows the user to manually trigger a single event from the front panel of the HP 70110A digital multimeter. One measurement is performed with each press of a key.

RDNGS/
TRIGGER

The HP 70110A digital multimeter can perform multiple readings per measurement for all three types of trigger events described above. When this key is highlighted the user can change the number of readings per trigger with the RPG, the up/down arrow keys, or the number pad. The default number of readings per trigger is 1.

TIMER
ON OFF

When more than one reading per trigger event is in effect the time between each reading can be specified with this key. When this key is highlighted the user can change the time period between readings with the RPG, the up/down arrow keys, or the number pad. The default time between readings, (when the timer is on), is 1.0 second. The default state of this function is off.

EXT TRG
POS NEG

For external triggering the HP 70110A digital multimeter can be configured to trigger on either the positive or negative edge of a TTL signal. Depressing this key toggles between the positive and negative edge conditions. The current state of triggering is shown by underlining of either POS or NEG. The default condition is for the HP 70110A digital multimeter to externally trigger on a negative, or low going, TTL signal.

Math Menu and Softkey Descriptions
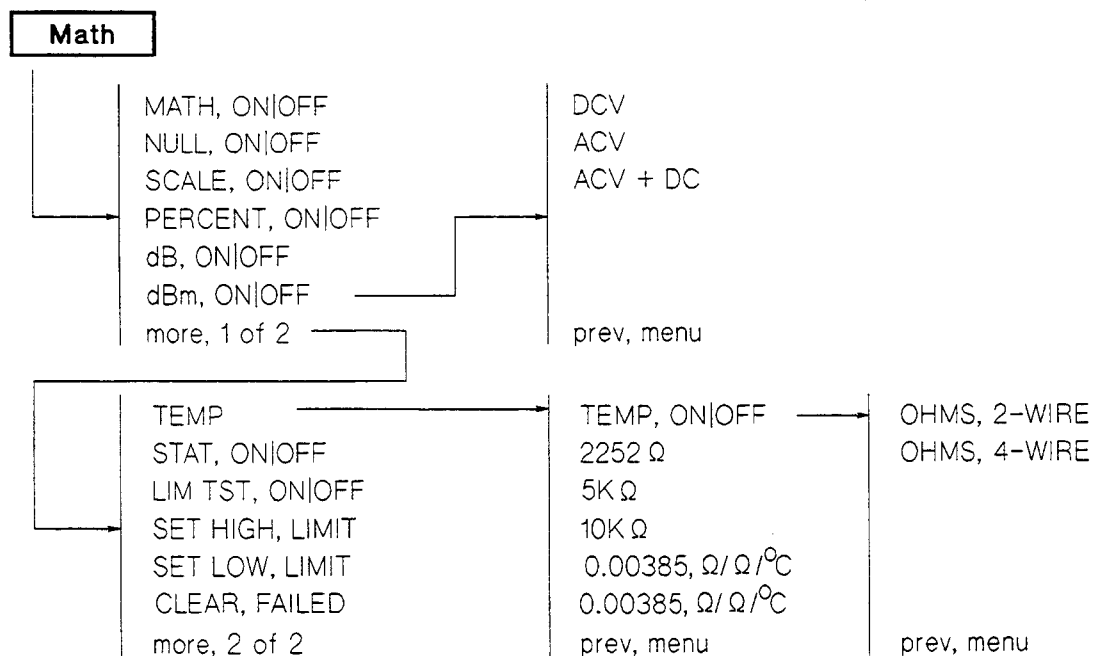
```
┌──────────┐
│   Math   │
└──────────┘
    │
    │   │   MATH, ON|OFF              DCV
    │   │   NULL, ON|OFF              ACV
    │   │   SCALE, ON|OFF            ACV + DC
    └──→│   PERCENT, ON|OFF ──────────────→
        │   dB, ON|OFF
        │   dBm, ON|OFF  ──────────┘
        │   more, 1 of 2 ──────────┐      prev, menu
                                   │
    ┌──────────────────────────────┘
    │   │   TEMP  ──────────────────→  TEMP, ON|OFF ────→  OHMS, 2-WIRE
    │   │   STAT, ON|OFF               2252 Ω              OHMS, 4-WIRE
    │   │   LIM TST, ON|OFF            5K Ω
    └──→│   SET HIGH, LIMIT            10K Ω
        │   SET LOW, LIMIT             0.00385, Ω/ Ω /°C
        │   CLEAR, FAILED             0.00385, Ω/ Ω /°C
        │   more, 2 of 2              prev, menu          prev, menu
```

**MATH
ON OFF**

The HP 70110A digital multimeter allows the front panel user to turn on and off all of the math operations which manipulate or modify a measured value with a single math menu key. This key does not alter the on and off conditions of the individual math operations. It turns off the entire sequence without altering the setup. This allows the math setup to be saved. For example, if a measurement function is changed, (which automatically turns math off), you can reinstate the previous math setup by merely turning math back on.

Note

👆

If a math mode has not previously been on then pressing **MATH ON OFF** will have no effect on the multimeter. If the dBm math operation (measurement mode in volts) or the temperature math operation (measurement mode in ohms) have been on but then the measurement mode is changed to a noncompatible mode then the math operation (dBm or temperature) has been turned OFF and pressing **MATH ON OFF** will have no effect.

NULL
ON OFF

This key activates the Null operation which subtracts a value from each subsequent measurement. The equation is:

$$Result = Reading - Offset$$

where:

Reading is any measurement after Null is turned on. *Offset* is a value selected by the user.

A possible application of the Null operation is in making more accurate 2-wire ohms measurements.

To make more accurate 2-wire ohms measurements:

1. Select 2-wire ohms (see the section *Resistance* in Chapter 2).
2. Short the ends of the test leads together.
3. Now enable the Null operation.

   The first reading taken (the lead resistance) is stored in the Offset register.
4. Connect the test leads to the unknown resistance to be measureed.

   The multimeter subtracts the test lead resistance from each resistance measurement, thus the effects of the test lead resistance are eliminated.

SCALE
ON OFF

The Scale operation modifies readings by multiplying by a scale factor. The equation is:

$$Result = Reading \times Scale$$

where:

Reading is any measured value. *Scale* is a value selected by the user.

PERCENT
ON OFF

The percent math operation determines the difference, in percent, between a measured reading and the value in the Percent register. The equation is

$$Result = \left[\frac{(Reading - Reference)}{Reference} \right] \times 100$$

where:

Reading is any measure value. *Reference* is a value selected by the user.

To determine the difference (in percent) between an ideal value and the measured value. For example, you may want to know the percent error of a 10 Vdc voltage measurement. To do this, enable the percent math operation and enter the ideal value (10) in the Percent register. Now measure the dc voltage. If the measurement is exactly 10 Vdc, the HP 70110A digital multimeter displays a 0. If the measurement is for example, 10.1 Vdc, the result becomes:

$$Result = \left[\frac{(10.1 - 10)}{10}\right] \times 100 = 0.01 \times 100 = 1$$

The HP 70110A digital multimeter display shows 1, indicating the measured value is 1% higher than the ideal value.

dB
ON OFF

This key activates the dB math operation which calculates a ratio in decibels. The equation is:

$$Result = 20 \times log_{10}\left(\frac{Reading}{Reference}\right)$$

where:

Reading is any measured value. *Reference* is the value selected by the user.

A typical application for the dB operation is in determining an amplifier's voltage gain. First, measure the input voltage to the amplifier and store that value. Next, enable the dB math operation. Now measure the amplifier's output voltage. The gain of the amplifier is now calculated and displayed in dB. For example, if the input voltage is 0.1 V and the output voltage is 10 V, the gain is:

$$20 \times log_{10}\left(\frac{10}{0.1}\right) = 20 \times log_{10}100 = 40dB$$

dBm
ON OFF

This key activates the dBm math operation which calculates the power delivered to a resistance referenced to 1 mW. The equation is:

$$Result = 10 \times log_{10}\left(\frac{\frac{Reading^2}{Resistance}}{mW}\right)$$

where:

Reading is any measure value. *Resistance* is the resistance value entered by the user.

A typical application for the dBm operation is determining the input power to a loudspeaker. First, enter the speaker's impedance (for this example, assume 8 Ω). Now enable the dBm operation and measure the input voltage to the speaker. The HP 70110A digital multimeter calculates and displays the input power. For example, if the input voltage is 10 V, the power is:

$$10 \times log_{10}\left(\frac{\frac{10^2}{8}}{1mW}\right) = 40.97dBm$$

Note

The dBm math operation function will only activate when the measurement mode is volts. Thus, if **dBm ON OFF** is pressed and the multimeter is not in a voltage mode then a menu showing the softkeys DCV, ACV, and ACV+DC will

be displayed for the user to chose a mode of measurement. After a selection is made the previous menu will be shown and the user can now activate the

dBm operation by pressing `dBm ON OFF`. Once the dBm math operation has been activated, if the measurement mode is changed from volts then the dBm math operation will automatically be turned OFF.

`TEMP`

The HP 70110A digital multimeter can measure temperature using either a thermistor or an Resistance Temperature Detector (RTD). You can make thermistor and RTD measurements using either a 2-wire or 4-wire configuration. See *HP Application Note 290* for practical temperature measurement information.

`TEMP ON OFF`

Once the `TEMP` key has been pressed then the temperature function must be turned on using this key. After the temperature function is on, the thermistor type may be selected by pressing the softkey `2252Ω`, `5 kΩ`, or `10 kΩ` or for RTD measurements the RTD type may be selected by pressing the softkey `0.00385Ω/Ω/°C` or `0.00392 Ω/Ω/°C`. Figure 9-7 and Figure 9-8 show the proper way to configure 2-wire and 4-wire thermistor and RTD temperature measurements.

Note

The temperature measurement math functions will only activate when the measurement mode is OHMS. Thus, if the measurement mode is not OHMS, when the `TEMP ON OFF` softkey is pressed a submenu showing the two softkeys `OHMS 2-WIRE` and `OHMS 4-WIRE` will be activated. Now, choose one of these measurement modes and the previous menu will appear and the appropriate temperature probe can be chosen. Once temperature has been activated, if the measurement mode is changed from OHMS, then the temperature measurement will automatically be turned OFF.

`STAT ON OFF`

This key activates the statistics math operation which performs five running calculations on the present series of measurements and stores the results. The calculations are: standard deviation, average, number of readings, maximum reading (largest magnitude), and minimum reading (lowest magnitude). When this key is activated the statistics values will be shown in the lower left right of the screen as:

```
StdDv:
Avrge:
#Rdgs:
Max :
Min :
```

Any change in measurement mode or instrument setting that changes the resolution of the readings will automatically turn this function OFF.

`LIM TST`
`ON OFF`

This key activates limit testing which allows measured values to be tested against user supplied maximum and minimum acceptable limits. If a result is outside the user specified bounds a "Fail" warning is shown on screen along with numerical value of the failure. A change in measurement mode will turn this feature off. The current state of this function is shown by underlining of either ON or OFF.

`SET HIGH`
`LIMIT`

This key is used to set the maximum limit against which limit testing will be conducted. Values are selected by using the ⇑ or ⇓ keys, the RPG, or the number keys. When one of the number keys is pressed then a menu showing the keys 10^9, 10^6, 10^3, `ENTER`, 10^{-3}, 10^{-6}, and 10^{-9} will appear for use in entering the user's chosen values.

`SET LOW`
`LIMIT`

This key is used to set the minimum limit against which limit testing will be conducted. Values are selected by using the ⇑ or ⇓ keys, the RPG, or the number keys. When one of the number keys is pressed then a menu showing the keys 10^9, 10^6, 10^3, `ENTER`, 10^{-3}, 10^{-6}, and 10^{-9} will appear for use in entering the user's chosen values.

`CLEAR`
`FAILED`

This key is used to clear the fail notification for limit testing.

State Menu and Softkey Descriptions
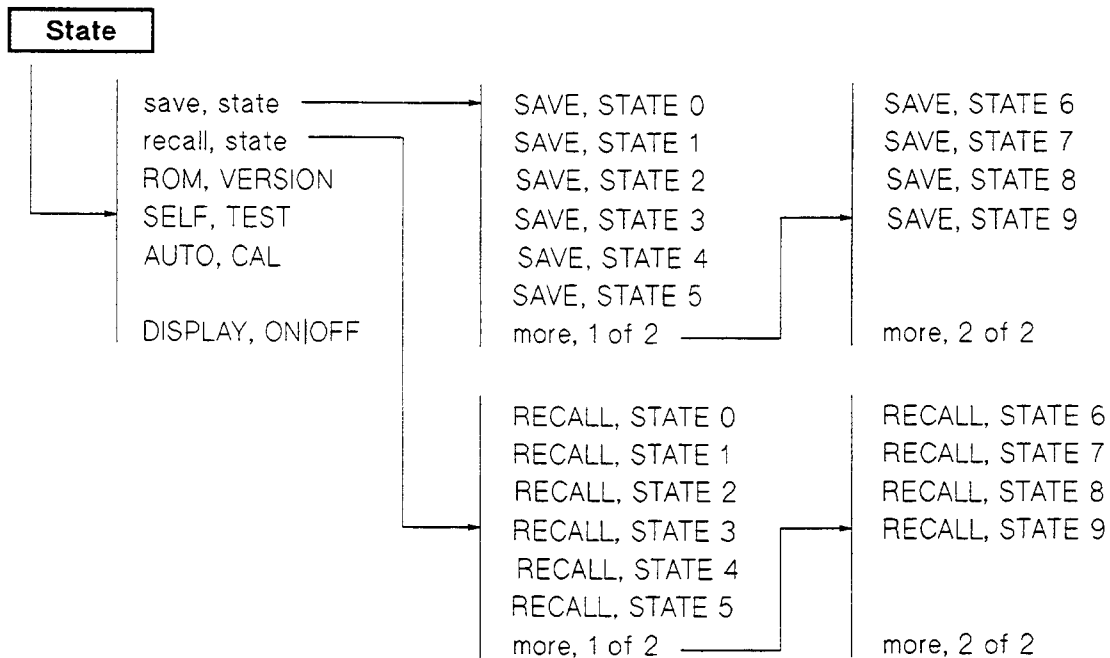
```
┌──────────┐
│  State   │
└──────────┘
    │
    │         save, state ────────────────►  SAVE, STATE 0        SAVE, STATE 6
    │         recall, state ──────────┐      SAVE, STATE 1        SAVE, STATE 7
    │         ROM, VERSION            │      SAVE, STATE 2        SAVE, STATE 8
    └────────► SELF, TEST             │      SAVE, STATE 3 ──┐    SAVE, STATE 9
              AUTO, CAL               │      SAVE, STATE 4   │
                                      │      SAVE, STATE 5   │
              DISPLAY, ON|OFF         │      more, 1 of 2 ───┘    more, 2 of 2
                                      │
                                      │      RECALL, STATE 0      RECALL, STATE 6
                                      │      RECALL, STATE 1      RECALL, STATE 7
                                      │      RECALL, STATE 2      RECALL, STATE 8
                                      └────► RECALL, STATE 3 ─┐   RECALL, STATE 9
                                             RECALL, STATE 4  │
                                             RECALL, STATE 5  │
                                             more, 1 of 2 ────┘   more, 2 of 2
```

The State menus allow the user to save or recall configurations for up to ten different configurations. The current instrument firmware revision can be identified. A complete instrument self test or a complete automatic calibration routine may be run. The display feature may be turned on and off.

save
state

This key brings up a submenu of softkeys SAVE STATE N that allows up to ten states, 0 through 9, to be saved.

recall
state

This key brings up a submenu of softkeys RECALL STATE N that allows any of the ten states, 0 through 9, to be active.

ROM
VERSION

By pressing this key the current instrument firmware revision will be displayed on screen. The revision information is displayed for approximately eight seconds and then blanks out.

SELF
TEST

This key will run the complete instrument self test. This routine typically takes less than 12 seconds to run. At the completion of instrument self test the user is provided with either a passed or failed on screen message of the test outcome.

AUTO
CAL

This key will run the complete instrument automatic calibration routine. This routine typically takes less than 35 seconds to run. At the completion of the instrument self calibration the user is provided with either a passed or failed on screen message of the test outcome.

DISPLAY
ON OFF

This key is used to turn the display feature of the HP 70110A digital multimeter on and off. This feature is useful if a remote program has left the instrument in the display off mode and a local user desires access.

Error Messages

This chapter contains the error messages for the HP 70110A digital multimeter.

Error Messages for the HP 70110A digital multimeter

Code	Message	Cause
−100	Command error	
−101	Invalid character	Unrecognized character in specified parameter.
−102	Syntax error	Command is missing a space or comma between parameters.
−103	Invalid separator	Command parameter is separated by a space rather than a comma.
−104	Data type error	The wrong data type (for example, number, character, string, expression) was used when specifying a parameter.
−105	GET no allowed	
−108	Parameter not allowed	Parameter specified in a command which has no parameters.
−109	Missing parameter	No parameter specified in the command in which a parameter is required.
−112	Program mnemonic too long	
−113	Undefined header	Command header was incorrectly specified.
−121	Invalid character in number	
−123	Exponent too large	
−124	Too many digits	More than 256 digits were specified for a parameter.
−128	Numeric data not allowed	Number specified for a parameter when a letter is required.
−131	Invalid suffix	Parameter suffix incorrectly specified (for example 5 K rather than 5 KOHM).
−138	Suffix not allowed	Parameter suffix is specified when one is not allowed.
−141	Invalid character data	The parameter type specified is not allowed (for example, MEAS:TEMP? TC,O = − "O" is not a choice).
−144	Character data too long	
−148	Character data not allowed	
−150	String data error	
−151	Invalid string data	
−158	String data not allowed	
−160	Block data error	
−161	Invalid block data	
−168	Block data not allowed	

−170	Expression error	
−171	Invalid expression	
−178	Expression data not allowed	A parameter other than the channel list is enclosed in parentheses.
−180	Macro error	
−181	Invalid outside macro definition	
−183	Invalid inside macro definition	
−200	Execution error	
−211	Trigger ignored	Trigger occurred while the multimeter is in the idle state, or a trigger occurred from a source other than the specified source.
−213	INIT ignored	An INIT command is received when the multimeter is already in the wait−for−trigger state following TRIG:SOUR HOLD.
−214	Trigger deadlock	The multimeter is triggered from another source (for example, READ?) after the trigger source has been set to TRIG:SOUR BUS.
−221	Settings conflict	Multimeter parameters are set such that a measurement cannot be made (for example, specifying a fixed resolution while autoranging).
−222	Data out of range	The parameter value specified is too large or too small.
−223	Too much data	A legal program data element of block expression or string was received that contained more data than the device could handle.
−224	Illegal parameter value	The numeric value specified is not allowed (for example, MEAS:TEMP? RTD).
−230	Data corrupt or stale	Data in mainframe memory is fetched after a command (for example, MEASure, READ?) has returned data to the output buffer.
−231	Data questionable	Resolution is too great for specified range. Measurement is still taken.
−241	Hardware missing	Command could not be executed because an option was not installed.
−270	Macro error	
−272	Macro execution error	
−273	Illegal macro label	
−276	Macro recursion error	
−277	Macro redefinition not allowed	
−310	System error	
−311	Memory error	
−312	PUD memory lost	
−313	Calibration memory lost	
−350	Queue overflow	The error queue is full as more than 30 errors have occurred.

-410	Query INTERRUPTED	Data is not read from the output buffer before another command is executed.
-420	Query UNTERMINATED	Command which generates data not able to finish executing due to a multimeter configuration error.
-430	Query DEADLOCKED	Command execution cannot continue since the mainframe's command input.
-440	Query UNTERMINATED after indefinite response	
1000	Out of memory	Not enough memory to store the number of measurements requested.
1001	Cal security disabled by jumper	
1002	Cal security on, send CAL:SEC OFF,code	
1003	Internal cal memory lost	
1004	Cal write fail	
1005	Cal value out of range	
1006	Cal measurement out of range	
1007	No cal for period or high resistance	
1008	Cal read fail	
1010	Internal cal ac fail convergence	
1011	Internal cal extended resistance fail	
1012	Internal cal ac fail high	
1013	Internal cal ac fail low	
1101	UART fail	
1102	A/D timeout	
1103	A/D checksum fail	
1104	A/D link data error	
2600	Function not supported	
2601	Channel list required for this function	
2602	Timer too fast	Aperture time is longer than the sample rate.

7

Remote Programming Commands Quick Reference

This chapter provides a quick reference guide of Standard Commands for Programmable Instruments (SCPI) and a quick reference guide of *IEEE Std 488.2-1987* Common Commands applicable to the HP 70110A digital multimeter. This chapter contains the following sections:

- SCPI Commands Quick Reference

- *IEEE Std 488.2-1987* Common Commands Quick Reference

SCPI Commands Quick Reference

The following tables summarize Standard Commands for Programmable Instruments (SCPI) for the HP 70110A digital multimeter.

Command	Description
ABORt	Place multimeter in idle state.
CALCulate	
:AVERage	
:AVERage?	Query the average of a set of measurements.
:COUNt?	Query the count of a set of measurements.
:MAXimum?	Query the maximum of a set of measurements.
:MINimum?	Query the minimum of a set of measurements.
:STANdarddev?	Query the standard deviation..
:STATe OFF|0|ON|1	Enable/disable collection of statistical information.
:STATe?	Query collection of statistical information.
:LIMit	
:LOWer	
[:DATA] <*limit*> |MIN|MAX	Set lower threshold for limit testing.
[:DATA]? [MIN|MAX]	Query lower threshold for limit testing.
:STATe OFF|0|ON|1	Enable/disable limit testing.
:STATe?	Query limit testing.
:UPPer	
[:DATA] <*limit*> |MIN|MAX	Set upper threshold for limit testing.
[:DATA]? [MIN|MAX]	Query upper threshold for limit testing.
[:MATH]	
:DB	Math operation dB.
:REFerence	
[:DATA] <*reference*> |MIN|MAX	Set reference value for dB.
[:DATA]? [MIN|MAX]	Query reference value for dB.
:STATe OFF|0|ON|1	Enable/disable dB math operation.
:STATe?	Query dB math operation.
:DBM	Math operation dBm.
:RESistance	
[:DATA] <*resistance*> |MIN|MAX	Set resistance value for dBm.
[:DATA]? [MIN|MAX]	Query resistance value for dBm.
:STATe OFF|0|ON|1	Enable/disable dBm math operation.
:STATe?	Query dBm math operation.
:NULL	Math operation null.
:OFFSet	
[:DATA] <*offset*> |MIN|MAX	Set offset value for null.
[:DATA]? [MIN|MAX]	Query offset value for null.
:STATe OFF|0|ON|1	Enable/disable null math operation.
:STATe?	Query null math operation.
:PATH?	Query order of math operations.

:PERCent	Math operation percent.
:REFerence	
[:DATA] <reference> |MIN|MAX	Set reference value for percent.
[:DATA]? [MIN|MAX]	Query reference value for percent.
:STATe OFF|0|ON|1	Enable/disable percent math operation.
:STATe?	Query percent math operation.
:SCALe	Math operation scale.
:FACTor	
[:DATA] <factor> |MIN|MAX	Set factor value for scale.
[:DATA]? [MIN|MAX]	Query factor value for scale.
:STATe OFF|0|ON|1	Enable/disable scale math operation.
:STATe?	Query scale math operation.
CALibration	
:POINt?	Perform service calibration adjustment.
:COUNt?	Read calibration count.
:INTernal? AC|RES|ALL	Perform one or both autocals.
:SECurity	
:CODE <security code>	Set a new calibration security code.
[:STATe] OFF|0|ON|1 [,<security code>]	Set calibration secure state.
[:STATe]?	Query calibration secure state.
:VALue <value> |MIN|MAX	Set the value to be used for calibration adjustment.
:VALue? [MIN|MAX]	Query the value to be used for calibration adjustment.
:ZERO	
:AUTO OFF|0|ON|1|ONCE	Enable/disable autozero mode.
:AUTO?	Query autozero mode.
CONFigure[:SCALar]	
:CURRent	
:AC [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for ac current.
:ACDC [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for ac+dc current.
[:DC] [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for dc current.
:FRESistance [<exp val>[,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for 4-wire ohms.
:RESistance [<exp val>[,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for 2-wire ohms.
:TEMPerature <transducer>, <type>[,<chan lst>]	Configure multimeter for temperature.
[:VOLTage]	
:AC [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for ac voltage.
:ACDC [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for ac+dc voltage.
[:DC] [<exp val> [,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for dc voltage.
:FREQuency [<exp val>[,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for frequency.
:PERiod [<exp val>[,<res>][,<chan lst>]]|[<chan lst>]	Configure multimeter for period.
CONFigure?	Query multimeter configuration.
DIAGnostic:	
BOOT[:SOURce] <source>	Selects module boot source (service only).
BOOT[:SOURce]?	Query state of boot source.

DISPlay	
[:WINDow][:TEXT]:STATe OFF|0|ON|1	Enable/Disable the display.
[:WINDow][:TEXT]:STATe?	Query state of the display.
FETCh?	Place stored readings in output buffer.
FETCh[:SCALar]	Place stored readings in output buffer.
:CURRent	
:AC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:ACDC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
[:DC]? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:FRESistance? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:RESistance? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:TEMPerature? $<transducer>$, $<type>$[,$<chan\ lst>$]	
[:VOLTage]	
:AC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:ACDC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
[:DC]? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:FREQuency? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
:PERiod? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	
INITiate[:IMMediate]	Place multimeter in wait-for trigger state.
INPut	
:COUPling AC|DC	Select input coupling source.
:COUPling?	Query input coupling source.
:GUARd LOW|FLOat	Select the multimeter guard connection.
:GUARd?	Query the multimeter guard connection.
:IMPedance	
:AUTO OFF|0|ON|1	Enable/disable automatic input impedance.
:AUTO?	Query input impedance mode.
[:STATe] OFF|0|ON|1	Enable/disable input terminals.
[:STATe]?	Query input terminal configuration.
MEASure[:SCALar]	
:CURRent	
:AC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make ac current measurement.
:ACDC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make ac+dc current measurement.
[:DC]? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make dc current measurement.
:FRESistance? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make 4-wire ohms measurement.
:RESistance? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make 2-wire ohms measurement.
:TEMPerature? $<transducer>$, $<type>$[,$<chan\ lst>$]	Make temperature measurement.
[:VOLTage]	
:AC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make ac voltage measurement.
:ACDC? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make ac+dc voltage measurement.
[:DC]? [$<exp\ val>$ [,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make dc voltage measurement.
:FREQuency? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make frequency measurement.
:PERiod? [$<exp\ val>$[,$<res>$][,$<chan\ lst>$]]|[$<chan\ lst>$]	Make period measurement.

READ?
 	
READ[:SCALar]
  :CURRent
    :AC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    :ACDC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    [:DC]? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
  :FRESistance? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
  :RESistance? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
  :TEMPerature? <*transducer*>, <*type*>[,<*chan lst*>]
  [:VOLTage]
    :AC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    :ACDC? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    [:DC]? [<*exp val*> [,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    :FREQuency? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
    :PERiod? [<*exp val*>[,<*res*>][,<*chan lst*>]]|[<*chan lst*>]
	Place multimeter in wait-for-trigger state;
	place readings in output buffer.

ROUTe
  :CLOSe <*chan lst*>
  :CLOSe? <*chan lst*>
  :OPEN <*chan lst*>
  :OPEN? <*chan lst*>
  :TERMinals FRONt|REAR
  :TERMinals?
	
	Close the channels indicated by the channel list.
	Query which channels are closed.
	Open the channels indicated by the channel list.
	Query which channels are open.
	Select which terminals are connected.
	Query which terminals are connected.

SAMPle
  :COUNt 1-16,777,215|MIN|MAX
  :COUNt? [MIN|MAX]
  :SOURce IMM|TIM
  :SOURce?
  :TIMer 680 μs-2100s|MIN|MAX
  :TIMer? [MIN|MAX]
	
	Set number of readings per trigger.
	Query number of readings per trigger.
	Set pacing source.
	Query pacing source.
	Define period between readings.
	Query period between readings.

[SENSe:]
  CURRent|VOLTage
    :AC|[:DC]
      :APERture <*time*>|MIN|MAX
      :APERture? [MIN|MAX]
      :NPLCycles <*number*>|MIN|MAX
      :NPLCycles? [MIN|MAX]
      :RANGe:AUTO OFF|0|ON|1
      :RANGe:AUTO?
      :RANGe[:UPPer] <*exp val*>|MIN|MAX
      :RANGe[:UPPer]? [MIN|MAX]
      :RESolution <*res*>|MIN|MAX
      :RESolution? [MIN|MAX]
  DETector
    :BANDwidth|BWIDth 20|400|MIN|MAX
    :BANDwidth|BWIDth? [MIN|MAX]
	
	Set aperture time in seconds.
	Query aperture time.
	Set integration time in PLCs.
	Query integration time.
	Enable/disable autoranging.
	Query autorange mode.
	Select range for current measurements.
	Query current range.
	Specify resolution.
	Query resolution.
	
	Select slow or fast ac measurement mode.
	Query ac measurement mode.

FUNCtion[:ON][<*function*>]	Select measurement function.
FUNCtion[:ON]?	Query measurement function.
RESistance	
:APERture <*time*>|MIN|MAX	Set aperture time in seconds.
:APERture? [MIN|MAX]	Query aperture time.
:NPLCycles <*number*>|MIN|MAX	Set integration time in PLCs.
:NPLCycles? [MIN|MAX]	Query integration time.
:OCOMpensated OFF|0|ON|1	Enable/disable offset compensation.
:OCOMpensated?	Query offset compensation mode.
:RANGe:AUTO OFF|0|ON|1	Enable/disable autoranging.
:RANGe:AUTO?	Query autorange mode.
:RANGe[:UPPer] <*exp val*>|MIN|MAX	Select range.
:RANGe[:UPPer]? [MIN|MAX]	Query range.
:RESolution <*res*>|MIN|MAX	Specify resolution.
:RESolution? [MIN|MAX]	Query resolution.
STATus	
:OPERation	
:CONDition?	Read Operation Status condition register.
:ENABle <*number*>	Set conditions in Operation Status enable register.
:ENABle?	Query set conditions in Operation Status Register.
[:EVENt]?	Read Operation Status event register.
:NTRansition <*mask*>	Sets the Operation Status Register's negative transition.
:NTRansition?	Query the Operation Status Register's negative transition.
:PTRansition <*mask*>	Sets the Operation Status Register's positive transition.
:PTRansition?	Query the Operation Status Register's positive transition.
:PRESet	Presets Operation/Questionable Status registers.
:QUEStionable	
:CONDition?	Read Questionable Data/Signal Status Register.
:ENABle <*number*>	Set conditions in Questionable Data/Signal Status Register.
:ENABle?	Query set conditions in Questionable Data/Signal Status Register.
[:EVENt]?	Read Questionable Data/Signal event register.
:NTRansition <*mask*>	Sets the Questionable Status Register's negative transition.
:NTRansition?	Query the Questionable Status Register's negative transition.
:PTRansition <*mask*>	Sets the Questionable Status Register's positive transition.
:PTRansition?	Query the Questionable Status Register's positive transition.
SYSTem	
:ERRor?	Read error queue.
:LFRequency 50|60|400|MIN|MAX	Change line frequency reference.
:LFRequency? [MIN|MAX]	Query line frequency reference.
:SERial <*serial#*>	Set the multimeter serial number.
:SERial?	Query the multimeter serial number.
:VERSion?	Query SCPI version.

TEST	
[:ALL]?	Perform all self-tests.
:INGuard	
:AMP	Perform amp function gain self-test.
:FLATness?	Perform ac flatness self-test.
:GAIN?	Perform gain self-test.
:INTegrator?	Perform integrator convergence self-test.
:LINK?	Perform Inguard CPU and link self-test.
:OFFSet?	Perform dc offset self-test.
:PRECharge?	Perform ohms precharge self-test.
:ZERO?	Perform front end zero measurement self-test.
:OUTGuard	
:MEMory	Perform system RAM, ROM, and calibration memory self-tests.
TRIGger	
[:SEQuence|:SEQuence1|STARt]	
:BUFFered OFF|0|ON|1	Enable/disable trigger buffering.
:BUFFered?	Query trigger buffering mode.
:COUNt 1-16,777,215|MIN|MAX	Set number of triggers or scans.
:COUNt? [MIN|MAX]	Query trigger count.
:DELay	
:AUTO OFF|0|ON|1	Enable/disable automatic trigger delay.
:AUTO?	Query automatic trigger delay mode.
:DELay 1 μs-2100s|MIN|MAX	Set delay between trigger and start of measurement.
:DELay? [MIN|MAX]	Query trigger delay.
[:IMMediate]	Trigger immediately.
:SLOPe POS|NEG	Set trigger slope.
:SLOPe?	Query trigger slope.
:SOURce BUS|EXT|HOLD|IMM	Specify trigger source.
:SOURce?	Query trigger source.

IEEE Std 488.2-1987 Common Commands Quick Reference

Command	Title	Description
*CAL?	Internal Calibration	Perform multimeter autocals Returns "0" unless calibration fails.
*CLS	Clear Status Register	Clear all status registers and the error queue.
*DMC <label>	Define Macro	Assign macro label to sequence of program statement.
*EMC <value>	Enable Macro	Enable or disable macro.
*EMC?	Enable Macro Query	Return 1 if macros enabled; return 0 if macros disabled.
*ESE <mask>	Event Status Enable	Enable events in Standard Event Status Register to be reported.
*ESE?	Event Status Enable Query	Return sum of all enabled bits in the Standard Event Status Register.
*ESR?	Event Status Register Query	Returns content and clears Standard Event Status Register
*GMC? <label>	Get Macro Contents Query	Return macro definition of macro <label>.
*IDN?	Identification Query	Return identification string.
*LMC?	Learn Macro Query	Return labels of all currently defined macros.
*LRN?	Learn Query	Return string of TMSL commands which define current multimeter state.
*OPC	Set Operation Complete	Set OPC bit in Standard Event Status Register.
*OPC?	Operation Complete Query	Send "1" to the output buffer when complete.
*OPT?	Option Identification Query	Return option installed. 0: none; 10: Actuator; 20: Reed Relay.
*PMC	Purge Macros	Deletes all macros from memory.
*PSC <value>	Power-On Status Clear	Enable power-on clearing of enabled status register bits.
*PSC?	Power-On Status Clear Query	Return power-on clearing status.
*PUD <block>	Protected User Data	Store up to 63 bytes of arbitrary data.
*PUD?	Protected User Data Query	Returns block of stored data.
*RCL 0-9	Recall Instrument State	Recall configuration previously stored by *SAV.
*RMC <label>	Remote Individual Macro	Remove individual macro which is specified in <label>.
*RST	Reset	Reset multimeter to power-on state.
*SAV 0-9	Store Instrument State	Store present configuration.
*SRE <mask>	Service Request Enable	Enable status register bits to assert SRQ.
*SRE?	Service Request Enable Query	Return sum of enabled bits.
*STB?	Read Status Byte Query	Return sum of all bits set in Status Byte Register.
*TRG	Bus Trigger	Trigger multimeter.
*TST?	Self-Test	Returns "0" unless self-test fails.
*WAI	Wait-to-continue	Prevents further commands until no-operation-pending is true.

8

Remote Programming Commands Reference

This chapter describes Standard Commands for Programmable Instruments (SCPI) and summarizes *IEEE Std 488.2-1987* Common Commands applicable to the HP 70110A digital multimeter. This chapter contains the following sections:

■ Command Types

■ Multimeter Range and Resolution Tables

■ *IEEE Std 488.2-1987* Common Command Reference

■ SCPI Command Reference

Command Types

Commands are separated into two types: *IEEE Std 488.2-1987* Common Commands and SCPI Commands.

Common Command Format

The *IEEE Std 488.2-1987* defines the common commands that perform functions like reset, self-test, status byte query, and so forth common commands are four or five characters in length, always begin with the asterisk character (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of common commands are shown below:

```
*RST *ESR 32 *STB?
```

SCPI Command Format

SCPI commands perform functions such as making measurements, querying instrument states, or retrieving data. A command subsystem is a hierarchical structure that usually has a top level (or root) command, one or more low-level commands, and their parameters. The following example shows a typical subsystem:

```
CALibration
    :INTernal? <type>
    :COUNt?
    :ZERO:AUTO <mode>
    :ZERO:AUTO?
```

CALibration is the root command; INTernal?, COUNt?, and ZERO are second level commands; and AUTO is a third level command.

Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

```
CALibration:ZERO:AUTO?
```

Colons separate the root command from the second level command (CALibration:ZERO) and the second level from the third level (ZERO:AUTO?).

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, use the abbreviated form. For better program readability, you may use the entire command. The instrument will accept either the abbreviated form or the entire command.

For example, if the command syntax shows MEASure, then MEAS and MEASURE are both acceptable forms. Other forms of MEASure, such as MEASU or MEASUR will generate an error. You may use upper or lower case letters. Therefore, MEASURE, measure, and MeAsUrE are all acceptable.

Implied Commands

Implied commands are those that appear in square brackets ([ ]) in the command syntax. (Notice that the brackets are not part of the command and are not sent to the instrument.) Suppose you send a second level command but do not send the preceding implied command. In this case, the instrument assumes you intend to use the implied command and it responds as if you had sent it. Examine the partial SENSe subsystem shown below (this subsystem also contains optional *parameters* enclosed in square brackets; see *Optional Parameters* for more information).

```
[SENSe:]
    RESistance
        :APERture <time>
        :APERture? [MINimum|MAXimum]
        :NPLCycles <number>
        :NPLCycles? [MINimum|MAXimum]
```

The root command SENSe is an implied command.

To set the multimeter's aperture to maximum: you can send either of the following command statements:

```
SENS:RES:APER MAX or RES:APER MAX
```

Parameters

Parameter Types: The following table contains explanations and examples of parameter types you might see later in this chapter.

Table 8-1. Parameter Types

Type	Explanations and Examples
Numeric	Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation.
	123, 123E2, -123, -1.23E2, 0.123, 1.23E-2, 1.23000E-01. Special cases may include MIN, MAX, and INF.
Boolean	Represents a single binary condition that is either true or false.
	ON, OFF, 1, 0.
Discrete	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting.
	An example is the TRIGger:SOURce <source> command where source can be BUS, EXT, HOLD, or IMM.

Optional Parameters. Parameters shown within square brackets ([ ]) are optional parameters. (Note that the brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument chooses a default value. For example, consider the TRIGger:COUNt?[MINimum|MAXimum] command. If you send the command without specifying a MIN or MAX parameter, the present TRIGger:COUNt value is returned. If you send the MIN parameter, the command returns the minimum trigger count available. If you send the MAX parameter, the command returns the maximum trigger count available. Be sure to place a space between the command and the parameter.

Channel Lists

Channel lists are used to specify the multiplexer ports of the multimeter. The channel list is used with the ROUTe:OPEN and ROUTe:CLOSe commands to specify which switch connections are to be made. The CONFigure[:SCALar] and MEASure[:SCALar] commands use the channel list parameter to specify which multiplexer inputs are to be scanned for a measurement.

The basic form of a channel list is (@101,102,104) where 101 refers to card 1, channel 1. A range of consecutive channels may be selected using the form (@100:103), where 00 is the first channel selected and 03 is the last channel selected on card 1. An example of combining these notations is (@100,103:106). Alternatively, the card number may be entered separate from the channels in the following form: (@1(0,3,4:6,7)).

Multimeter Range and Resolution Tables

The following tables list the voltage, current, and resistance ranges available for the multimeter. Also shown are the associated resolution values versus aperture time in seconds or integration time in power line cycles (PLCs). You will be asked to refer to these tables throughout this chapter.

Table 8-2.
DC, AC, or AC+DC Voltage: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
30 mV	30.30000 mV	10 nV	10 nV	10 nV	100 nV	1 μV	10 μV
300 mV	303.0000 mV	100 nV	100 nV	100 nV	1 μV	10 μV	100 μV
3 V	3.030000 V	1 μV	1 μV	1 μV	10 μV	100 μV	1 mV
30 V	30.30000 V	10 μV	10 μV	10 μV	100 μV	1 mV	10 mV
300 V	303.0000 V	100 μV	100 μV	100 μV	1 mV	10 mV	100 mV

1 In 10 and 100 NPLC, more digits may be returned.

2 50 Hz aperture times are enclosed in parentheses.

Table 8-3.
DC, AC, or AC+DC Current: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
300 μA[3]	303.0000 μa	100 pA	100 pA	100 pA	1 nA	10 nA	100 nA
3 mA[3]	3.030000 ma	1 nA	1 nA	1 nA	10 nA	100 nA	1 μA
30 mA	30.30000 ma	10 nA	10 nA	10 nA	100 nA	1 μA	10 μA
300 mA	303.0000 mA	100 nA	100 nA	100 nA	1 μA	10 μA	100 μA
3 A[4]	3.030000 A	1 μA	1 μA	1 μA	10 μA	100 μA	1 mA

1 In 10 and 100 NPLC, more digits may be returned.

2 50 Hz aperture times are enclosed in parentheses.

3 This range applies to dc current only.

4 Limited by internal fuse, 2 A rating.

Table 8-4.
2-Wire or 4-Wire Ohms: Resolution versus Aperture or Integration Times

Range	Maximum Reading	Effective Resolution versus Aperture Time (seconds) or Integration Time (PLCs)[1]					
		1.67s (2.0s)[2] 100 PLCs	167 ms (200 ms) 10 PLCs	16.7 ms (20.0 ms) 1 PLCs	1.67 ms (2.0 ms) 0.1 PLCs	100 μs (100 μs) .005 PLCs	10 μs (10 μs) 0.0005 PLCs
30 Ω	30.30000 Ω	10 μΩ	10 μΩ	10 μΩ	100 μΩ	1 mΩ	10 mΩ
300 Ω	303.0000 Ω	100 μΩ	100 μΩ	100 μΩ	1 mΩ	10 mΩ	100 mΩ
3 kΩ	3.030000 kΩ	1 mΩ	1 mΩ	1 mΩ	10 mΩ	100 mΩ	1 Ω
30 kΩ	30.30000 kΩ	10 mΩ	10 mΩ	10 mΩ	100 mΩ	1 Ω	10 Ω
300 kΩ	303.0000 kΩ	100 mΩ	100 mΩ	100 mΩ	1 Ω	10 Ω	100 Ω
3 MΩ	3.030000 MΩ	1 Ω	1 Ω	1 Ω	10 Ω	100 Ω	1 kΩ
30 MΩ	30.30000 MΩ	10 Ω	10 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ
300 MΩ	303.0000 MΩ	100 Ω	100 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
3 GΩ	3.030000 GΩ	1 kΩ	1 kΩ	1 kΩ	10 kΩ	100 kΩ	1 MΩ

1 In 10 and 100 NPLC, more digits may be returned.

2 50 Hz aperture times are enclosed in parentheses.

IEEE Std 488.2-1987 **Common Commands**

This section describes the *IEEE Std 488.2-1987* Common Commands and Queries for the HP 70110A digital multimeter. Descriptive information about function and operation are included for each command. For complete details of the common commands refer to *ANSI/IEEE Std 488.2-1987*.

*CAL? (Internal Calibration Query)

The Internal Calibration Query performs the multimeter's ac flatness, ac offset, extended ohms, and precharge autocals. The routines take approximately 35 seconds to complete. The command returns "0" for successful autocals. If an autocal routine is not successful, the command returns a number indicating the failed condition (an error is also placed in the error queue). The following table lists the failure codes.

Failure Code	Failed Autocal
1	AC Offset (300 V)
2	AC Offset (3 V)
4	AC Flatness (300 mV)
8	AC Flatness (3 V)
16	Precharge
32	Extended Ohms Range
64	Timeout

*CLS (Clear Status)

The Clear Status command clears status data structures, the Request-for-OPC flag, and forces the multimeter into the Operation Complete Command Idle State and the Operation Complete Query Idle State. The status data structures include all Event registers and all Queues, except the Output Queue.

*DMC (Define Macro)

The Define Macro command lets you assign a sequence of program elements to a macro label. The sequence is executed when the label is received as a command or query program header. This macro helps minimize backplane command traffic. The detailed description is described in the *IEEE Std 488.2-1987*. You can define a macro by sending the *DMC command, followed by a string designating the label. Following the label, you must send an <*Arbitrary Block Program Data*> element defining the macro. For example:

```
*DMC "TRG_EXT",#213TRIG:SOUR EXT
```

defines a macro with the name "TRG_EXT" that selects the rear panel "EXT TRIG" connector as the multimeter's source. The components of a macro command statement are composed of the following syntactic elements:

```
                                           *DMC "TRG_EXT",#213TRIG:SOUR EXT
                                           ──────  ──────── ┬┬─────
        Define macro command ──┘                          │││
                                                           │││
        Quoted string as the macro name ──┘               ││
                                                           ││
        "#" sign ───────────────────────────────────┘     │
                                                           │
        The number of digits that follow: ───────────┘     │
        here, it is two because numeral 1,
        and numeral 3 follow it.

        The number of characters in the ──────────────┘
        message that follows:  the message
        has 13 characters including spaces.
```

Macro definitions also allow you to pass parameters with the macro. Placeholders for
parameters appear as a dollar sign (ASCII $, 36 decimal) followed by a single digit in the
range 1 to 9 (49-57 decimal). For example:

```
        *DMC "SMP_CNT",#212SAMP:COUN $1;:ARM:STOP:SOUR
        EXT;:ARM:LEV $1
```

defines a macro with one parameter. Sending the command

```
        "SMP_CNT 10"
```

would be equivalent to sending this command to the multimeter:

```
        SAMP:COUN 10
```

The macro label may be either a command or a query. The label cannot be the same as
a common command or common query. It may be the same as a multimeter dependent
command. When a macro label is the same as a multimeter dependent command, the
multimeter will execute the macro rather than the multimeter command if macros are
enabled.

*EMC (Enable Macro)

This command enables and disables the expansion of macros by a multimeter. However, it
does not affect the macro definitions. An example of the use of this command is to turn
off macros in order to use a multimeter dependent command which has the same name as a
macro. Sending this command followed by 0 will disable all macros. Sending an integer other
than 0 in the range −32768 to 32767 will enable macros. If the number does not round to an
integer within this range −200, "Execution Error", will be reported.

For example, sending

```
        *EMC 0
```

will disable macros. Sending

```
        *EMC −12
```

will enable macros.

*EMC? (Enable Macro Query)

The Enable Macro Query allows the user to determine whether or not macros are enabled on the multimeter. The multimeter will return a value of 1 (ASCII 49 decimal) when macros are enabled. It will return a value of 0 (ASCII 48 decimal) when macros are disabled.

*ESE (Standard Event Status Enable)

The Standard Event Status Enable command sets the Standard Event Status Enable Register bits. The data is defined as *<Decimal Numeric Program Data>*. The multimeter rounds this number to an integer. Expressing this number in base 2 (binary) represents values of the individual bits of the Standard Event Status Enable Register. For example to set bit 5 (Command Error) and bit 2 (Query Error) the command

        *ESE 36

would be sent to the multimeter. The number sent to the multimeter must be in the range 0 to 255 or an error, −222, "Data out of range", occurs. (Refer to STATus command description for more information about the Standard Event Status Register.)

*ESE? (Standard Event Status Enable Query)

This command reads the contents of the Standard Event Status Enable Register (SESER). In response to this query the multimeter sends the contents of the SESER in integer format. It will be in the range 0 to 255.

*ESR? (Event Status Register Query)

The Event Status Register Query reads the contents of the Standard Event Status Register. Reading this register clears it. It returns an integer, which, when converted to a binary number represents the contents of the individual bits of the register. This number will be in the range 0 to 255 decimal.

*GMC? (Get Macro Contents Query)

The Get Macro Contents Query allows you to obtain the current definition of a macro from the multimeter. Simply send the *GMC? query followed by the label string of the macro. The multimeter responds with a *<Definite Length Arbitrary Block Response Data>* element which contains the macro definition. For example, sending

        *GMC? "TRG_EXT"

to a multimeter will tell it to send the macro definition for the macro "TRG_EXT" defined earlier. An attempt to retrieve the contents of an undefined macro returns a zero length block and reports an error, −270, "Macro error".

*IDN? (Identification Query)

The Identification Query causes the multimeter to send its "identity" over the bus as an *<Arbitrary ASCII Response Data>* element. The response string for the HP 70110A digital multimeter MMS Multimeter will appear as follows:

    HEWLETT-PACKARD,70110A,XXXXXXXXXX,910920

The entire length of the response is 72 characters or less. The third field (represented by ten X's) will contain the module's serial number. The last field of the response (910920) is the firmware revision date code.

*LMC? (Learn Macro Query)

The Learn Macro Query instructs the multimeter to respond with the labels of all the currently defined macros. The multimeter will respond with strings separated by commas. If no macros are defined the multimeter will return a null string of two consecutive double quote (" ") marks. The response is the same whether or not macros are enabled or disabled.

*LRN? (Learn Query)

The Learn command returns a string of SCPI commands which defines the multimeter current state.

*OPC (Operation Complete)

The Operation Complete command tells the multimeter to set bit 0 in the Standard Event Status Register when it completes all pending operations.

*OPC? (Operation Complete Query)

The Operation Complete Query tells the multimeter to place an ASCII '1' (decimal 49) in the multimeter's output queue when it completes all pending operations.

*OPT? (Option Identification Query)

The Option Identification Query is for identifying reportable device options. Return values are:

- 0 means no option is installed in the module.
- 001 means Armature Relay/Actuator (Option 001) is installed in the module.
- 002 means Reed Relay Multiplexer (Option 002) is installed in the module.
- 10 means Relay Actuator Card is installed in the module.

*PMC (Purge Macros)

The Purge Macros Command causes the multimeter to delete all macros in memory that were defined by the *DMC command. All macro sequences and labels are removed from memory. You can purge single macros by using the *RMC command (Remote Individual Macro).

*PSC (Power-on Status Clear)

The Power-on Status Clear command controls the automatic power-on clearing of the Service Request Enable Register and the Standard Event Status Enable Register. The data sent with this command is <*Decimal Numeric Program Data*> and must be within the range −32767 through +32767. The value of the data sent determines whether the power-on-status-clear flag of the multimeter is TRUE or FALSE. A non-zero value enables the power-on clear and disallows any SRQ assertion after power-on. A value of zero allows the multimeter to assert SRQ after power-on.

*PSC? (Power-on Status Clear Query)

The Power-on Status Clear Query returns a value of "0" or "1". "0" indicates that the Standard Even Status Enable Register and Service Request Enable Register will retain their status after cycling power. A value of "1" indicates these registers will be cleared after cycling power.

*PUD (Protected User Data)

The Protected User Data command stores up to 63 bytes of user defined data in non-volatile memory. The protection mechanism is the CALibration:SECurity[:STATe] command. The syntax of the data is an <*Arbitrary Block Program Data*>.

*PUD? (Protected User Data Query)

The Protected User Data Query returns the block of data stored by the *PUD command.

*RCL (Recall)

The Recall command restores the state of a multimeter from a copy previously stored in local memory through the *SAV command. The multimeter has I/O storage areas, so the command includes a numeric parameter to indicate which storage area to use. These numbers will begin at zero and end at nine.

*RMC(Remote Individual Macro)

The Remote Individual Macro command provides a non-global means for removing defined macros. This is in addition to the *PMC (Purge All Macro) command. For example, to remove the "TRG_EXT" macro, send *RMC "TRG_EXT".

*RST (Reset)

This command resets the multimeter. The Reset command:

1. Sets the multimeter-dependent functions to a known state, independent of its current state. (Refer to Table 1-2.)

2. Disables macros.

3. Aborts all pending operations.

4. Forces the multimeter to forget about any previously received Operation Complete commands.

The Reset command does *not* affect:

1. The Output Queue.

2. The Error Queue.

3. The Service Request Enable Register.

4. The Standard Event Status Enable Register.

5. The power-on flag.

6. Macros (except to disable them).

7. Calibration data.

8. The Protected User Data (for example, Save/Recall states).

*SAV (Save)

The Save Command stores the present state of the multimeter in local memory. The multimeter has ten locations in which to store this data. Therefore, the command is followed by a numeric parameter designating the storage area to use. These numbers begin at zero and end at nine. The instrument states are stored until power is removed from the multimeter.

*SRE (Service Request Enable)

The Service Request Enable command sets the Service Request Enable Register. This register determines what bits in the Status Byte will cause a service request from the multimeter. The data sent with the command is a <*Decimal Numeric Program Data*>. The multimeter rounds this number to an integer. Expressing this number in base 2 (binary) would then represent the values of the individual bits of the Service Request Enable Register.

For example, to set bit 4 (Message Available) the command

        *SRE 16

would be sent. The multimeter would then cause a service request when data is ready.

*SRE? (Service Request Enable Query)

The Service Request Enable Query reads the contents of the Service Request Enable Register. The multimeter returns the data as an <NR1> (integer), in the range 0 to 63 or 128 to 191, since bit 6 (the RQS bit) cannot be set.

*STB? (Status Byte Query)

The Status Byte Query reads the status byte with the Master Summary Status (MSS) bit. The multimeter responds with an integer in the range 0 to 255. These bits represent the contents of the status byte. Bit 6 represents MSS rather than RQS (Request Service). (Refer to STATus command for more information about the Status Byte Register.)

*TRG (Trigger)

The Trigger command causes the multimeter to immediately start/stop a measurement if the corresponding TRIGger source is previously programmed to "BUS". When "BUS" is selected as a source, the word-serial command <GET> or *TRG will satisfy the triggering condition. The measurement must be INITiated prior to sending *TRG (refer to the INITiate command).

*TST? (Self-Test Query)

The Self-Test Query performs a series of internal self-tests on the multimeter. If any test fails, the multimeter returns a decimal-weighted number representing the failed condition (see below). The number is sent to the output buffer.

Weighted Value	Description
0	All tests passed.
1	Inguard UART failure.
2	Inguard CPU failure.
4	Inguard link failure.
8	Integrator convergence error.
16	Front end zero measurement error.
32	Gain test error.
64	Amps Function gain.
128	AC amplifier's dc offset test failure.
256	AC flatness check failure.
512	Ohms precharge failure.
2048	System RAM checksum failure.
4096	Calibration memory checksum failure.
8192	Autocalibration memory checksum failure.
16384	ROM checksum failure.

Always disconnect all input signals before you run self-test. If you leave an input signal connected to the multimeter, it may cause a self-test failure. The *TST? command may take up to 10 seconds to execute.

*WAI (Wait)

The Wait to Continue command makes the multimeter wait until all the previous commands or queries complete. It thus forces the sequential execution of commands. The multimeter then continues executing commands that follow the *WAI command.

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI) for the HP 70110A digital multimeter. Commands are listed alphabetically by subsystem and within each subsystem. Command guides are printed in the top margin of each page. The inside guide indicates the subsystem for the command listed on that page. The outside guide indicates the command listed on that page. If a subsystem description appears on a page, the inside and outside guides will be the same.

ABORt

The ABORt command subsystem removes the multimeter from the wait-for-trigger state and places it in the idle state. ABORt can only be used with the following trigger sources: TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

Subsystem Syntax	ABORt
Example	**Aborting a Measurement**

CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR HOLD	*Suspend triggering; wait for TRIG:IMM command.*
INIT	*place multimeter in wait-for-trigger state.*
ABOR	*place multimeter in idle state.*

Comments

■ ABORt does not affect any other settings of the trigger system. When the INITiate command is sent, the trigger system will respond as it did before ABORt was executed.

■ When TRIGger:SOURce BUS is selected as the trigger source, ABORt returns the multimeter to the idle state. When a Group Execute Trigger (GET) bus command or * TRG common command is executed after an ABORt, the "Trigger ignored" error is generated.

■ When TRIGger:SOURce HOLD is selected as the trigger source, ABORt returns the multimeter to the idle state. All subsequent single triggers sent using TRIGger:IMMediate are ignored and the "Trigger ignored" error is generated.

■ **Related Commands:** INITiate, TRIGger

■ ***RST Condition:** After a *RST, the multimeter acts as though an ABORt has occurred.

CALCulate

The CALCulate command subsystem allows the multimeter to:

■ Collect statistical information on a series of measurements.

■ Limit test data by setting upper and lower limits which are compared, when active, to each measurement.

■ Apply specified mathematical functions on each measurement.

Subsystem	CALCulate
Syntax	:AVERage

```
            :AVERage
                :AVERage?
                :COUNt?
                :MAXimum?
                :MINimum?
                :STANdarddev?
                :STATe OFF|0|ON|1
                :STATe?
            :LIMit
                :LOWer
                    [:DATA] <limit> |MIN|MAX
                    [:DATA]? [MIN|MAX]
                :STATe OFF|0|ON|1
                :STATe?
                :UPPer
                    [:DATA] <limit> |MIN|MAX
                    [:DATA]? [MIN|MAX]
            [:MATH]
                :DB
                    :REFerence
                        [:DATA] <reference>
                        [:DATA]?
                    :STATe OFF|0|ON|1
                    :STATe?
                :DBM
                    :RESistance
                        [:DATA] <resistance>
                        [:DATA]?
                    :STATe OFF|0|ON|1
                    :STATe?
                :NULL
                    :OFFSet
                        [:DATA] <offset>
                        [:DATA]?
                    :STATe OFF|0|ON|1
                    :STATe?
                :PATH?
                :PERCent
```

```
          :REFerence
              [:DATA] <reference>
              [:DATA]?
          :STATe OFF|0|ON|1
          :STATe?
      :SCALe
          :FACTor
              [:DATA] <factor>
              [:DATA]?
          :STATe OFF|0|ON|1
          :STATe?
      :STATe OFF|0|ON|1
      :STATe?
```

:AVERage:AVERage?

CALCulate:AVERage:AVERage? queries the average. The average is one of the
statistical parameters stored into memory whenever statistical collection is enabled by
CALC:AVERage:STATE ON.

Example   **Query Average**

CALC:AVER:AVER?   *Queries the average.*

enter statement   *Enter value into computer.*

Comments   ■ The average subsystem calculates the average on a series of measurements

using the formula: Average $= \dfrac{\sum_{i=+1}^{n} X_i}{n}$

■ Any change in measurement mode or in the math functions will be reflected
in the collection of statistical information by resetting the count to 0.

■ **Related Commands:** CALCulate:AVERage:STANdarddev?,
CALCulate:AVERage:COUNt?, CALCulate:AVERage:MAXimum?,
CALCulate:AVERage:MINimum?, CALCultate:AVERage:STATe

:AVERage:COUNt?

CALCulate:AVERage:COUNt? queries the count. The count is one of the statistical parameters stored into memory whenever statistical collection is enabled by CALC:AVERage:STATE ON.

Example   **Query Count**

        `CALC:AVER:COUN?`   *Queries the count.*

        `enter statement`   *Enter value into computer.*

Comments   ■ The average subsystem calculates the count on a series of measurements using the formula: Count = n

                ■ Any change in measurement mode or in the math functions will be reflected in the collection of statistical information by resetting the count to 0.

                ■ **Related Commands:** CALCulate:AVERage:STANdarddev?, CALCulate:AVERage:AVERage?, CALCulate:AVERage:MAXimum?, CALCulate:AVERage:MINimum?, CALCultate:AVERage:STATe

:AVERage:MAXimum?

CALCulate:AVERage:MAXimum? queries the maximum. The maximum is one of the statistical parameters stored into memory whenever statistical collection is enabled by CALC:AVERage:STATE ON.

Example   **Query Maximum**

                `CALC:AVER:MAX?`   *Queries the maximum.*

                `enter statement`   *Enter value into computer.*

Comments   ■ The average subsystem calculates the maximum on a series of measurements using the formula: Maximum = Maximum reading in the series of measurements.

               ■ Any change in measurement mode or in the math functions will be reflected in the collection of statistical information by resetting the count to 0.

               ■ **Related Commands:** CALCulate:AVERage:STANdarddev?, CALCulate:AVERage:AVERage?, CALCulate:AVERage:COUNt?, CALCulate:AVERage:MINimum?, CALCultate:AVERage:STATe

:AVERage:MINimum?

CALCulate:AVERage:MINimum? queries the minimum. The minimum is one of the statistical parameters stored into memory whenever statistical collection is enabled by CALC:AVERage:STATE ON.

Example   **Query Minimum**

CALC:AVER:MIN?   *Queries the minimum.*

enter statement   *Enter value into computer.*

Comments   ■ The average subsystem calculates the minimum on a series of measurements using the formula: Minimum = Minimum reading in the series of measurements.

■ Any change in measurement mode or in the math functions will be reflected in the collection of statistical information by resetting the count to 0.

■ **Related Commands:** CALCulate:AVERage:STANdarddev?, CALCulate:AVERage:AVERage?, CALCulate:AVERage:COUNt?, CALCulate:AVERage:MAXimum?, CALCultate:AVERage:STATe

:AVERage:STANdarddev?

CALCulate:AVERage:STANdarddev? queries the standard deviation. The standard deviation is one of the statistical parameters stored into memory whenever statistical collection is enabled by CALC:AVERage:STATE ON.

Example   **Query Standard Deviation**

            CALC:AVER:STAN?   *Queries the standard deviation.*

            enter statement   *Enter value into computer.*

Comments   ■ The average subsystem calculates the standard deviation on a series of measurements using the formula: Standard Deviation $= \sqrt{\frac{\sum_{i=+1}^{n}(X_i - \bar{X})^2}{n-1}}$

           ■ Any change in measurement mode or in the math functions will be reflected in the collection of statistical information by resetting the count to 0.

           ■ **Related Commands:** CALCulate:AVERage:Average?, CALCulate:AVERage:COUNt?, CALCulate:AVERage:MAXimum?, CALCulate:AVERage:MINimum?, CALCultate:AVERage:STATe

:AVERage:STATe

CALCulate:AVERage:STATe $<state>$ enables or disables collection of statistical information on a string of measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling Collection of Statistical Information**

`STAT:QUES:ENAB 4096`   *Enable bit 12 in Questionable Register.*
`CALC:AVER:STAT ON`   *Enable statistical collection.*

Comments   ■ The AVERage subsystem calculates several statistical parameters on a series of measurements. The parameters stored into memory are:

$$
\text{STANdarddev} = \sqrt{\frac{\sum_{i=+1}^{n}(X_i - \bar{X})^2}{n-1}}
$$

$$
\text{AVERage} = \frac{\sum_{i=+1}^{n} X_i}{n}
$$

$$
\text{COUNt} = n
$$

$$
\text{MAXimum} = \text{Maximum reading in group}
$$

$$
\text{MINimum} = \text{Minimum reading in group}
$$

■ Any change in measurement mode or in the math functions will be reflected in the collection of statistical information by resetting the count to 0.

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate:AVERage:STATe OFF

:AVERage:STATe?

CALCulate:AVERage:STATe? queries the state of statistical collection. A "0" is returned if statistical collection is disabled and a "1" is returned if statistical collection is enabled.

Example   **Query State of Statistical Collection**

           CALC:AVER:STAT?   *Queries if statistical collection is enabled or disabled.*

           enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: CALCulate:AVERage:STATe OFF

:LIMit:LOWer[:DATA]

CALCulate:LIMit:LOWer[:DATA] <*limit*> is used to define the lower limit to be used in the limit test. When the data returned from the multimeter is less than the value specified an error will be reported.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
limit	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	none

Example   Setting a Lower Limit

        STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
        CALC:LIM:STAT ON   *Enable limit testing.*
        CALC:LIM:LOW -10   *Sets the lower limit to −10.*

Comments   ■ If the data sent to the desired output is less than the lower limits, bit 12 (4096) in the Questionable Data/Signal Register gets set if it has previously been enabled.

   ■ MIN value is −9.9E+37

   ■ MAX value is +9.9E+37

   ■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

   ■ **Related Commands:** CALCulate:LIMit:STATe, STATus:QUEStionable:ENABle

   ■ ***RST Condition:** Lower limit set to −9.9E+37 and limit test disabled.

:LIMit:LOWer[:DATA]?

CALCulate:LIMit:LOWer[:DATA]? [MIN|MAX] returns to the output buffer the lower limits for the limit test. If MIN is specified, the query returns the minimum value of −9.9E+37 to the output buffer. If MAX is specified, +9.9E+37 is returned to the output buffer.

Example   **Querying a Lower Limit**

           `CALC:LIM:LOW -10`   *Sets lower limit to −10.*

           `CALC:LIM:LOW?`   *Query multimeter to return the present lower limit.*

           `enter statement`   *Enter value into computer.*

:LIMit:STATe

CALCulate:LIMit:STATe <state> enables or disables limit testing.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   Enabling Limit Testing

    STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
    CALC:LIM:STAT ON   *Enable limit testing.*

Comments   ■ If limit testing is not enabled, but lower and upper limits have been selected, the data will not be compared to the limits and the Questionable Register will not be updated when data falls outside the limits.

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate:LIMit:STATe OFF

:LIMit:STATe?

CALCulate:LIMit:STATe? queries the state of limit test. A "0" is returned if limit testing is disabled and a "1" is returned if limit testing is enabled.

Example   **Query State of Limit Testing**

                    `CALC:LIM:STAT?`   *Queries if limit testing is enabled or disabled.*
                    `enter statement`   *Enter value into computer.*

Comments   ■ ***RST Condition:** CALCulate:LIMit:STATe OFF

:LIMit:UPPer[:DATA]

CALCulate:LIMit:UPPer[:DATA] <*limit*> is used to define the upper limit to be used in the limit test. When the data returned from the multimeter is greater than the value specified an error will be reported.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
limit	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX| none

Example   **Setting an Upper Limit**

        STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
        CALC:LIM:STAT ON   *Enable limit testing.*
        CALC:LIM:UPP +10   *Sets the upper limit to +10.*

Comments   ■ If the data sent to the desired output is greater than the upper limits, bit 12 (4096) in the Questionable Data/Signal Register gets set if it has previously been enabled.

■ MIN value is −9.9E+37

■ MAX value is +9.9E+37

■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

■ **Related Commands:** CALCulate:LIMit:STATe,STATus:QUEStionable:ENABle

■ ***RST Condition:** Upper limit set to +9.9E+37 and limit test disabled.

:LIMit:UPPer[:DATA]?

CALCulate:LIMit:UPPer[:DATA]? [MIN|MAX] returns to the output buffer the upper limits for the limit test. If MIN is specified, the query returns the minimum value of $-9.9E+37$ to the output buffer. If MAX is specified, $+9.9E+37$ is returned to the output buffer.

Example   **Querying an Upper Limit**

CALC:LIM:UPP -10	*Sets lower limit to -10.*
CALC:LIM:UPP?	*Query multimeter to return the present upper limit.*
enter statement	*Enter value into computer.*

[:MATH]:DB:REFerence[:DATA]

CALCulate[:MATH]:DB:REFerence[:DATA] *<reference>* is used to select the reference value to be used in calculating the dB ratio.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
reference	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	dB

Example   **Setting the dB Reference**

> STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
> CALC:DB:REF 0.1   *Set the dB reference to 0.1 V*

Comments

- The dB math operation calculates a ratio in decibels. The equation is: Result $= 20 \times \log_{10}($Reading $\div$ Reference$)$ where Reading is any measured value and Reference is the value provided by using CALCulate[:MATH]:DB:REFerence.

- MAX value is +9.9E+37

- MIN value is −9.9E+37

- MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

- **Related Commands:** CALCulate[:MATH]:DB:REF?

- ***RST Condition:** 1.000000 V

[:MATH]:DB:REFerence[:DATA]?

CALCulate[:MATH]:DB:REFerence[:DATA]? [MIN|MAS] returns to the output buffer the reference value being used to compute the dB ratio. If MIN is specified, the query returns the minimum value of −9.9D+8 to the output buffer. If MAX is specified, +9.9E+37 is returned to the output buffer.

Example   **Querying a dB Ratio**

                CALC:DB:REF?   *Query multimeter to return the reference value for dB.*

                enter statement   *Enter value into computer.*

Comments   ■ The dB math operation calculates a ratio in decibels. The equation is: Result = $20 \times \log_{10}$(Reading $\div$ Reference) where Reading is any measured value and Reference is the value provided by using CALCulate:DB:REFerence.

[:MATH]:DB:STATe

CALCulate[:MATH]:DB:STATe <*state*> enables or disables the dB math operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling the dB Math Operation**

STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
CALC:DB:STAT ON   *Enable dB math operation.*

Comments   ■ If dB math operation is not enabled, but the dB reference has been selected, calculation of dB will not be made.

■ The dB math operation calculates a ratio in decibels. The equation is: Result $= 20 \times \log_{10}(\text{Reading} \div \text{Reference})$ where Reading is any measured value and Reference is the value provided by using CALCulate[:MATH]:DB:REFerence.

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate[:MATH]:DB:STAT OFF

[:MATH]:DB:STATe?

CALCulate[:MATH]:DB:STATe? queries the state of the dB math operation. A "0" is returned if dB math operation is disabled and a "1" is returned if dB math operation is enabled.

Example   **Query State of dB Math Operation**

                CALC:DB:STAT?   *Queries if the dB math operation is enabled or disabled.*

                enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: CALCulate[:MATH]:DB:STATe OFF

[:MATH]:DBM:RESistance[:DATA]

CALCulate[:MATH]:DBM:RESistance[:DATA] <*resistance*> is used to select the resistance value to be used in calculating the dBm ratio.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resistance	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	ohms

Example   **Setting the dBm Resistance**

             STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*

             CALC:DBM:RES 1   *Set the dBm resistance to 1 Ω*

Comments   ■ The dBm math operation calculates the power delivered to a resistance, referenced to 1 mW. The equation is: Result = 10 × $\log_{10}$(Reading^2/Resistance/1 mW) where Reading is any measured value and Resistance is the resistance value provided by using CALCulate[:MATH]:DBM:RESistance.

             ■ MAX value is +9.9E+37

             ■ MIN value is −9.9E+37

             ■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

             ■ **Related Commands:** CALCulate[:MATH]:DBM:RES?

             ■ ***RST Condition:** 50 Ω

[:MATH]:DBM:RESistance[:DATA]?

CALCulate[:MATH]:DBM:RESistance[:DATA]? [MIN|MAX] returns to the output buffer
the resistance value being used to compute dBm. If MIN is specified, the query returns the
minimum value of $-9.9D+8$ to the output buffer. If MAX is specified, $+9.9E+37$ is returned
to the output buffer.

Example   **Querying a dBm Resistance Value**

CALC:DBM:RES?   *Query multimeter to return the resistance value*
                                    for dBm.

enter statement   *Enter value into computer.*

Comments   ■ The dBm math operation calculates the power delivered to a
resistance, referenced to 1 mW. The equation is: Result $= 10 \times$
$\log_{10}(\text{Reading}^2/\text{Resistance}/1 \text{ mW})$ where Reading is any measured
value and Resistance is the resistance value provided by using
CALCulate[:MATH]:DBM:RESistance.

[:MATH]:DBM:STATe

CALCulate[:MATH]:DBM:STATe <*state*> enables or disables the dBm math operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example **Enabling dBm Math Operation**

> STAT:QUES:ENAB 4096 *Enable bit 12 in Questionable Register.*
> CALC:DBM:STAT ON *Enable dBm math operation.*

Comments ■ If dBm math operation is not enabled, but the dBm resistance has been selected, the dBm value will not be supplied.

■ The dBm math operation calculates the power delivered to a resistance, referenced to 1 mW. The equation is: Result = 10 × $\log_{10}(\text{Reading}^2/\text{Resistance}/1 \text{ mW})$ where Reading is any measured value and Resistance is the resistance value provided by using CALCulate[:MATH]:DBM:RESistance.

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate[:MATH]:DBM:STAT OFF

[:MATH]:DBM:STATe?

CALCulate[:MATH]:DBM:STATe? queries the state of the dBm math operation. A "0" is returned if dBm math operation is disabled and a "1" is returned if dBm math operation is enabled.

Example   **Query State of dB Math Operation**

            CALC:DBM:STAT?   *Queries if the dBm math operation is enabled or disabled.*

            enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: CALCulate[:MATH]:DBM:STATe OFF

[:MATH]:NULL:OFFSet[:DATA]

CALCulate[:MATH]:NULL:OFFSet[:DATA] <*offset*> is used to select the offset value to be used in calculating the null operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
offset	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	none

Example   **Setting the Null Offset**

STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
CALC:NULL:OFFS 1   *Set the null offset to 1*

Comments
- The null math operation subtracts a value from each subsequent measurement. The equation is: Result = Reading − Offset where Reading is any measured value and Offset is a value selected by the user.

- MAX value is +9.9E+37

- MIN value is −9.9E+37

- MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

- **Related Commands:** CALCulate[:MATH]:NULL:OFFSet?

- ***RST Condition:** 0.0

[:MATH]:NULL:OFFSet[:DATA]?

CALCulate[:MATH]:NULL:OFFSet[:DATA]? [MIN|MAX] returns to the output buffer the offset value used to compute null. If MIN is specified, the query returns the minimum value of $-9.9D+8$ to the output buffer. If MAX is specified, $+9.9E+37$ is returned to the output buffer.

Example   **Querying a Null Offset**

                CALC:NULL:OFFS?   *Query multimeter to return the offset value for null operations.*

                enter statement   *Enter value into computer.*

Comments
- The null math operation subtracts a value from each subsequent measurement. The equation is: Result = Reading − Offset where Reading is any measured value and Offset is a value selected by the user.

- MAX value is $+9.9E+37$

- MIN value is $-9.9E+37$

- MIN and MAX values for manual entry are -9999999999.0 and $+9999999999.0$

- **Related Commands:** CALCulate[:MATH]:NULL:OFFS

[:MATH]:NULL:STATe

CALCulate[:MATH]:NULL:STATe <*state*> enables or disables the Null math operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling Null Math Operation**

    STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
    CALC:NULL:STAT ON   *Enable dBm math operation.*

Comments
- If Null math operation is not enabled, but the Null offset has been selected, the Null value will not be supplied.

- The null math operation subtracts a value from each subsequent measurement. The equation is: Result = Reading − Offset where Reading is any measured value and Offset is a value selected by the user.

- **Related Commands:** STATus:QUEStionable:ENABle

- ***RST Condition:** CALCulate[:MATH]:NULL:STAT OFF

[:MATH]:NULL:STATe?

CALCulate[:MATH]:NULL:STATe? queries the state of the Null math operation. A "0" is returned if null math operation is disabled and a "1" is returned if null math operation is enabled.

Example   **Query State of Null Math Operation**

                       CALC:NULL:STAT?   *Queries if the null math operation is enabled or disabled.*

                       enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: CALCulate[:MATH]:NULL:STATe OFF

[:MATH]:PATH?

CALCulate[:MATH]:PATH? queries the order in which math operations are being calculated.

Example   **Query Order of Math Operations**

                CALC:PATH?   *Queries the order of the math operations.*
                enter statement   *Enter value into computer.*

Comments   ■ Whenever math operations are being calculated, they are occurring in a
                 specific order dependent upon the order in which they were first turned
                 on. CALCulate[:MATH]:PATH? will return that order for the user. The
                 response will be a series of words naming the operations separated by
                 commas.

[:MATH]:PERCent:REFerence[:DATA]

CALCulate[:MATH]:PERCent:REFerence[:DATA] <*reference*> is used to select the reference value to be used in calculating the Percent operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
reference	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	none

Example   **Setting the Percent Reference**

    STAT:QUES:ENAB 4096 *Enable bit 12 in Questionable Register.*

    CALC:PERC:REF 10   *Set the dB reference to 10*

Comments

- The percent math operation determines the difference, in percent, between a measured reading and the value in the Percent register. The equation is: Result = [(Reading − Reference) ÷ Reference] × 100 where Reading is any measured value and Reference is the value provided by using CALCulate[:MATH]:PERCent:REFerence.

- MAX value is +9.9E+37

- MIN value is −9.9E+37

- MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

- **Related Commands:** CALCulate[:MATH]:PERCent:REF?

- ***RST Condition:** 1.000000

[:MATH]:PERCent:REFerence[:DATA]?

CALCulate[:MATH]:PERCent:REFerence[:DATA]? [MIN|MAX] returns to the output buffer the reference used to compute percent values. If MIN is specified, the query returns the minimum value of −9.9D+8 to the output buffer. If MAX is specified, +9.9E+37 is returned to the output buffer.

Example   **Querying the Percent Reference**

      CALC:PERC:REF? *Query multimeter to return the percent reference value.*

      enter statement *Enter value into computer.*

Comments ■ The percent math operation determines the difference, in percent, between a measured reading and the value in the Percent register. The equation is: Result = [(Reading − Reference) ÷ Reference] × 100 where Reading is any measured value and Reference is the value provided by using CALCulate[:MATH]:PERCent:REFerence.

      ■ MAX value is +9.9E+37

      ■ MIN value is −9.9E+37

      ■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

      ■ **Related Commands:** CALCulate[:MATH]:PERCent:REF

      ■ ***RST Condition:** 1.000000

[:MATH]:PERCent:STATe

CALCulate[:MATH]:PERCent:STATe <*state*> enables or disables the percent math operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling the Percent Math Operation**

        STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
        CALC:PERC:STAT ON   *Enable percent math operation.*

Comments
- If percent math operation is not enabled, but the percent reference has been selected, calculation of percent will not be made.

- The percent math operation determines the difference, in percent, between a measured reading and the value in the Percent register. The equation is: Result = [(Reading − Reference) ÷ Reference] × 100 where Reading is any measured value and Reference is the value provided by using CALCulate[:MATH]:PERCent:REFerence.

- MAX value is +9.9E+37

- MIN value is −9.9E+37

- MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

- **Related Commands:** STATus:QUEStionable:ENABle

- ***RST Condition:** CALCulate[:MATH]:PERCent:STAT OFF

[:MATH]:PERCent:STATe?

CALCulate[:MATH]:PERCent:STATe? queries the state of the percent math operation. A "0" is returned if percent math operation is disabled and a "1" is returned if percent math operation is enabled.

Example   **Query State of Percent Math Operation**

                        `CALC:PERC:STAT?`   *Queries if the percent math operation is enabled or disabled.*

                        `enter statement`   *Enter value into computer.*

Comments   ■ ***RST Condition:** CALCulate[:MATH]:PERCent:STATe OFF

[:MATH]:SCALe:FACTor[:DATA]

CALCulate[:MATH]:SCALe:FACTor[:DATA] <*factor*> is used to select the factor value to be used in calculating the scale operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
factor	numeric	−9.9E+37 through +9.9E+37 |MIN|MAX	none

Example   **Setting the Scale Factor**

       STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*

       CALC:SCAL:FACT .9   *Set the scale factor to .9*

Comments

■ The scale math operation modifies readings by multiplying by a scale factor. The equation is: Result = Reading × Factor where Reading is any measured value and Factor is the value provided by using CALCulate[:MATH]:SCALe:FACTor.

■ MAX value is +9.9E+37

■ MIN value is −9.9E+37

■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

■ **Related Commands:** CALCulate[:MATH]:SCALe:FACT?

■ ***RST Condition:** 1.000000

[:MATH]:SCALe:FACTor[:DATA]?

CALCulate[:MATH]:SCALe:FACTor[:DATA]? [MIN|MAX] returns to the output buffer the factor used to compute scale. If MIN is specified, the query returns the minimum value of −9.9D+8 to the output buffer. If MAX is specified, +9.9E+37 is returned to the output buffer.

Example   **Querying the Scale Factor**

                  CALC:SCAL:FACT?   *Query multimeter to return the factor value.*

                  enter statement   *Enter value into computer.*

Comments
- The scale math operation modifies readings by multiplying by a scale factor. The equation is: Result = Reading × Factor where Reading is any measured value and Factor is the value provided by using CALCulate[:MATH]:SCALe:FACTor.

- MAX value is +9.9E+37

- MIN value is −9.9E+37

- MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

- **Related Commands:** CALCulate[:MATH]:SCALe:FACTor

- ***RST Condition:** 1.000000

[:MATH]:SCALe:STATe

CALCulate[:MATH]:SCALe:STATe <*state*> enables or disables the scale math operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling the Scale Math Operation**

> STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
> CALC:SCAL:FACT ON   *Enable scale math operation.*

Comments   ■ If scale math operation is not enabled, but the scale factor has been selected, calculation of scale will not be made.

■ The scale math operation modifies readings by multiplying by a scale factor. The equation is: Result = Reading × Factor where Reading is any measured value and Factor is the value provided by using CALCulate[:MATH]:SCALe:FACTor.

■ MAX value is +9.9E+37

■ MIN value is −9.9E+37

■ MIN and MAX values for manual entry are −9999999999.0 and +9999999999.0

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate[:MATH]:SCALe:STATe OFF

[:MATH]:SCALe:STATe?

CALCulate[:MATH]:SCALe:STATe? queries the state of the scale math operation. A "0" is returned if scale math operation is disabled and a "1" is returned if scale math operation is enabled.

Example   **Query State of Scale Math Operation**

CALC:SCAL:STAT?   *Queries if the scale math operation is enabled or disabled.*

enter statement   *Enter value into computer.*

Comments   ■ ***RST Condition:** CALCulate[:MATH]:SCALe:STATe OFF

[:MATH]:STATe

CALCulate[:MATH]:STATe <*state*> enables or disables all of the math operations.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling Math Operation**

STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
CALC[:MATH]:STAT ON   *Enable math operation.*

Comments   ■ If MATH:STATe is not enabled then none of the math operations are enabled.

■ If MATH:STATe is disabled after being enabled then the sequence of math operations are disabled without altering their setup. This allows the math setup to be saved. For example, if a measurement function is changed, (which automatically turns math off), the previous math setup can be reinstated by merely enabling the MATH:STATe

■ **Related Commands:** STATus:QUEStionable:ENABle

■ ***RST Condition:** CALCulate[:MATH]:STAT OFF

[:MATH]:STATe?

CALCulate[:MATH]:STATe? queries the state of the math operations. A "0" is returned if the math operations are disabled and a "1" is returned if dBm math operations are enabled.

Example   **Query State of dB Math Operation**

CALC[:MATH]:STAT?   *Queries if the math operations are enabled or disabled.*

enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: CALCulate[:MATH]:STATe OFF

CALibration

The CALibration command subsystem:

■ Instructs the multimeter to perform one or both of its automatic calibrations (CALibration:INTernal?).

■ Returns a number indicating the number of times your multimeter has been calibrated (CALibration:COUNt?).

■ Enables or disables the autozero mode (CALibration:ZERO:AUTO).

Subsystem   CALibration
Syntax   :COUNt?
                    :INTernal? <*type*>
                    :POINt?
                    :SECurity
                        :CODE <*security code*>
                        [:STATe] <*mode*>[,<*security code*>]
                        [:STATe]?
                    :VALUe <*value*>
                    :VALUe? [MINimum|MAXimum]
                    :ZERO:AUTO <*mode*>
                    :ZERO:AUTO?

:COUNt?

CALibration:COUNt? returns a decimal number indicating the number of times your multimeter has been calibrated. The number is sent to the output buffer.

Example   **Querying the Calibration Number**

                        `CAL:COUN?`   *Query multimeter to return calibration number.*
                        `enter statement`   *Enter value into computer.*

Comments   ■ Your multimeter was calibrated before it left the factory. When you receive your multimeter, read the calibration number to determine its initial value.

               ■ The calibration number is stored in non-volatile multimeter memory (remains intact when power is removed).

               ■ The calibration number increments by one for each instrument point calibrated. A complete calibration increments the calibration number by several counts. The calibration number increments up to a maximum of 32,767 after which it wraps-around to 0.

               ■ Automatic calibration (**CALibration:INTernal?**) does not affect the calibration number.

:INTernal?

CALibration:INTernal? *<type>* instructs the multimeter to perform one or both of its automatic calibrations (autocals). This command returns "0" for successful autocals.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
type	discrete	AC|RESistance|ALL	none

Example

Performing the AC Autocal

CAL:INT? AC   *perform ac autocal.*

enter statement   *Enter value into computer.*

Comments

- The ac autocal performs the ac flatness and ac offset autocal. This increases short term accuracy for ac or ac+dc voltage measurements. This routine takes approximately 3 seconds to complete.

- The RES autocal performs the extended ohms and precharge autocal. This increases short term accuracy on the 3 GΩ range for 2-wire and 4-wire ohms measurements. This routine takes approximately 32 seconds to complete.

- ALL performs both the ac and RES autocals. This routine takes approximately 35 seconds to complete. The * CAL? common command also performs both autocal routines.

- The CALibration:INTernal? command returns "0" for successful autocals. If an autocal routine is not successful, the command returns a number indicating the failed condition (an error is also placed in the error queue). The following table lists the failure codes.

Failure Code	Failed Autocal
1	AC Offset (300 V)
2	AC Offset (3 V)
4	AC Flatness (300 mV)
8	AC Flatness (3 V)
16	Precharge
32	Extended Ohms Range
64	Timeout

- Always perform the RES autocal before making measurements on the 3 GΩ range.

- Always disconnect all input signals before you perform an autocal. If you leave an input signal connected to the multimeter, it may adversely affect the autocal.

- The autocal constants are stored in non-volatile multimeter memory (remain intact when power is removed). Therefore, it is not necessary to

perform autocal after power has been removed and re-applied. A one-hour
warmup is also recommended before performing an autocal.

:POINt?

CALibration:POINt? calibrates the present function and range. This command is used when adjustment procedures are run by a service technician. "0" is returned if the adjustment was accepted. A non-zero number is returned if an error has occurred. Send SYSTem:ERRor? to obtain more information about the error. The number is sent to the output buffer.

Example   **Calibrating**

VOLT:AC:RANG 3	*Set the voltmeter to the 3 Vac voltage range.*
CAL:SEC OFF,ABCD	*Enable calibration by turning security off. ABCD is the security code.*
CAL:VALUE 3	*Send the input value of the voltage standard.*
CAL:POIN?	*perform adjustment.*

Caution   Do not perform any adjustments using CALibration:POINt? unless you are a qualified service trained technician, following service adjustment procedures for the HP 70110A digital multimeter.

Comments   ■ CALibration:SECurity must be OFF to enable CALibration:POINt?.

■ **Related Commands:** CALibration:SECurity[:STATe] and CALibration:VALue

:SECurity:CODE

CALibration:SECurity:CODE <*security code*> sets a new value for the calibration security code.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
security code	character	maximum of twelve alpha-numeric characters, starting with a letter	none

Example   **Changing the Calibration Security Code**

CAL:SEC OFF, ABCD   *Turn off calibration security.*
CAL:SEC:CODE WXYZ   *Change the security code to WXYZ.*
CAL:SEC ON, WXYZ   *Turn on calibration security.*

Comments

Caution   Do not change the CALibration:SECurity:CODE unless you are a qualified service trained technician, following service adjustment procedures for the HP 70110A digital multimeter.

■ CALibration:SECurity must be OFF to change the CALibration:SECurity:CODE.

■ **Related Commands:** CALibration:SECurity[:STATe]

:SECurity[:STATe]

CALibration:SECurity[:STATe] <*mode*>[,<*security code*>] is used to enable service adjustments.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none
security code	character	maximum of twelve alpha-numeric characters, starting with a letter	none

Example   **Enabling Calibration Security**

           `CAL:SEC OFF, ABCD`   *Calibration Security is disabled.*

Comments

Caution

Do not enable CALibration:SECurity unless you are a qualified, service trained technician, following service adjustment procedures for the HP 70110A digital multimeter.

■ **Related Commands:** CALibration:SECurity:CODE, CALibration:VALue, CALibration:POINt?, *PUD

:SECurity[:STATe]?

CALibration:SECurity[:STATe]? returns a number to show where the calibration is secured.
"1" = ON (secured), "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Calibration Secure Mode**

                  CAL:SEC?   *Query multimeter to return calibration secure state.*

                  enter statement   *Enter value into computer.*

:VALue

CALibration:VALue <*value*> specifies the value to be applied to the input terminals as calibration adjustment.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
value	numeric	$-3 \ E^7$ through $3 \ E^7\|$ MIN|MAX	based on FUNC Ohm, Volts, Amps

Example   **Calibrating**

VOLT:AC:RANG 3	*Set the voltmeter to the 3 Vac voltage range.*
CAL:SEC OFF,ABCD	*Enable calibration by turning security off. ABCD is the security code.*
CAL:VALUE 3	*Send the input value of the voltage standard.*
CAL:POIN?	*perform adjustment.*

Comments   ■ **Related Commands:** CALibration:POINt?, CALibration:SECurity[:STATe], CALibration:VALue.

:VALue?

CALibration:VALue? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The calibration adjustment if MIN or MAX is not specified.

■ The minimum calibration adjustment available if MIN is specified.

■ The maximum calibration adjustment available if MAX is specified.

Example   **Querying the Calibration Adjustment Value**

CAL:VAL 50	*Frequency is 50 Hz.*
CAL:VAL?	*Query multimeter to return adjustment value.*
enter statement	*Enter value into computer.*

:ZERO:AUTO

CALibration:ZERO:AUTO <*mode*> enables or disables the autozero mode.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1|ONCE	none

Example **Turning Autozero OFF**

> CAL:ZERO:AUTO OFF   *Disable autozero.*

Comments ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters. The OFF and ONCE parameters have the same effect.

■ When autozero is ON, the multimeter makes a zero measurement (measurement with input disabled) following every measured reading and subtracts the zero measurement from the reading. This doubles the time required per reading for most modes.

■ When autozero is OFF, the multimeter makes one zero measurement and subtracts this from all subsequent measurements. A new zero measurement is made whenever you change the function, range, number of PLCs, input coupling, or offset compensation mode.

■ Do not turn autozero OFF when in the 4-wire ohms function if the resistance in the LO lead can change.

■ The CONFigure[:SCALar] and MEASure[:SCALar] commands turn autozero ON.

■ *RST Condition: **CAL:ZERO:AUTO ON**

:ZERO:AUTO?

CALibration:ZERO:AUTO? returns a number to show whether the autozero mode is enabled or disabled: "1" = ON, "0" = OFF or ONCE. The number is sent to the output buffer.

Example   **Querying the Autozero Mode**

CAL:ZERO:AUTO OFF	*Disable autozero.*
CAL:ZERO:AUTO?	*Query multimeter to return autozero mode ("0").*
enter statement	*Enter value into computer.*

CONFigure[:SCALar]

The CONFigure[:SCALar] command subsystem configures the multimeter to perform the specified measurement with the given range and resolution. CONFigure[:SCALar] *does not* automatically make the measurement after setting the configuration.

Use the INITiate command to place the multimeter in the wait-for-trigger state and store readings in multimeter memory. Or, use the READ? command to make the measurement and send the readings to the output buffer when the trigger is received.

Executing CONFigure[:SCALar] is equivalent to configuring the multimeter with the low-level commands shown in the following table.

Default Configuration Using CONFigure[:SCALar] or MEASure[:SCALar]

Parameter	Command	Description
Limit Test	CALCulate:LIMit:STATe	OFF
Autozero	CALibration:ZERO:AUTO	ON (performs autozero after each measurement).
Input Coupling	INPut:COUPling	ac voltage.
Input Guard	INPut:GUARd	Low
Input State	INPut[:STATe]	ON (connects input source).
Input Impedance	INPut:IMPedance:AUTO	ON (useful for dc measurements only).
Terminals	ROUTe:TERMinals	FRONT if no channel list specified. REAR if channel list specified.
Readings per Trigger	SAMPle:COUNt	1 reading. If channel list specified, set to number of channels in list.
Function	[SENSe:]FUNCtion[:ON] "CURRent:AC", [SENSe:]FUNCtion[:ON] "CURRent:DC", [SENSe:]FUNCtion[:ON] "FREQuency", [SENSe:]FUNCtion[:ON] "FRESistance", [SENSe:]FUNCtion[:ON] "PERiod", [SENSe:]FUNCtion[:ON] "RESistance", [SENSe:]FUNCtion[:ON] "VOLTage:AC", or [SENSe:]FUNCtion[:ON] "VOLTage:DC"	As specified by CONFigure[:SCALar].
Range	[SENSe:]CURRent:AC:RANGe, [SENSe:]CURRent:[DC]:RANGe, [SENSe:]RESistance:RANGe, [SENSe:]VOLTage:AC:RANGe, or [SENSe:]VOLTage:[DC]:RANGe	As specified, or autorange.
Aperture Time	[SENSe:]VOLTage:AC:APERture, [SENSe:]VOLTage:[DC:]APERture, [SENSe:]RESistance:APERture, [SENSe:]VOLTage:AC:APERture, or [SENSe:]VOLTage:[DC:]APERture	16.7 ms (60 Hz) or 20 ms (50 Hz), or based on specified resolution.
Integration Time	[SENSe:]CURRent:AC:NPLCycles, [SENSe:]CURRent:[DC:]NPLCycles, [SENSe:]RESistance:NPLCycles, [SENSe:]VOLTage:AC:NPLCycles, or [SENSe:]VOLTage:[DC:]NPLCycles	1 Power Line Cycle (PLC), or based on specified resolution.
Offset Compensation	[SENSe:]RESistance:OCOMpensated	OFF (useful for resistance measurements only).
AC Bandwidth	[SENSe:]DETector:BANDwidth	Selects slow measurement mode (useful for ac voltage, frequency, and period measurements only).
Trigger Buffer	TRIGger:BUFFered	OFF
Trigger Count	TRIGger:COUNt	1 trigger.
Trigger Delay	TRIGger:DELay	Default (see Table 3-12
Trigger Source	TRIGger:SOURce	IMMediate (trigger signal is always true).

Subsystem
Syntax

```
CONFigure[:SCALar]
    :CURRent
        :AC [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
        :ACDC [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
        [:DC] [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
    :FRESistance [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
    :RESistance [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
    :TEMPerature <transducer>, <type>[,<channel list>]
    [:VOLTage]
        :AC [<expected value> [,<resolution>][,<channel list>]]|[<channel list>]
        :ACDC [<expected value> [,<resolution>][,<channel list>]]|[<channel list>]
        [:DC] [<expected value> [,<resolution>][,<channel list>]]|[<channel list>]
        :FREQuency [<expected value>[,<resolution>]][,<channel list>]]|[<channel list>]
        :PERiod [<expected value>[,<resolution>][,<channel list>]]|[<channel list>]
```

:CURRent:AC

CONFigure[:SCALar]:CURRent:AC [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the ac current and allows you to specify the expected value and desired resolution for a given channel list.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 through 2A| AUTOmatic|DEFault| | MINimum|MAXimum |	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| | MINimum|MAXimum |	amps
channel list	numeric	108 – 109	none

Example   **Making AC Current Measurements**

dimension array	*Dimension computer array.*
CONF:CURR:AC 0.7,MAX	*Function: ac current; range selected: 2 A; MAX resolution: 1 μA.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected current. The multimeter then selects the correct range.

- The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

- The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify CONF:CURR:AC AUTO or CONF:CURR:AC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer Option H10 or Option 001 is installed, a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- Option 002 (Reed Relay Multiplexer) cannot measure current.

- **Related Commands:** FETCh?, INITiate, READ?

:CURRent:ACDC

CONFigure[:SCALar]:CURRent:ACDC [*<expected value>* [,*<resolution>*][,*<channel list>*]]|[*<channel list>*] selects the dc-coupled ac current and allows you to specify the expected value and desired resolution.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 through 2A| AUTOmatic|DEFault| | MINimum|MAXimum |	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| | MINimum|MAXimum |	amps
channel list	numeric	108 – 109	none

Example

Making AC Current Measurements (DC-Coupled)

dimension array	*Dimension computer array.*
CONF:CURR:ACDC 0.5,MAX	*Function: ac current; range selected: 2 A; MAX resolution: 1 μA.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected current. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

CONFigure[:SCALar]:CURRent:ACDC   **CONFigure[:SCALar]**

- To specify a MIN or MAX resolution while autoranging, you must specify CONF:CURR:ACDC AUTO or CONF:CURR:ACDC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer Option H10 or Option 001 is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- Option 002 (Reed Relay Multiplexer) cannot measure current.

- **Related Commands:** FETCh?, INITiate, READ?

:CURRent[:DC]

CONFigure[:SCALar]:CURRent[:DC] [<*expected value*> [,<*resolution*>][,<*channel list*>]][<*channel list*>] selects the dc current and allows you to specify the expected value and desired resolution.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 through 2A| AUTOmatic|DEFault| | MINimum|MAXimum |	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| | MINimum|MAXimum |	amps
channel list	numeric	108 – 109	none

Example   **Making DC Current Measurements**

dimension array	*Dimension computer array.*
CONF:CURR:DC 1.5,MAX	*Function: ac current; range selected: 2 A; MAX resolution: 1 μA.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments ■ The :DC parameter is optional. Both of the following command statements select the dc current function:

   CONF:CURR:DC *or* CONF:CURR

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a

fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify CONF:CURR:DC AUTO or CONF:CURR:DC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer Option H10 or Option 001 is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ Option 002 (Reed Relay Multiplexer) cannot measure current.

■ **Related Commands:** FETCh?, INITiate, READ?

:FRESistance

CONFigure[:SCALar]:FRESistance [<*expected value*> [,<*resolution*>] 1284[,<*channel list*>]]|[<*channel list*>] selects the 4-wire ohms function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 Ω through 3 GΩ | AUTOmatic|DEFault| | MINimum|MAXimum |	ohms
resolution	numeric	*resolution* (see Table 8-4| DEFault| | MINimum|MAXimum |	ohms
channel list	numeric	110 – 113	none

Example   **Making 4-Wire Ohms Measurements**

dimension array	*Dimension computer array.*
CONF:FRES 1560,MAX	*Function: 4-wire ohms; range selected: 3 kΩ; MAX resolution: 1Ω*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected resistance. The multimeter then selects the correct range.

- The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

- The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0Ω; MAX = 3 GΩ For *resolution*: MIN selects the best resolution (the smallest value from Table 8-4) for the selected range. MAX selects the worst resolution (the largest value from Table 8-4) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify CONF:FRES AUTO or CONF:FRES DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- **Related Commands:** FETCh?, INITiate, READ?

:RESistance

CONFigure[:SCALar]:RESistance [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the 2-wire ohms function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 Ω through 3 GΩ | AUTOmatic|DEFault| | MINimum|MAXimum |	ohms
resolution	numeric	*resolution* (see Table 8-4| DEFault| | MINimum|MAXimum |	ohms
channel list	numeric	100 – 107	none

Example   **Making 2-Wire Ohms Measurements**

dimension array	*Dimension computer array.*
CONF:RES 1320,MAX	*Function: 2-wire ohms; range selected: 3 kΩ; MAX resolution: 1Ω.*
TRIG:COUN 3	*Multimeter will accept 3 triggers.*
INIT	*place multimeter in wait-for-trigger state; store readings in multimeter memory; trigger source is IMMediate by default.*
FETC?	*place readings in output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected resistance. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0Ω; MAX = 3 GΩ For *resolution*: MIN selects the best resolution (the smallest value from Table 8-4) for the selected range. MAX selects the worst resolution (the largest value from Table 8-4) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify CONF:RES AUTO or CONF:RES DEF (you cannot omit the *expected value parameter*). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- **Related Commands:** FETCh?, INITiate, READ?

:TEMPerature

CONFigure[:SCALar]:TEMPerature *<transducer>*, *<type>* [,*<channel list>*] selects the temperature function. All measurements are returned in degrees Celsius. The following transducers can be measurements using the multimeter:

- Thermistors (2-wire or 4-wire measurement)
- RTDs (2-wire or 4-wire measurement)

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
transducer	discrete	THERmistor|FTHermistor| RTD|FRTD |	none
type	numeric	THER/FTH:2252|5000|10000 RTD.FRTD: 85|92	ohms alpha
channel list	numeric	100 – 107	none

Example

Making Thermistor Measurements

CONF:TEMP THER,5000	*Measure 5000Ω thermistor (2-wire measurement); trigger source is IMMediate by default.*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
enter statement	*Enter reading into computer.*

Comments

- You can measure RTD types 85 (alpha=0.00385 $\Omega/\Omega/°C$) and 92 (alpha=0.00392 $\Omega/\Omega/°C$).

- You can also use 385, 0.00385, 392, 0.00392 for the *type* parameter.

- The multimeter automatically makes temperature measurements using a 1 PLC integration time and autoranging.

- If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

-

Transducer Type	Basic Measurement	Valid Channels
THERmistor	2W Ω	100:107
FTHermistor	4W Ω	110:113
RTD	2W Ω	100:107
FRTD	4W Ω	110:113

- **Related Commands:** FETCh?, INITiate, READ?

[:VOLTage]:AC

CONFigure[:SCALar][:VOLTage]:AC [*<expected value>* [,*<resolution>*][,*<channel list>*]]|[*<channel list>*] selects the ac-coupled RMS voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| | MINimum|MAXimum |	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| | MINimum|MAXimum |	volts
channel list	numeric	100 – 107	none

Example   Making AC Voltage Measurements (AC-Coupled)

dimension array	*Dimension computer array.*
CONF:VOLT:AC 0.54,MAX	*Function: ac volts; range selected: 3 V; MAX resolution: 1 mV.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0V; MAX = ± 300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify CONF:VOLT:AC AUTO or CONF:VOLT:AC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** FETCh?, INITiate, READ?

[:VOLTage]:ACDC

CONFigure[:SCALar][:VOLTage]:ACDC [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc-coupled RMS voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| | MINimum|MAXimum |	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| | MINimum|MAXimum |	volts
channel list	numeric	100 - 107	none

Example   **Making AC Voltage Measurements (DC-Coupled)**

dimension array	*Dimension computer array.*
CONF:VOLT:ACDC 0.54,MAX	*Function: ac volts (dc coupled); range selected: 3 V; MAX resolution: 1 mV.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0V; MAX = ±300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify CONF:VOLT:ACDC AUTO or CONF:VOLT:ACDC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** FETCh?, INITiate, READ?

[:VOLTage][:DC]

CONFigure[:SCALar][:VOLTage][:DC] [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| | MINimum|MAXimum |	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| | MINimum|MAXimum |	volts
channel list	numeric	100 – 107	none

Example   **Making DC Voltage Measurements**

dimension array	*Dimension computer array.*
CONF:VOLT 8.25,MAX	*Function: dc voltage; range selected: 30 V; MAX resolution: 10 mV.*
TRIG:COUN 3	*Multimeter will accept 3 triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ The :DC parameter is optional. Both of the following command statements select the dc voltage function:

CONF:VOLT:DC   *or*   CONF:VOLT

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value* : MIN = 0V; MAX = ±300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify CONF:VOLT:DC AUTO or CONF:VOLT:DC DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- **Related Commands:** FETCh?, INITiate, READ?

[:VOLTage]:FREQuency

CONFigure[:SCALar][:VOLTage]:FREQuency [*<expected value>* [,*<resolution>*][,*<channel list>*]]|[*<channel list>*] selects the frequency function.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	10 Hz through 1.5 MHz| AUTOmatic|DEFault| | MINimum|MAXimum |	hertz
resolution	numeric	1 Hz through 1 ppm| | DEFault| | MINimum|MAXimum |	hertz
channel list	numeric	100 – 107	none

Example   **Making Frequency Measurements**

dimension array	*Dimension computer array.*
CONF:VOLT:FREQ	*Function: frequency.*
INP:COUP DC	*Input source is ac+dc voltage (dc-coupled).*
TRIG:COUN 3	*Multimeter will accept three triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments

■ Specify *expected value* as the input signal's maximum expected frequency. The multimeter verifies that the input frequency is between 10 Hz and 1.5 MHz. The multimeter automatically voltage autoranges in the frequency function.

■ The AUTO, DEF, MIN, and MAX options for the *expected value* parameter are not used for frequency measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The multimeter provides a constant 1 ppm of resolution (the minimum resolution is 1 Hz). Specifying a resolution greater than 1 ppm generates an error.

■ The DEF, MIN, and MAX options for the *resolution* parameter are not used for frequency measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ Specifying expected value and/or resolution will cause the "Command warning" bit (14) in the Questionable Data/Signal Register to be set. Prior to sending the CONF: command, send STAT:QUES:ENAB 168384 to set bit 14.

■ Use the INPut:COUPling command to specify whether the input signal is ac voltage or ac+dc voltage.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** FETCh?, INITiate, INPut:COUPling, READ?

[:VOLTage]:PERiod

CONFigure[:SCALar][:VOLTage]:PERiod [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the period function.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0.67 μs through 0.1 s| AUTOmatic|DEFault| | MINimum|MAXimum |	seconds
resolution	numeric	1 s through 1 ppm| DEFault| | MINimum|MAXimum |	seconds
channel list	numeric	100 – 107	none

Example **Making Period Measurements**

dimension array	*Dimension computer array.*
CONF:VOLT:PER	*Function: period.*
INP:COUP DC	*Input source is ac+dc voltage (dc-coupled).*
TRIG:COUN 3	*Multimeter will accept three triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments ■ Specify *expected value* as the input signal's maximum expected period. The multimeter verifies that the input period is between 0.67 μs and 0.1 seconds. The multimeter automatically voltage autoranges in the period function.

■ The AUTO, DEF, MIN, and MAX options for the *expected value* parameter are not used for period measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The multimeter provides a constant 1 ppm of resolution (the minimum resolution is 1 s). Specifying a resolution greater than 1 ppm generates an error.

■ The DEF, MIN, and MAX options for the *resolution* parameter are not used for period measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ Specifying expected value and/or resolution will cause the "Command warning" bit (14) in the Questionable Data/Signal Register to be set. Prior to sending the CONF: command, send STAT:QUES:ENAB 168384 to set bit 14.

■ Use the INPut:COUPling command to specify whether the input signal is ac voltage or ac+dc voltage.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** FETCh?, INITiate, INPut:COUPling, READ?

CONFigure?

The CONFigure? command queries the multimeter to return the configuration set by the most recent CONFigure[:SCALar] or MEASure[:SCALar] command. It returns a quoted string to the output buffer in the following format:

"*<function>* *<parameter>*,*<parameter>*,*<parameter>*"

Subsystem	CONFigure?
Syntax	

Example **Querying the Multimeter Configuration**

dimension string array	*Dimension computer array.*
CONF:FRES 1560,MAX	*Function: 4-wire ohms; range selected: 3 kΩ; MAX resolution: 1Ω*
CONF?	*Query configuration.*
enter statement	*Enter string into computer.*

String Returned:

"FRES 3.000000E+003,1.000000E+000"

Comments

■ When the multimeter is configured for voltage, resistance, frequency, or period measurements, CONFigure[:SCALar]? returns the function followed by the selected range and resolution. For example:

"FREQ DEF,DEF"
"FRES 3.000000E+002,1.000000E-003"
"PER DEF,DEF"
"RES 3.000000E+006,1.000000E-006"
"CURR:AC 3.000000E-001,1.000000E-007"
"CURR:ACDC 3.000000E-001,1.000000E-007"
"CURR 3.000000E-001,1.000000E-007"
"VOLT:AC 3.000000E+000,1.000000E-006"
"VOLT:ACDC 3.000000E-003,1.000000E-006"
"VOLT 3.000000E-001,1.000000E-005,(@100,101,102,103)"

■ Since you cannot set the range or resolution for temperature measurements, CONFigure[:SCALar]? returns "TEMP" followed by the specified transducer and type. For example:

"TEMP FRTD,385"
"TEMP THER,2252"

■ If you specify AUTO, DEF, MIN, or MAX for the *range* or *resolution* parameters in CONFigure[:SCALar] or MEASure[:SCALar], the CONFigure[:SCALar]? command returns the selected value.

■ **Related Commands:** CONFigure[:SCALar], MEASure[:SCALar]

DIAGnostic

The DIAGnostic command subsystem provides diagnostic routines related to the Program Loader.

Subsystem   DIAGnostic
Syntax   :BOOT[:SOURce]

> Description of the DIAGnostic:BOOT[:SOURce] command follows. Other command descriptions are provided in Chapter 10.

:BOOT[:SOURce]

DIAGnostic:BOOT[:SOURce] <*source*> instructs the instrument to run the Multimeter or the Program Loader on the next power up.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	LOADer|INSTrument	none

Example   Select the program loader to be run on the next power up.

Comments

■ LOAD instructs the module to run the program loader on the next power up.

■ INST instructs the module to run the Multimeter instrument on the next power up.

■ The DIAGnostic:BOOT[:SOURce] <*source*> is stored in non- volatile electrically erasable memory. It is recommended to only use this command when necessary because this memory is limited to 10,000 write cycles.

■ If the Program Loader configuration switch is set then the Program Loader will be run regardless of the state of the DIAGnostic:BOOT <*source*> command.

■ During power up of the program loader DIAGnotic:BOOT[:SOURce] is set to INST. This setting will be used in the next power-up.

■ ***RST Condition: INST**

DISPlay

The DISPlay command subsystem provides methods for enabling the display.

Subsystem DISPlay
Syntax
    [:WINDow] [:TEXT] :STATe
    [:WINDow] [:TEXT] :STATe?

[:WINDow][:TEXT]:STATe

DISPlay[:WINDow][:TEXT]:STATe <*state*> enables or disables the display.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	discrete	OFF|0|ON|1	none

Example   **Enabling the Display**

          STAT:QUES:ENAB 4096   *Enable bit 12 in Questionable Register.*
          DISP:STAT ON   *Enable the display.*

Comments   ■ **Related Commands:** STATus:QUEStionable:ENABle

              ■ ***RST Condition:** DISPlay:STATe ON

DISPlay[:WINDow][:TEXT]:STATe?

DISPlay[:WINDow][:TEXT]:STATe? queries the state of the display. A "0" is returned if the display is disabled and a "1" is returned if the display is enabled.

Example   **Query State of the Display**

            DISP:STAT?   *Queries if the display is enabled or disabled.*

            enter statement   *Enter value into computer.*

Comments   ■ *RST Condition: DISPlay[:WINDow][:TEXT]:STATe OFF

FETCh?

The FETCh? command retrieves measurements stored in multimeter memory by the most recent INITiate command and places them in the output buffer. This command is most commonly used with CONFigure[:SCALar].

Subsystem   FETCh?
Syntax

Example   **Transferring Stored Readings to Output Buffer**

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
SAMP:COUN 100	*100 readings per trigger.*
INIT	*Store readings in multimeter memory; trigger source is IMMediate by default.*
FETC?	*place readings in output buffer.*
enter statement	*Enter readings into computer.*

Comments

- Execute INITiate before sending the FETCh? command to place the multimeter in the wait-for-trigger state. If the multimeter is in the idle state (for example, if INITiate has not been executed), FETCh? will generate the "Data corrupt or stale" error.

- Each reading sent to the output buffer consists of 17 bytes (characters) in Real ASCII format: ±1.23456789E ± 123 *LF* If multiple readings are returned by a command, the readings are separated by commas. A Line Feed (*LF*) and the HP-IB End-or-Identify (EOI) signal follow the last reading returned.

- The multimeter's output buffer capacity is 1024 bytes. The multimeter remains "busy" until you begin removing readings from the output buffer using your computer's enter statement. New data sent to the output buffer overwrites data sent from previous commands.

- **Related Commands:** CONFigure[:SCALar], INITiate, READ?

- ***RST Condition:** Since *RST places the multimeter in the idle state, executing FETCh? immediately after a * RST generates the "Data corrupt or stale" error.

FETCh:<function>?

This command is similar to the FETCh? command. This page only documents the differences from the FETCh? command.

Subsystem
Syntax

    FETCh[:SCALar]
        :CURRent
            :AC? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :ACDC? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            [:DC]? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :FRESistance? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :RESistance? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :TEMPerature? <*transducer*>, <*type*>[,<*channel list*>]
        [:VOLTage]
            :AC? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :ACDC? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            [:DC]? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :FREQuency? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :PERiod? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]

Example   FETC:AC?   *place readings in output buffer for ac voltage measurement.*

Comments   ■ The <function> specified must match the function which the multimeter
                  is currently measuring. This will have been previously specified with a
                  CONFigure, MEASure or [SENSe:]FUNCtion command. If the <function>
                  does not match, error -221, "Settings conflict" will be generated.

                ■ If any parameters are specified with this command they are ignored, and
                  the command warning bit (bit 14) in the status questionable register will be
                  set. The measurement will be returned using the previous setup.

                ■ **Related Commands:** FETCh?, CONFigure[:SCALar], MEASure,
                  [SENSe]:FUNCtion[:ON]

INITiate

The INITiate command subsystem places the multimeter in the wait-for-trigger state. This command is most commonly used with CONFigure[:SCALar].

Subsystem   INITiate
Syntax   [:IMMediate]

[:IMMediate]

INITiate[:IMMediate] places the multimeter in the wait-for-trigger state and stores readings in multimeter memory when a trigger occurs. Readings stored in memory from previous commands are replaced by the new readings.

Example   **Placing Multimeter in Wait-For-Trigger State**

CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
INIT	*place multimeter in wait-for-trigger state; store readings in multimeter memory when trigger is received.*
FETC?	*place readings in output buffer.*
INIT	*You must re-initiate the wait-for-trigger state after each trigger cycle.*

Comments
- The :IMMediate parameter is optional. Both of the following command statements place the multimeter in the wait-for-trigger state:

  INIT:IMM *or* INIT

- After the trigger system is initiated using INITiate, use the TRIGger command subsystem to control the behavior of the trigger system.

- If TRIGger:SOURce is IMMediate, the measurement starts and readings are stored in multimeter memory as soon as INITiate is executed. Readings stored in memory from previous commands are replaced by the new readings.

- To transfer readings from multimeter memory to the output buffer, use the FETCh? command.

- If the multimeter is in the wait-for-trigger state, the ABORt command places the multimeter in its idle state and terminates any measurement in progress.

- The multimeter has enough memory to store 4,096 readings. Each reading stored is eight bytes long. Since readings are stored in an eight-byte format, INITiate is faster than sending readings directly to the output buffer using the READ? command.

- The READ? command executes INITiate implicitly. The MEASure[:SCALar] command executes READ? implicitly.

- **Related Commands:** ABORt, CONFigure[:SCALar], FETCh?, READ?

- ***RST Condition:** *RST places the multimeter in the idle state.

INPut

The INPut command subsystem:

- Selects the input coupling source for ac voltage, frequency, and period measurements (INPut:COUPling).

- Enables or disables the automatic input impedance mode for dc voltage measurements (INPut:IMPedance:AUTO).

- Selects the input source for making measurements (INPut[:STATe]).

Subsystem   INPut
Syntax
                    :COUPling *<source>*
                    :COUPling?
                    :GUARd *<mode>*
                    :GUARd?
                    :IMPedance
                          :AUTO *<mode>*
                          :AUTO?
                    [:STATe] *<mode>*
                    [:STATe]?

:COUPling

INPut:COUPling <*source*> configures the multimeter to accept either ac voltage or ac+dc voltage as the input coupling source for ac voltage, current, frequency, or period measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	AC|DC	none

Example **Selecting the Input Coupling Source**

CONF:FREQ	*Function: frequency; trigger source is IMMediate by default.*
INP:COUP DC	*Input source is ac+dc voltage (dc-coupled).*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
enter statement	*Enter reading into computer.*

Comments
- AC configures the multimeter for ac voltage or current inputs (ac-coupled). DC configures the multimeter for ac+dc voltage or current inputs (dc-coupled).

- The INPut:COUPling command does not alter the present SENSe:BANDwidth:DETector (ac fast or slow) configuration.

- *RST Condition: INP:COUP AC

:COUPling?

INPut:COUPling? returns "AC" or "DC" to show the present input source. The string is sent to the output buffer.

Example   **Querying the Input Source**

INP:COUP DC	*Input source is ac+dc voltage.*
INP:COUP?	*Query multimeter to return input source setting.*
enter statement	*Enter string into computer.*

:GUARd

INPut:GUARd <*mode*> connects guard to the signal low terminal or allows the guard to float.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	discrete	LOW|FLOat	none

Example   **Connect the guard to Signal**

            INP:GUAR

Comments   ■ *RST Condition: LOW

:GUARd?

INPut:GUARd? returns "LOW" or "FLOat" to show the present connection of the multimeter guard.

Example   **Querying the Guard Connection**

INP:GUAR	*Connect the guard to signal.*
INP:GUAR?	*Query multimeter to return guard connection.*
enter statement	*Enter string into computer.*

:IMPedance:AUTO

INPut:IMPedance:AUTO <*mode*> enables or disables the automatic input impedance mode for dc voltage measurements. When disabled (AUTO OFF), the multimeter maintains its input impedance of 10 MΩ for all dc voltage ranges. This is useful to prevent a change in input impedance (caused by changing ranges) from affecting the measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1|	none

mode Parameter	30 mV, 300 mV, 3 V DCV ranges	30 V, 300 V DCV ranges
OFF or 0	10 MΩ	10 MΩ
ON or 1	10 GΩ	10 MΩ

Example   **Disabling Automatic Input Impedance** (use 10 MΩ impedance for all ranges)

INP:IMP:AUTO OFF   *Disable automatic input impedance.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ The automatic input impedance mode remains disabled (AUTO OFF) after you change from dc voltage measurements to 2-wire or 4-wire resistance measurements. This can affect the resistance measurements since the 10 MΩ resistance remains connected in parallel with the input terminals. Enable the automatic input impedance mode (AUTO ON) before selecting resistance measurements.

■ The automatic input impedance mode is temporarily enabled (AUTO ON) when you change from dc voltage measurements to ac voltage, ac+dc voltage, frequency, or period measurements. When you return the measurement function to dc voltage, automatic input impedance is once again disabled (AUTO OFF).

■ ***RST Condition:** INP:IMP:AUTO ON

:IMPedance:AUTO?

INPut:IMPedance:AUTO? returns a number to show whether the automatic input impedance mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Input Impedance Mode**

INP:IMP:AUTO OFF	*Disable automatic input impedance.*
INP:IMP:AUTO?	*Query multimeter to return input impedance mode ("0").*
enter statement	*Enter value into computer.*

INPut[:STATe]

INPut[:STATe] <*mode*> enables or disables the multimeter's input terminals. The input terminals are either connected (INPut[:STATe] ON) or open (INPut[:STATe] OFF).

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling the Input Terminals**

INP:STAT OFF   *Open input terminals.*

INP ON   *Connect input terminals.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ INPut[:STATe] ON will connect the input terminals currently specified by the ROUTe:TERMinals command.

■ This command enables/disables only the HI, LO, Ω SENSE HI, and Ω SENSE LO terminals. The Guard, External Trigger, and Voltmeter Complete terminals are not affected.

■ **Related Commands:** ROUTe:TERMinals

■ ***RST Condition:** INP:STAT ON

[:STATe]?

INPut[:STATe]? returns a number to show whether the input terminals are enabled or disabled: "1" = ON (enabled), "0" = OFF (disabled). The number is sent to the output buffer.

Example   **Querying the Input Terminal State**

INP:STAT OFF	*Open input terminals.*
INP:STAT?	*Query multimeter to return input terminal state ("0").*
enter statement	*Enter value into computer.*

MEASure[:SCALar]

The MEASure[:SCALar] command subsystem configures the multimeter to perform the specified measurement with the given range and resolution. MEASure[:SCALar] makes the measurement and sends the readings to the output buffer.

Executing MEASure[:SCALar] is equivalent to configuring the multimeter with the low-level commands shown in the following table.

Default Configuration Using CONFigure[:SCALar] or MEASure[:SCALar]

Parameter	Command	Description
Function	[SENSe:]FUNCtion[:ON] "CURRent:AC", [SENSe:]FUNCtion[:ON] "CURRent:DC", [SENSe:]FUNCtion[:ON] "FREQuency", [SENSe:]FUNCtion[:ON] "FRESistance", [SENSe:]FUNCtion[:ON] "PERiod", [SENSe:]FUNCtion[:ON] "RESistance", [SENSe:]FUNCtion[:ON] "VOLTage:AC", or [SENSe:]FUNCtion[:ON] "VOLTage:DC"	As specified by CONFigure[:SCALar].
Range	[SENSe:]CURRent:AC:RANGe [SENSe:]CURRent:[DC]:RANGe [SENSe:]RESistance:RANGE or [SENSe:]VOLTage:AC:RANGe [SENSe:]VOLTage:[DC]:RANGe	As specified, or autorange.
Autozero	CALibration:ZERO:AUTO	ON (performs autozero after each measurement).
Input State	INPut[:STATe]	ON (connects input source).
Input Coupling	INPut:COUPling	ac voltage.
Integration Time	[SENSe:]CURRent:AC:NPLCycles, [SENSe:]CURRent:[DC:]NPLCycles, [SENSe:]RESistance:NPLCycles, [SENSe:]VOLTage:AC:NPLCycles, or [SENSe:]VOLTage:[DC:]NPLCycles	1 Power Line Cycle (PLC), or based on specified resolution.
Aperture Time	[SENSe:]VOLTage:AC:APERture [SENSe:]VOLTage:[DC:]APERture [SENSe:]RESistance:APERture or [SENSe:]VOLTage:AC:APERture [SENSe:]VOLTage:[DC:]APERture	16.7 ms (60 Hz) or 20 ms (50 Hz), or based on specified resolution.
Offset Compensation	[SENSe:]RESistance:OCOMpensated	OFF (useful for resistance measurements only).
Input Impedance	INPut:IMPedance:AUTO	ON (useful for dc voltage measurements only).
AC Bandwidth	[SENSe:]DETector:BANDwidth	Selects slow measurement mode (useful for ac voltage, frequency, and period measurements only).
Readings per Trigger	SAMPle:COUNt	1 reading. If channel list specified, set to number of channels in list.
Terminals	ROUTe:TERMinals	FRONT if no channel list specified. REAR if channel list specified.
Trigger Source	TRIGger:SOURce	IMMediate (trigger signal is always true).
Trigger Count	TRIGger:COUNt	1 trigger.
Trigger Delay	TRIGger:DELay	Default (see Table 3-12

Subsystem
Syntax

    MEASure[:SCALar]
        :CURRent
            :AC? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :ACDC? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            [:DC]? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :FRESistance? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :RESistance? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
        :TEMPerature? <*transducer*>, <*type*>[,<*channel list*>]
        [:VOLTage]
            :AC? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :ACDC? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            [:DC]? [<*expected value*> [,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :FREQuency? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]
            :PERiod? [<*expected value*>[,<*resolution*>] [,<*channel list*>]] | [<*channel list*>]

**MEA-
Sure[:SCALar]
Subsystem
Data Format**

■ Each reading sent to the output buffer consists of 17 bytes (characters) in Real ASCII format: $\pm1.23456789E \pm 123$ *LF* If multiple readings are returned by a command, the readings are separated by commas. A Line Feed (*LF*) and the HP-IB End-or-Identify (EOI) signal follow the last reading returned.

■ The multimeter's output buffer capacity is 1024 bytes. Therefore, 52 readings over HP-IB and 13 readings over HP-MSIB can be transferred to the output buffer at a time. The multimeter remains "busy" until you begin removing readings from the output buffer using your computer's enter statement. New data sent to the output buffer overwrites data sent from previous commands.

:CURRent:AC?

MEASure[:SCALar]:CURRent:AC? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the ac-coupled RMS current function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 A through ± 2 A | AUTOmatic|DEFault| MINimum|MAXimum	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| MINimum|MAXimum	amps
channel list	numeric	108 – 109	none

Example **Making AC Current Measurements (AC-Coupled)**

MEAS:CURR:AC? 0.7,MAX   *Function: ac current; range selected: 2 A; MAX resolution: 1 μA; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected current. The multimeter then selects the correct range.

- The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

- The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify MEAS:CURR:AC? AUTO or MEAS:CURR:AC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer Option H10 or 001 is installed a channel list can be used
to specify a multiplexer channel to be used for the measurement. The
channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card
number (c always = 1) and nn = channel number (for example, 105 is
channel 05 of card number 1).

■ Option 002 (Reed Relay Multiplexer) cannot measure current.

■ **Related Commands:** READ?

:CURRent:ACDC?

MEASure[:SCALar]:CURRent:ACDC? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc-coupled RMS current function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 A through ± 2 A | AUTOmatic|DEFault| MINimum|MAXimum	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| MINimum|MAXimum	amps
channel list	numeric	108 – 109	none

Example   **Making AC Current Measurements (DC-Coupled)**

MEAS:CURR:ACDC? 0.5,MAX   *Function: ac current (dc coupled); range selected: 2 A; MAX resolution: 1 μA; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected current. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify MEAS:CURR:ACDC? AUTO or MEAS:CURR:ACDC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer Option H10 or 001 is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- Option 002 (Reed Relay Multiplexer) cannot measure current.

- **Related Commands:** READ?

:CURRent[:DC]?

MEASure[:SCALar]:CURRent[:DC]? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc current function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 A through ± 2 A | AUTOmatic|DEFault| MINimum|MAXimum	amps
resolution	numeric	*resolution* (see Table 8-3| DEFault| MINimum|MAXimum	amps
channel list	numeric	108 – 109	none

Example   **Making DC Current Measurements**

MEAS:CURR:DC? 1.5,MAX   *Function: dc current; range selected: 2 A; MAX resolution: 1 μA; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments   ■ The :DC parameter is optional. Both of the following command statements select the dc current function:

    MEAS:CURR:DC? *or* MEAS:CURR?

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected current. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 A; MAX = 2 A For *resolution*: MIN selects the best resolution (the smallest value from Table 8-3) for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify MEAS:CURR:DC? AUTO or MEAS:CURR:DC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer Option H10 or 001 is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ Option 002 (Reed Relay Multiplexer) cannot measure current.

■ **Related Commands:** READ?

:FRESistance?

MEASure[:SCALar]:FRESistance? [<*expected value*> [,<*resolution*>][,<*channel list*>]]][<*channel list*>] selects the 4-wire ohms function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0Ω through 3 GΩ | AUTOmatic|DEFault| MINimum|MAXimum	ohms
resolution	numeric	*resolution* (see Table 8-4)| DEFault| MINimum|MAXimum	ohms
channel list	numeric	110 – 113	none

Example   **Making 4-Wire Ohms Measurements**

MEAS:FRES? 1560,MAX   *Function: 4-wire ohms; range selected: 3 kΩ; MAX resolution: 1Ω; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected resistance. The multimeter then selects the correct range.

- The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

- The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 Ω; MAX = 3 GΩ For *resolution*: MIN selects the best resolution (the smallest value from Table 8-4) for the selected range. MAX selects the worst resolution (the largest value from Table 8-4) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify MEAS:FRES? AUTO or MEAS:FRES? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer option is installed a channel list can be used to specify a
multiplexer channel to be used for the measurement. The channel list is
of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c
always = 1) and nn = channel number (for example, 105 is channel 05 of
card number 1).

■ **Related Commands: READ?**

:RESistance?

MEASure[:SCALar]:RESistance? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the 2-wire ohms function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 Ω through 3 GΩ | AUTOmatic|DEFault| MINimum|MAXimum	ohms
resolution	numeric	*resolution* (see Table 8-4| DEFault| MINimum|MAXimum	ohms
channel list	numeric	100 – 107	none

Example   **Making 2-Wire Ohms Measurements**

          MEAS:RES? 1320,MAX   *Function: 2-wire ohms; range selected: 3 kΩ; MAX resolution: 1Ω; trigger source is IMMediate by default.*
          enter statement   *Enter reading into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected resistance. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0Ω; MAX = 3 GΩ For *resolution*: MIN selects the best resolution (the smallest value from Table 8-4) for the selected range. MAX selects the worst resolution (the largest value from Table 8-4) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify MEAS:RES? AUTO or MEAS:RES? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** READ?

:TEMPerature?

MEASure[:SCALar]:TEMPerature? *<transducer>*,*<type>* [,*<channel list>*] selects the temperature function. All measurements are returned in degrees Celsius. The following transducers can be measured using the multimeter:

■ Thermistors (2-wire or 4-wire measurement)

■ RTDs (2-wire or 4-wire measurement)

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
transducer	discrete	THERmistor|FTHermistor|RTD|FRTD |	none
type	numeric	THER/Fth:2252|5000|10000 RTD/FRTD:85|92 |	ohms alpha
channel list	numeric	100 – 107	none

Example   Making Thermistor Measurements

        MEAS:TEMP? THER,5000   *Measure 5000Ω thermistor (2-wire measurement); trigger source is IMMediate by default.*
        enter statement   *Enter reading into computer.*

Comments   ■ You can measure RTD types 85 (alpha=0.00385 $\Omega/\Omega/°C$) and 92 (alpha=0.00392 $\Omega/\Omega/°C$).

■ You can also use 385, 0.00385, 392, 0.00392 for the *type* parameter.

■ The multimeter automatically makes temperature measurements using a 1 PLC integration time and autoranging.

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■

Transducer Type	Basic Measurement	Valid Channels
THERmistor	2W Ω	100:107
FTHermistor	4W Ω	110:113
RTD	2W Ω	100:107
FRTD	4W Ω	110:113

■ **Related Commands:** READ?

[:VOLTage]:AC?

MEASure[:SCALar][:VOLTage]:AC? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the ac-coupled RMS voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| MINimum|MAXimum	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| MINimum|MAXimum	volts
channel list	numeric	100 – 107	none

Example   **Making AC Voltage Measurements (AC-Coupled)**

MEAS:VOLT:AC? 0.54,MAX   *Function: ac volts; range selected: 3 V; MAX resolution: 1 mV; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments   ■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 V; MAX = ±300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

■ To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

■ To specify a MIN or MAX resolution while autoranging, you must specify MEAS:VOLT:AC? AUTO or MEAS:VOLT:AC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- ■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- ■ **Related Commands:** READ?

[:VOLTage]:ACDC?

MEASure[:SCALar][:VOLTage]:ACDC? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc-coupled RMS voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| MINimum|MAXimum	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| MINimum|MAXimum	volts
channel list	numeric	100 – 107	none

Example   **Making AC Voltage Measurements (DC-Coupled)**

MEAS:VOLT:ACDC? 0.54,MAX   *Function: ac volts (dc coupled); range selected: 3 V; MAX resolution: 1 mV; trigger source is IMMediate by default.*
enter statement   *Enter reading into computer.*

Comments

- To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

- The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

- The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 V; MAX = ±300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

- When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify MEAS:VOLT:ACDC? AUTO or MEAS:VOLT:ACDC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

■ If the multiplexer option is installed a channel list can be used to specify a
multiplexer channel to be used for the measurement. The channel list is
of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c
always = 1) and nn = channel number (for example, 105 is channel 05 of
card number 1).

■ **Related Commands:** READ?

[:VOLTage][:DC]?

MEASure[:SCALar][:VOLTage][:DC]? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the dc voltage function and allows you to specify the expected value and desired resolution.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | AUTOmatic|DEFault| MINimum|MAXimum	volts
resolution	numeric	*resolution* (see Table 8-2| DEFault| MINimum|MAXimum	volts
channel list	numeric	100 – 107	none

Example   **Making DC Voltage Measurements**

MEAS:VOLT:DC? 8.25,MAX   *Function: dc voltage; range selected: 30 V; MAX resolution: 10 mV; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments   ■ The :DC parameter is optional. Both of the following command statements select the dc voltage function:

MEAS:VOLT:DC? *or* MEAS:VOLT?

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ The AUTO and DEF options for the *expected value* parameter have the same effect (enable autorange). The DEF option for the *resolution* parameter defaults the integration time to 1 PLC.

■ The MIN and MAX parameters select the minimum or maximum values for *expected value* and *resolution*: For *expected value*: MIN = 0 V; MAX = ±300 V For *resolution*: MIN selects the best resolution (the smallest value from Table 8-2) for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

■ When autoranging, MIN or MAX are the only *resolution* settings which are allowed. Specify a numeric resolution only when making measurements on a fixed range. If you specify a numeric value for *resolution* while autoranging, the "Settings conflict" error is generated.

- To select autorange, specify AUTO (or DEF) for *expected value* or do not specify a value for the parameter.

- To specify a MIN or MAX resolution while autoranging, you must specify MEAS:VOLT:DC? AUTO or MEAS:VOLT:DC? DEF (you cannot omit the *expected value* parameter). This prevents the MIN or MAX resolution from being interpreted as a range setting.

- If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

- **Related Commands:** READ?

[:VOLTage]:FREQuency?

MEASure[:SCALar][:VOLTage]:FREQuency? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the frequency function.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	10 Hz through 1.5 MHz AUTOmatic|DEFault| MINimum|MAXimum	hertz
resolution	numeric	1 Hz through 1 ppm| DEFault| MINimum|MAXimum	hertz
channel list	numeric	100 – 107	none

Example   **Making Frequency Measurements**

        MEAS:VOLT:FREQ?   *Function: frequency; trigger source is IMMediate by default.*

        enter statement   *Enter reading into computer.*

Comments   ■ Specify *expected value* as the input signal's maximum expected frequency. The multimeter verifies that the input frequency is between 10 Hz and 1.5 MHz. The multimeter automatically voltage autoranges in the frequency function.

■ The AUTO, DEF, MIN, and MAX options for the *expected value* parameter are not used for frequency measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The multimeter provides a constant 1 ppm of resolution (the minimum resolution is 1 Hz). Specifying a resolution greater than 1 ppm generates an error.

■ The DEF, MIN, and MAX options for the *resolution* parameter are not used for frequency measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The MEASure[:SCALar] command automatically sets the input coupling to ac voltage (INPut:COUPling AC).

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands: READ?**

[:VOLTage]:PERiod?

MEASure[:SCALar][VOLTage]:PERiod? [<*expected value*> [,<*resolution*>][,<*channel list*>]]|[<*channel list*>] selects the period function.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0.67 µs through 0.1s| AUTOmatic|DEFault| MINimum|MAXimum	seconds
resolution	numeric	1 s through 1 ppm| DEFault| MINimum|MAXimum	seconds
channel list	numeric	100 – 107	none

Example   **Making Period Measurements**

MEAS:VOLT:PER?   *Function: period; trigger source is IMMediate by default.*

enter statement   *Enter reading into computer.*

Comments   ■ Specify *expected value* as the input signal's maximum expected period. The multimeter verifies that the input period is between 0.67 µs and 0.1 seconds. The multimeter automatically voltage autoranges in the period function.

■ The AUTO, DEF, MIN, and MAX options for the *expected value* parameter are not used for period measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The multimeter provides a constant 1 ppm of resolution (the minimum resolution is 1 s). Specifying a resolution greater than 1 ppm generates an error.

■ The DEF, MIN, and MAX options for the *resolution* parameter are not used for period measurements. If you specify one of these options, the multimeter will ignore it and no errors are generated.

■ The MEASure[:SCALar] command automatically sets the input coupling to ac voltage (INPut:COUPling AC).

■ If the multiplexer option is installed a channel list can be used to specify a multiplexer channel to be used for the measurement. The channel list is of the form (@cnn),(@cnn,cnn), or (@cnn:cnn), where c=card number (c always = 1) and nn = channel number (for example, 105 is channel 05 of card number 1).

■ **Related Commands:** READ?

READ?

The READ? command is most commonly used with CONFigure[:SCALar] to:

- Place the multimeter in the wait-for-trigger state (executes the INITiate command).

- Transfer the readings directly to the output buffer when the trigger is received (same action as FETCh? but the readings are not stored in multimeter memory).

Subsystem   READ?
Syntax

Example   **Transferring Readings Directly to Output Buffer**

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
SAMP:COUN 100	*Specify 100 readings per trigger.*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer; trigger source is IMMediate by default.*
enter statement	*Enter readings into computer.*

Comments
- The READ? command is slower than the INITiate command since readings are formatted and sent to the output buffer as they are taken. However, the sample count and trigger count are not limited with READ? since multimeter memory is not used.

- Each reading sent to the output buffer consists of 17 bytes (characters) in Real ASCII format: ± 1.23456789E ±123 *LF* If multiple readings are returned by a command, the readings are separated by commas. A Line Feed (*LF*) and the HP-IB End-or-Identify (EOI) signal follow the last reading returned.

- The multimeter's output buffer capacity is 1024 bytes. Therefore, sixty readings (17 bytes each) can be transferred to the output buffer at a time. The multimeter remains "busy" until you begin removing readings from the output buffer using your computer's enter statement. New data sent to the output buffer overwrites data sent from previous commands.

- **Related Commands:** CONFigure[:SCALar], FETCh?, INITiate

READ:<function>?

This command is similar to the READ? command. This page only documents the differences from the READ? command.

Subsystem
Syntax

    READ[:SCALar]
        :CURRent
            :AC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
            :ACDC? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
            [:DC]? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :FRESistance? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :RESistance? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
        :TEMPerature? <transducer>, <type>[,<channel list>]
        [:VOLTage]
            :AC? [<expected value> [,<resolution>][,<channel list>]] | [<channel list>]
            :ACDC? [<expected value> [,<resolution>][,<channel list>]] | [<channel list>]
            [:DC]? [<expected value> [,<resolution>][,<channel list>]] | [<channel list>]
            :FREQuency? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]
            :PERiod? [<expected value>[,<resolution>][,<channel list>]] | [<channel list>]

Example   READ:AC?   *place readings in output buffer for ac voltage measurement.*

Comments   ■ The <function> specified must match the function which the multimeter is currently measuring. This will have been previously specified with a CONFigure, MEASure or [SENSe:]FUNCtion command. If the <function> does not match, error -221, "Settings conflict" will be generated.

■ If any parameters are specified with this command they are ignored, and the command warning bit (bit 14) in the status questionable register will be set. The measurement will be returned using the previous setup.

■ **Related Commands:** READ?, CONFigure[:SCALar], MEASure, [SENSe]:FUNCtion[:ON]

ROUTe:

The ROUTe subsystem controls switching for the multiplexer options in a switchbox.

Subsystem	ROUTe
Syntax	:CLOSe *<channel list>*
	:CLOSe? *<channel list>*
	:OPEN *<channel list>*
	:OPEN? *<channel list>*
	:TERMinals *<mode>*
	:TERMinals?

:CLOSe

ROUTe:CLOSe <*channel list*> closes multiplexer channels specified in the *channel list*. The *channel list* is in the form (@cnn),(@cnn,cnn),or (@cnn:cnn) where c = card number (1) and nn = channel number (00 – 15). For a complete description of <*channel list*> read the explanation at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units	Multiplexer Option
channel list	numeric	100 – 115	none	H10, 001
channel list	numeric	100 – 114	none	002

Example　　　　**Closing Multiplexer Channels** This example closes channel 00 of the builtin multiplexer card.

　　　　　　　　`ROUT:CLOS(@100)`　　*100 closes channel 00 of multiplexer #1.*

Comments　　■ To close:

　　　　　　a single channel, use ROUTe:CLOSe(@cnn)

　　　　　　multiple channels, use ROUTe:CLOS(@cnn,cnn)

　　　　　　sequential channels, use ROUTe:CLOS(@cnn:cnn)

　　　　　　a group of sequential channels, use ROUTe:CLOS(@cnn:cnn,cnn:cnn) or any combination

　　　　　　Close order for multiple channels with a single command is not guaranteed.

　　　　■ Only one of channels 0–13 can be closed at the same time.

　　　　■ Either channel 8 or channel 14 may be closed at the same time. If a command to close channel 14 is given when channel 8 is closed, a "settings conflict" error will be generated. A command to close channel 8 will open channel 14.

　　　　■ Either channel 9 or channel 15 may be closed at the same time. IF command to close channel 15 is given when channel 9 is closed, a "settings conflict" error will be generated. A command to close channel 9 will open channel 15.

　　　　■ This command requires optional multiplexer hardware. If this hardware is not installed a "hardware missing" error will be generated.

　　　　■ If Option 002 (Reed Relay Multiplexer) is installed, only one channel can be closed at a time.

　　　　■ **Related Commands** ROUTe:OPEN, ROUTe:CLOSe?

　　　　■ ***RST Condition:** All multiplexer channels are open.

:CLOSe?

ROUTe:CLOSe? <*channel list*> returns the current state of the channel queried. The *channel list* is in the form (@cnn),(@cnn,cnn),or (@cnn:cnn) where c = card number (1) and nn = channel number (00 – 15). For a complete description of <*channel list*> read the explanation at the beginning of this chapter. The command returns 1 or 0 for each channel in the list, in the same order that the list is specified. A response of 1 indicates the channel is closed and a 0 means the channel is open.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units	Multiplexer Option
channel list	numeric	100 – 115	none	H10, 001
channel list	numeric	100 – 114	none	002

Example   **Query Multiplexer Channel Closure**

                ROUT:CLOS(@100)   *100 closes channel 00 of multiplexer card #1.*
                ROUT:CLOS?(@100)   *Query channel 100.*

Comments   ■ Query is Software Readback: The ROUTe:CLOSe? command returns the current software state of the channel specified. It does not account for relay hardware failures.

               ■ This command requires optional multiplexer hardware. If this hardware is not installed a "hardware missing" error will be generated.

:OPEN

ROUTe:OPEN <*channel list*> opens multiplexer channels specified in the *channel list*. The *channel list* is in the form (@cnn),(@cnn,cnn),or (@cnn:cnn) where c = card number (1) and nn = channel number (00–15). For a complete description of of <*channel list*> read the explanation at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units	Multiplexer Option
channel list	numeric	100 – 115	none	H10, 001
channel list	numeric	100 – 114	none	002

Example   **Opening Multiplexer Channels** This example opens channel 00 of the built-in multiplexer card.

ROUT:OPEN(@100,)   *100 opens channel 00 of the built-in multiplexer.*

Comments   ■ To open:

a single channel, use ROUTe:OPEN(@cnn)

multiple channels, use ROUTe:OPEN(@cnn,cnn)

sequential channels, use ROUTe:OPEN(@cnn:cnn)

a group of sequential channels, use ROUTe:OPEN(@cnn:cnn,cnn:cnn)

or any combination

Opening order for multiple channels with a single command is not guaranteed.

■ If channel 8 is currently closed, and is opened by this command, then channel 14 will be closed.

■ If channel 9 is currently closed, and is opened by this command, then channel 15 will be closed.

■ The command ROUTe:OPEN (@100:115) is guaranteed to open all channels regardless of current state.

■ This command requires optional multiplexer hardware. If this hardware is not installed a "hardware missing" error will be generated.

■ **Related Commands** ROUTe:CLOSe, ROUTe:OPEN?

■ ***RST Condition:** All multiplexer channels are open.

:OPEN?

ROUTe:OPEN? <*channel list*> returns the current state of the channel queried. The *channel list* is in the form (@cnn),(@cnn,cnn),or (@cnn:cnn) where c = card number (1) and nn = channel number (00–15). For a complete description of of <*channel list*> read the explanation at the beginning of this chapter. The command returns 1 if the channel is open or returns 0 if the channel is closed.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units	Multiplexer Option
channel list	numeric	100 – 115	none	H10, 001
channel list	numeric	100 – 114	none	002

Example   **Query Multiplexer Channel Open State**

ROUT:OPEN(@100)   *100 opens channel 00 of the built-in multiplexer.*
ROUT:OPEN?(@100)   *Query channel 100.*

Comments   ■ Query is Software Readback: The ROUTe:OPEN? command returns the current software state of the channel specified. It does not account for relay hardware failures.

■ This command requires optional multiplexer hardware. If this hardware is not installed a "hardware missing" error will be generated.

:TERMinals

ROUTe:TERMinals<*mode*> selects which terminals are connected to the multimeter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	discrete	FRONt|REAR	none

Example   **Selecting Terminals**

      ROUT:TERM REAR   *Connects the rear terminals to the multimeter.*

Comments   ■ FRONt connects only the front panel terminals to the multimeter.

■ REAR connects only the rear panel option to the multimeter.

■ This command has no effect on INPut[:STATe]. INPut[:STATe] must also be ON to make a measurement with the multimeter.

■ *RST Condition: ROUTe:TERMinals FRONt

:TERMinals?

ROUTe:TERMinals? returns the current state of the terminals connected to the multimeter.

Example   **Query Terminals State**

ROUT:TERM?   *Query Multimeter Terminals Connected.*

SAMPle

The SAMPle command subsystem operates with the TRIGger command subsystem. The SAMPle subsystem:

■ Designates the number of readings made for each trigger signal received (SAMPle:COUNt).

■ Selects the pacing source for the sample rate (SAMPle:SOURce).

■ Sets the sample rate when the sample count is greater than one (SAMPle:TIMer).

Subsystem	SAMPle
Syntax	:COUNt <*number*>
	:COUNt? [MINimum|MAXimum]
	:SOURce <*source*>
	:SOURce?
	:TIMer <*period*>
	:TIMer? [MINimum|MAXimum]

:COUNt

SAMPle:COUNt <*number*> designates the number of readings per trigger.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	1 through 16,777,215| MINimum|MAXimum	none

Example   **Setting the Sample Count**

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
SAMP:COUN 10	*Specify 10 readings per trigger.*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ MIN sets 1 reading per trigger. MAX sets 16,777,215 readings per trigger.

■ CONFigure[:SCALar] and MEASure[:SCALar] set the sample count to 1.

■ *RST Condition: SAMP:COUN 1

:COUNt?

SAMPle:COUNt? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

- The present sample count (1 through 16,777,215) if MIN or MAX is not specified.

- The minimum sample count available (1) if MIN is specified.

- The maximum sample count available (16,777,215) if MAX is specified.

Example   **Querying the Sample Count**

SAMP:COUN 10	*Specify 10 readings per trigger.*
SAMP:COUN?	*Query multimeter to return sample count.*
enter statement	*Enter value into computer.*

:SOURce

SAMPle:SOURce <*source*> selects the pacing source for the sample rate when SAMPle:COUNt is greater than 1. The sources available are:

■ **IMMediate:** Initiate reading whenever multimeter is not busy.

■ **TIMer:** Specify sample rate using the SAMPle:TIMer command.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	IMMediate|TIMer	none

Example   **Setting the Pacing Source**

dimension array	*Dimension computer array.*
CONF:VOLT:DC 25	*Function: dc voltage; range selected: 30 V (disable autorange for fastest rate).*
SAMP:COUN 10	*Specify 10 readings per trigger.*
SAMP:SOUR TIM	*Sample source is SAMPle:TIMer command.*
SAMP:TIM 0.065	*Set 65 ms sample rate.*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ CONFigure[:SCALar] and MEASure[:SCALar] set the sample source to IMM.

             ■ **Related Commands:** SAMPle:COUNt, SAMPle:TIMer

             ■ ***RST Condition:** SAMP:SOUR IMM

:SOURce?

SAMPle:SOURce? returns "IMM" or "TIM" to show the present pacing source. The string is sent to the output buffer.

Example   **Querying the Pacing Source**

SAMP:SOUR TIM	*Sample source is SAMPle:TIMer command.*
SAMP:SOUR?	*Query multimeter to return pacing source setting.*
enter statement	*Enter string into computer.*

:TIMer

SAMPle:TIMer <*period*> defines the period between readings in a burst of readings when
SAMPle:COUNt is greater than 1 and SAMPle:SOURce is TIMer.

Parameters

Parameter Name	Parameter Type	Range of Values[1]	Default Units
period	numeric	680 μs through 2100s| MINimum|MAXimum	seconds

1 Resolution: 1.0 μs

Example   **Setting the Sample Rate**

dimension array	*Dimension computer array.*
CONF:VOLT:DC 25	*Function: dc voltage; range selected: 30 V (disable autorange for fastest rate).*
SAMP:COUN 10	*Specify 10 readings per trigger.*
SAMP:SOUR TIM	*Sample source is SAMPle:TIMer command.*
SAMP:TIM 0.065	*Set 65 ms sample rate.*
READ?	*place multimeter in wait-for-trigger state and make measurements; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ MIN sets the time to 680 μs. MAX sets the time to 2100 seconds.

■ When using SAMP:TIM, the first measurement occurs without the
specified period. However, you can insert a time interval before the first
measurement using the TRIGger:DELay command.

■ To achieve specific sample rates, the aperture time must be set accordingly
(see the SENSe subsystem). The following table shows the minimum sample
rate for each available aperture time setting. The aperture times and
sample rate shown assume a fixed range and autozero off. Reading rates are
for the dc voltage function with readings stored in multimeter memory.

Table 8-5.
Minimum Sample Rate for Available Aperture Time Settings

Aperture Time	Minimum Sample Rate (SAMPle:TIMer)	Maximum Reading Rate Readings/second)
2.0 s	2.5 s	0.4
1.67 s	2.04 s	0.49
200 ms	250 ms	4.0
167 ms	204 ms	4.9
20 ms	21.2 ms	47
16.7 ms	17.8 ms	56
2.0 ms	3.2 ms	312
1.67 ms	2.7 ms	360
100 μs	800 μs	1250
10 μs	680 μs	1450

■ The sample rate must be longer than the specified aperture time.

■ **Related Commands:** SAMPle:COUNt, SAMPle:SOURce, SENSe

■ ***RST Condition:** SAMP:TIM 1.0

:TIMer?

SAMPle:TIMer? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present sample rate (680 μs through 2100 seconds) if MIN or MAX is not specified.

■ The minimum sample rate available (680 μs) if MIN is specified.

■ The maximum sample rate available (2100 seconds) if MAX is specified.

Example   **Querying the Sample Rate**

SAMP:SOUR TIM	*Sample source is SAMPle:TIMer command.*
SAMP:TIM MAX	*Set sample rate to maximum.*
SAMP:TIM?	*Query multimeter to return sample rate (2100 seconds).*
enter statement	*Enter value into computer.*

[SENSe:]

The SENSe command subsystem is most commonly used with CONFigure[:SCALar] to change specific "low-level" measurement parameters. SENSe enables you to change the following measurement parameters without completely re-configuring the multimeter:

■ AC Bandwidth

■ Function

■ Range

■ Resolution

■ Aperture and Integration Times

■ Offset Compensation

Subsystem   [SENSe:]
Syntax   CURRent

```
            CURRent
                :AC|[:DC]
                :APERture <time>
                :APERture? [MINimum|MAXimum]
                :NPLCycles <number>
                :NPLCycles? [MINimum|MAXimum]
                :RANGe
                    :AUTO <mode>
                    :AUTO?
                    [:UPPer] <expected value>
                    [:UPPer]? [MINimum|MAXimum]
                :RESolution <resolution>
                :RESolution? [MINimum|MAXimum]
            DETector
                :BANDwidth|BWIDth <frequency>
                :BANDwidth|BWIDth [MINimum|MAXimum]
            FUNCtion[:ON] "<function>"
            FUNCtion[:ON]?
            RESistance
                :APERture <time>
                :APERture? [MINimum|MAXimum]
                :NPLCycles <number>
                :NPLCycles? [MINimum|MAXimum]
                :OCOMpensated <mode>
                :OCOMpensated?
                :RANGe
                    :AUTO <mode>
                    :AUTO?
                    [:UPPer] <expected value>
                    [:UPPer]? [MINimum|MAXimum]
                :RESolution <resolution>
                :RESolution? [MINimum|MAXimum]
            VOLTage
```

```
:AC|[:DC]
    :APERture <time>
    :APERture? [MINimum|MAXimum]
    :NPLCycles <number>
    :NPLCycles? [MINimum|MAXimum]
    :RANGe
        :AUTO <mode>
        :AUTO?
        [:UPPer] <expected value>
        [:UPPer]? [MINimum|MAXimum]
    :RESolution <resolution>
    :RESolution? [MINimum|MAXimum]
```

Note	The root command SENSe is an implied command and can be omitted.

CURRent:AC:APERture

[SENSe:]CURRent:AC:APERture <*time*> sets the integration time in seconds for ac current measurements. Values are rounded up to the nearest aperture time shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	1.67 s|2 s|167 ms|200 ms| 16.7 ms| 20 ms|1.67 ms| 2 ms|100 μs|10 μs| MINimum|MAXimum	seconds

Example   **Setting the Aperture Time in Seconds**

CURR:AC:APER 1.67E-01   *Aperture time is 167 ms.*

Comments

■ MIN sets the aperture time to 10 μs. MAX sets the aperture time to 2 seconds.

■ Setting the aperture time also sets the integration time in power line cycles (PLCs) and the resolution. For example, an aperture time of 16.7 ms (60 Hz line frequency) sets an integration time of 1 PLC. The corresponding resolution depends on the function and range you select.

■ The line frequency reference set by the SYSTem:LFRequency command can be overridden by the 50 or 60 Hz aperture time set by CURR:AC:APER. The last command executed has priority.

■ The CURR:AC:APER command overrides the results of previously executed CURRent:AC:NPLCycles and CURRent:AC:RESolution command. The last command executed has priority.

■ The greater the aperture time, the greater the normal-mode rejection (and the lower the reading rate).

■ **Related Commands:** SYSTem:LFRequency

■ ***RST Condition:** CURR:AC:APER 1.67E-02 (60 Hz) or CURR:AC:APER 2E-02 (50 Hz)

CURRent:AC:APERture?

[SENSe:]CURRent:AC:APERture? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

- The present aperture time in seconds if MIN or MAX is not specified.

- The minimum aperture time available (10 μs) if MIN is specified.

- The maximum aperture time available (2 seconds) if MAX is specified.

Example   **Querying the Aperture Time**

                                `CURR:AC:APER 1.67E-01`   *Aperture time is 167 ms.*
                                `CURR:AC:APER?`   *Query multimeter to return aperture time.*
                                `enter statement`   *Enter value into computer.*

CURRent:AC:NPLCycles

[SENSe:]CURRent:AC:NPLCycles <*number*> sets the integration time in power line cycles (PLCs) for ac current measurements. Values are rounded up to the nearest number of PLCs shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0.0005|0.005|0.1|1|10|100| MINimum|MAXimum	PLCs

Example   **Setting the Integration Time in PLCs**

        CURR:AC:NPLC 10   *Integration time is 10 PLCs.*

Comments
- MIN selects 0.0005 PLCs. MAX selects 100 PLCs.

- Setting the integration time in power line cycles (PLCs) also sets the aperture time and the resolution. For example, 10 PLCs (60 Hz line frequency) sets an aperture time of 167 ms. The corresponding resolution depends on the function and range you select.

- The CURR:AC:NPLC command overrides the results of previously executed CURRent:AC:APERture and CURRent:AC:RESolution commands. The last command executed has priority.

- The greater the number of PLCs, the greater the normal-mode rejection (and the lower the reading rate).

- Use the SYSTem:LFRequency command to select the line frequency reference for the multimeter's A/D converter.

- **Related Commands:** SYSTem:LFRequency

- ***RST Condition:** CURR:AC:NPLC 1

CURRent:AC:NPLCycles?

[SENSe:]CURRent:AC:NPLCycles? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present integration time in PLCs if MIN or MAX is not specified.

■ The minimum integration time available (0.0005) if MIN is specified.

■ The maximum integration time available (100) if MAX is specified.

Example   **Querying the Integration Time**

CURR:AC:NPLC 10	*Integration time is 10 PLCs.*
CURR:AC:NPLC?	*Query multimeter to return integration time.*
enter statement	*Enter value into computer.*

CURRent:AC:RANGe:AUTO

[SENSe:]CURRent:AC:RANGe:AUTO <*mode*> enables or disables the autorange function for ac current measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Autoranging**

      CURR:AC:RANG:AUTO OFF   *Disable autorange.*

Comments
- You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

- When autoranging is ON, the multimeter samples the input before each measurement and selects the appropriate range.

- If you explicitly select a range using CURRent:AC:RANGe autoranging is turned OFF.

- **Related Commands:** CONFigure[:SCALar], CURRent:AC:RANGe,

- ***RST Condition:** CURR:AC:RANG:AUTO ON

CURRent:AC:RANGe:AUTO?

[SENSe:]CURRent:AC:RANGe:AUTO? returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Autorange Mode**

CURR:AC:RANG:AUTO OFF   *Disable autorange.*

CURR:AC:RANG:AUTO?   *Query multimeter to return autorange mode.*

enter statement   *Enter value into computer.*

CURRent:AC:RANGe[:UPPer]

[SENSe:]CURRent:AC:RANGe[:UPPer] <*expected value*> selects the range for ac current measurements.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 A through 3 A| MINimum|MAXimum	amps

Example   **Changing the Range**

CONF:CURR:AC 0.25,MAX   *Function: ac amps; range selected: 300 mA; MAX resolution: 100 nA.*

CURR:AC:RANG 1   *Range selected: 3 A; MAX resolution: 1 μA.*

READ?   *place multimeter in wait-for-trigger state and make measurement; send reading to the output buffer.*

enter statement   *Enter reading into computer.*

Comments

- To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

- MIN selects the minimum range available (30 mA). MAX selects the maximum range available (3 A).

- Specifying a fixed range disables the autorange mode set by the CURR:AC:RANG:AUTO command.

- The CURR:AC:RANG command overrides the range setting from a previous CONFigure[:SCALar] command specifying the same function. With the new range, a new resolution is also selected. However, this resolution is based on the aperture time set by CONFigure[:SCALar].

- *RST Condition: CURR:AC:RANG 3

CURRent:AC:RANGe[:UPPer]?

[SENSe:]CURRent:AC:RANGe[:UPPer]? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present current range selected if MIN or MAX is not specified.

■ The minimum current range available (30 mA) if MIN is specified.

■ The maximum current range available (3 A) if MAX is specified.

Example   **Querying the Measurement Range**

CURR:AC:RANG 0.2   *Range selected: 300 mA.*

CURR:AC:RANG?   *Query multimeter to return the present range.*

enter statement   *Enter value into computer.*

CURRent:AC:RESolution

[SENSe:]CURRent:AC:RESolution <*resolution*> selects the resolution for voltage measurements.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resolution	numeric	*resolution* (see Table 8-3| MINimum|MAXimum	2 amps

Example   **Changing the Resolution**

CONF:CURR:AC 1.5,MAX	*Function: ac current; range selected: 2 A; MAX resolution.*
CURR:AC:RES 10E-06	*Set resolution to 10 µA; selects 1.67 ms aperture time (60 Hz line frequency).*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
enter statement	*Enter reading into computer.*

Comments

- MIN selects the best resolution (the smallest value from Table 8-3 for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

- You must select a fixed range *before* specifying resolution. Also, only specify a numeric resolution (for example, not MIN or MAX) when making measurements on a fixed range. Otherwise, the resolution will change to correspond with the range selected during autoranging.

- If autoranging is required, set the resolution using the MIN or MAX parameters or select a specific aperture time using CURRent:AC:APERture.

- If necessary to achieve the specified resolution, the multimeter will increase the integration time as needed. This command overrides the results of previously executed CURRent:AC:APERture and CURRent:AC:NPLCycles commands. The last command executed has priority.

- The CURR:AC:RES command overrides the resolution setting from a previous CONFigure[:SCALar] command on the same function.

- **Related Commands:** CONFigure[:SCALar], CURRent:AC:APERture, CURRent:AC:NPLCycles

- ***RST Condition:** Based on the *RST values for the CURRent:AC:APERture and CURRent:AC:NPLCycles commands.

CURRent:AC:RESolution?

[SENSe:]CURRent:AC:RESolution? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present resolution selected for the specified function and range if MIN or MAX are not specified.

■ The resolution with the smallest value (for example, the best resolution) for the specified function and range if MIN is specified.

■ The resolution with the largest value (for example, the worst resolution) for the specified function and range if MAX is specified.

Example   **Querying the Resolution**

                CURR:AC:RES 100E-06   *Set resolution to 100 µA.*
                CURR:AC:RES?   *Query multimeter to return the present resolution.*
                enter statement   *Enter value into computer.*

CURRent[:DC]:APERture

[SENSe:]CURRent[:DC]:APERture <*time*> sets the integration time in seconds for dc current measurements. Values are rounded up to the nearest aperture time shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	1.67 s|2 s|167 ms|200 ms| 16.7 ms| 20 ms|1.67 ms| 2 ms|100 μs|10 μs| MINimum|MAXimum	seconds

Example **Setting the Aperture Time in Seconds**

CURR:DC:APER 1.67E-01   *Aperture time is 167 ms.*

Comments
- MIN sets the aperture time to 10 μs. MAX sets the aperture time to 2 seconds.

- Setting the aperture time also sets the integration time in power line cycles (PLCs) and the resolution. For example, an aperture time of 16.7 ms (60 Hz line frequency) sets an integration time of 1 PLC. The corresponding resolution depends on the function and range you select.

- The line frequency reference set by the SYSTem:LFRequency command can be overridden by the 50 or 60 Hz aperture time set by CURR:DC:APER. The last command executed has priority.

- The CURR:DC:APER command overrides the results of previously executed CURRent:NPLCycles and CURRent:RESolution command. The last command executed has priority.

- The greater the aperture time, the greater the normal-mode rejection (and the lower the reading rate).

- **Related Commands:** SYSTem:LFRequency

- ***RST Condition:** CURR:DC:APER 1.67E-02 (60 Hz) or CURR:DC:APER 2E-02 (50 Hz)

CURRent[:DC]:APERture?

[SENSe:]CURRent[:DC]:APERture? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present aperture time in seconds if MIN or MAX is not specified.

■ The minimum aperture time available (10 μs) if MIN is specified.

■ The maximum aperture time available (2 seconds) if MAX is specified.

Example   **Querying the Aperture Time**

CURR:DC:APER 1.67E-01	*Aperture time is 167 ms.*
CURR:DC:APER?	*Query multimeter to return aperture time.*
enter statement	*Enter value into computer.*

CURRent[:DC]:NPLCycles

[SENSe:]CURRent[:DC]:NPLCycles <*number*> sets the integration time in power line cycles (PLCs) for dc current measurements. Values are rounded up to the nearest number of PLCs shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0.0005|0.005|0.1|1|10|100| MINimum|MAXimum	PLCs

Example   **Setting the Integration Time in PLCs**

               CURR:NPLC 10   *Integration time is 10 PLCs.*

Comments   ■ MIN selects 0.0005 PLCs. MAX selects 100 PLCs.

               ■ Setting the integration time in power line cycles (PLCs) also sets the aperture time and the resolution. For example, 10 PLCs (60 Hz line frequency) sets an aperture time of 167 ms. The corresponding resolution depends on the function and range you select.

               ■ The CURR:DC:NPLC command overrides the results of previously executed CURRent:DC:APERture and CURRent:DC:RESolution commands. The last command executed has priority.

               ■ The greater the number of PLCs, the greater the normal-mode rejection (and the lower the reading rate).

               ■ Use the SYSTem:LFRequency command to select the line frequency reference for the multimeter's A/D converter.

               ■ **Related Commands:** SYSTem:LFRequency

               ■ ***RST Condition:** CURR:DC:NPLC 1

CURRent[:DC]:NPLCycles?

[SENSe:]CURRent[:DC]:NPLCycles? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present integration time in PLCs if MIN or MAX is not specified.

■ The minimum integration time available (0.0005) if MIN is specified.

■ The maximum integration time available (100) if MAX is specified.

Example   **Querying the Integration Time**

CURR:DC:NPLC 10	*Integration time is 10 PLCs.*
CURR:DC:NPLC?	*Query multimeter to return integration time.*
enter statement	*Enter value into computer.*

CURRent[:DC]:RANGe:AUTO

[SENSe:]CURRent[:DC]:RANGe:AUTO *<mode>* enables or disables the autorange function for dc current measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Autoranging**

   CURR:DC:RANG:AUTO OFF   *Disable autorange.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ When autoranging is ON, the multimeter samples the input before each measurement and selects the appropriate range.

■ If you explicitly select a range using CURRent:DC:RANGe autoranging is turned OFF.

■ **Related Commands:** CONFigure[:SCALar], CURRent:DC:RANGe,

■ ***RST Condition:** CURR:DC:RANG:AUTO ON

CURRent[:DC]:RANGe:AUTO?

[SENSe:]CURRent[:DC]:RANGe:AUTO? returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Autorange Mode**

CURR:DC:RANG:AUTO OFF	*Disable autorange.*
CURR:DC:RANG:AUTO?	*Query multimeter to return autorange mode.*
enter statement	*Enter value into computer.*

CURRent[:DC]:RANGe[:UPPer]

[SENSe:]CURRent[:DC]:RANGe[:UPPer] <*expected value*> selects the range for dc current measurements.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 A through 3 A| MINimum|MAXimum	amps

Example   **Changing the Range**

`CONF:CURR:DC 0.25,MAX`	*Function: dc amps; range selected: 300 mA; MAX resolution: 100 nA.*
`CURR:DC:RANG 1`	*Range selected: 3 A; MAX resolution: 1 μA.*
`READ?`	*place multimeter in wait-for-trigger state and make measurement; send reading to the output buffer.*
`enter statement`	*Enter reading into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

- MIN selects the minimum range available (300 μA). MAX selects the maximum range available (3 A).

- Specifying a fixed range disables the autorange mode set by the CURR:DC:RANG:AUTO command.

- The CURR:DC:RANG command overrides the range setting from a previous CONFigure[:SCALar] command specifying the same function. With the new range, a new resolution is also selected. However, this resolution is based on the aperture time set by CONFigure[:SCALar].

- *RST Condition: CURR:DC:RANG 3

CURRent[:DC]:RANGe[:UPPer]?

[SENSe:]CURRent[:DC]:RANGe[:UPPer]? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present current range selected if MIN or MAX is not specified.

■ The minimum current range available (300 μA) if MIN is specified.

■ The maximum current range available (3 A) if MAX is specified.

Example   **Querying the Measurement Range**

CURR:DC:RANG 0.2	*Range selected: 300 mA.*
CURR:DC:RANG?	*Query multimeter to return the present range.*
enter statement	*Enter value into computer.*

CURRent[:DC]:RESolution

[SENSe:]CURRent[:DC]:RESolution <*resolution*> selects the resolution for voltage measurements.

For a complete listing of range and resolution values available, see Table 8-3 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resolution	numeric	*resolution* (see Table 8-3| MINimum|MAXimum	amps

Example   **Changing the Resolution**

CONF:CURR:DC 1.5,MAX   *Function: dc current; range selected: 2 A; MAX resolution.*

CURR:DC:RES 10E-06   *Set resolution to 10 μA; selects 1.67 ms aperture time (60 Hz line frequency).*

READ?   *place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*

enter statement   *Enter reading into computer.*

Comments
- MIN selects the best resolution (the smallest value from Table 8-3 for the selected range. MAX selects the worst resolution (the largest value from Table 8-3) for the selected range.

- You must select a fixed range *before* specifying resolution. Also, only specify a numeric resolution (for example, not MIN or MAX) when making measurements on a fixed range. Otherwise, the resolution will change to correspond with the range selected during autoranging.

- If autoranging is required, set the resolution using the MIN or MAX parameters or select a specific aperture time using CURRent:DC:APERture.

- If necessary to achieve the specified resolution, the multimeter will increase the integration time as needed. This command overrides the results of previously executed CURRent:DC:APERture and CURRent:DC:NPLCycles commands. The last command executed has priority.

- The CURR:DC:RES command overrides the resolution setting from a previous CONFigure[:SCALar] command on the same function.

- **Related Commands:** CONFigure[:SCALar], CURRent:DC:APERture, CURRent:DC:NPLCycles

- ***RST Condition:** Based on the *RST values for the CURRent:DC:APERture and CURRent:DC:NPLCycles commands.

CURRent[:DC]:RESolution?

[SENSe:]CURRent[:DC]:RESolution? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present resolution selected for the specified function and range if MIN or MAX are not specified.

■ The resolution with the smallest value (for example, the best resolution) for the specified function and range if MIN is specified.

■ The resolution with the largest value (for example, the worst resolution) for the specified function and range if MAX is specified.

Example   **Querying the Resolution**

                          CURR:DC:RES 100E-06   *Set resolution to 100 μA.*
                          CURR:DC:RES?   *Query multimeter to return the present resolution.*
                          enter statement   *Enter value into computer.*

DETector:BANDwidth

[SENSe:]DETector:BANDwidth <*frequency*> selects the slow or fast measurement mode for ac voltage, current, frequency, or period measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
frequency	numeric	< 400 Hz (select slow mod)| ≥ 400 Hz (select fast mode)| MINimum|MAXimum	hertz

Example   **Selecting the AC Bandwidth**

            DET:BAND 5000   *Select fast mode.*

Comments   ■ You specify *frequency* as the expected frequency of the input signal. The multimeter automatically selects the slow mode (20 Hz is used) or fast mode (400 Hz is used) based on the frequency you specify.

              ■ MIN selects the slow mode (20 Hz). MAX selects the fast mode (400 Hz).

              ■ The slow mode selects a long time constant for the ac voltage input filter and a long delay time for ac volts, frequency, and period. Use this mode for measurements where the frequency is below 400 Hz. The fast mode selects a short time constant and a short delay time. Use this mode for measurements where the frequency is equal to or greater than 400 Hz. Table 3-12 shows the slow and fast mode delays for all functions and ranges.

              ■ Since the fast mode has a short delay, it allows you to make a series of measurements faster than in the slow mode.

              ■ If you are unsure of the input frequency, or if the frequency may dip below 400 Hz, use the slow mode. This takes slightly more time per measurement, but ensures accurate measurements.

              ■ BWIDth is an alias for BANDwidth

              ■ *RST Condition: DET:BAND 20

DETector:BANDwidth?

[SENSe:]DETector:BANDwidth? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present bandwidth (in hertz) selected by the multimeter (either 20 or 400) if MIN or MAX is not specified.

■ The minimum bandwidth available (20) if MIN is specified.

■ The maximum bandwidth available (400) if MAX is specified.

Example   **Querying the AC Bandwidth**

                `DET:BAND 5000`   *Select fast mode.*

                `DET:BAND?`   *Query multimeter to return bandwidth value (returns "400").*

                `enter statement`   *Enter value into computer.*

Comments   ■ BWIDth is an alias for BANDwidth.

FUNCtion[:ON]

[SENSe:]FUNCtion[:ON] "*<function>*" selects the measurement function. You can select 2-wire or 4-wire resistance, dc voltage, ac RMS voltage, current, frequency, or period measurements. The default function is dc voltage.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
function	discrete	CURRent:AC| CURRent[:DC]| FREQuency| FRESistance| PERiod| RESistance| VOLTage:AC| VOLTage[:DC]	none

Example   **Changing Measurement Function**

CONF:VOLT:DC	*Function: dc voltage.*
FUNC "FRES"	*Change function to 4-wire resistance.*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
enter statement	*Enter reading into computer.*

Comments   ■ The :DC parameter is optional. Both of the following command statements select the dc voltage function:

FUNC "VOLT:DC" or FUNC "VOLT"

■ To select the ac+dc voltage function, set the input coupling to dc (INPut:COUPling DC) before executing the FUNC "VOLT:AC" command.

■ ***RST Condition:** FUNC "VOLT:DC"

FUNCtion?

[SENSe:]FUNCtion? returns one of the following strings to the output buffer: "CURR:AC", "CURR", "FREQ", "FRES", "PER", "RES", "VOLT:AC", or "VOLT".

Example   Querying the Measurement Function

             FUNC "FRES"   *Function: 4-wire ohms.*
             FUNC?   *Query multimeter to return selected function.*
             enter statement   *Enter quoted string into computer.*

RESistance:APERture

[SENSe:]RESistance:APERture <*time*> sets the integration time in seconds for resistance measurements. Values are rounded up to the nearest aperture time shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	1.67 s|2 s|167 ms|200 ms| 16.7 ms| 20 ms|1.67 ms| 2 ms|100 μs|10 μs| MINimum|MAXimum	seconds

Example   **Setting the Aperture Time in Seconds**

                        RES:APER 1.67E-01   *Aperture time is 167 ms.*

Comments   ■ MIN sets the aperture time to 10 μs. MAX sets the aperture time to 2 seconds.

                    ■ Setting the aperture time also sets the integration time in power line cycles (PLCs) and the resolution. For example, an aperture time of 16.7 ms (60 Hz line frequency) sets an integration time of 1 PLC. The corresponding resolution depends on the function and range you select.

                    ■ The line frequency reference set by the SYSTem:LFRequency command can be overridden by the 50 or 60 Hz aperture time set by RES:APER. The last command executed has priority.

                    ■ The RES:APER command overrides the results of previously executed RESistance:NPLCycles and RESistance:RESolution commands. The last command executed has priority.

                    ■ The greater the aperture time, the greater the normal-mode rejection (and the lower the reading rate).

                    ■ **Related Commands:** SYSTem:LFRequency

                    ■ ***RST Condition:** RES:APER 1.67E-02 (60 Hz) or RES:APER 2E-02 (50 Hz)

RESistance:APERture?

[SENSe:]RESistance:APERture? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present aperture time in seconds if MIN or MAX is not specified.

■ The minimum aperture time available (10 μs) if MIN is specified.

■ The maximum aperture time available (2 seconds) if MAX is specified.

Example   **Querying the Aperture Time**

RES:APER 1.67E-01	*Aperture time is 167 ms.*
RES:APER?	*Query multimeter to return aperture time.*
enter statement	*Enter value into computer.*

RESistance:NPLCycles

[SENSe:]RESistance:NPLCycles <*number*> sets the integration time in power line cycles (PLCs) for resistance measurements. Values are rounded up to the nearest number of PLCs shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0.0005|0.005|0.1|1|10|100| MINimum|MAXimum	PLCs

Example   **Setting the Integration Time in PLCs**

RES:NPLC 10   *Integration time is 10 PLCs.*

Comments
- MIN selects 0.0005 PLCs. MAX selects 100 PLCs.

- Setting the integration time in power line cycles (PLCs) also sets the aperture time and the resolution. For example, 10 PLCs (60 Hz line frequency) sets an aperture time of 167 ms. The corresponding resolution depends on the function and range you select.

- The RES:NPLC command overrides the results of previously executed RESistance:APERture and RESistance:RESolution commands. The last command executed has priority.

- The greater the number of PLCs, the greater the normal-mode rejection (and the lower the reading rate).

- Use the SYSTem:LFRequency command to select the line frequency reference for the multimeter's A/D converter.

- **Related Commands:** SYSTem:LFRequency

- ***RST Condition:** RES:NPLC 1

RESistance:NPLCycles?

[SENSe:]RESistance:NPLCycles? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present integration time in PLCs if MIN or MAX is not specified.

■ The minimum integration time available (0.0005) if MIN is specified.

■ The maximum integration time available (100) if MAX is specified.

Example   **Querying the Integration Time**

RES:NPLC 10	*Integration time is 10 PLCs.*
RES:NPLC?	*Query multimeter to return integration time.*
enter statement	*Enter value into computer.*

RESistance:OCOMpensated

[SENSe:]RESistance:OCOMpensated <*mode*> enables or disables the offset compensated ohms function.

Note

Offset compensation only works on the 30 Ω, 300 Ω, and 3 kΩ ranges.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example

Enabling Offset Compensation

    RES:OCOM ON   *Enable offset compensation.*

Comments

■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ With offset compensation enabled, the multimeter measures the offset voltage before each resistance measurement and subtracts it from the following reading. This prevents the offset voltage from affecting the resistance but doubles the time required per reading.

■ You can use offset compensation for 2-wire or 4-wire ohms measurements.

■ *RST Condition: RES:OCOM OFF

RESistance:OCOMpensated?

[SENSe:]RESistance:OCOMpensated? returns a number to show whether offset compensation is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Offset Compensation Mode**

RES:OCOM ON	*Enable offset compensation.*
RES:OCOM?	*Query multimeter to return offset compensation mode.*
enter statement	*Enter value into computer.*

RESistance:RANGe:AUTO

[SENSe:]RESistance:RANGe:AUTO <*mode*> enables or disables the autorange function for resistance measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Autoranging**

RES:RANG:AUTO OFF   *Disable autorange.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ When autoranging is ON, the multimeter samples the input before each measurement and selects the appropriate range.

■ If you explicitly select a range using RESistance:RANGe, autoranging is turned OFF.

■ **Related Commands:** CONFigure[:SCALar], RESistance:RANGe

■ ***RST Condition:** RES:RANG:AUTO ON

RESistance:RANGe:AUTO?

[SENSe:]RESistance:RANGe:AUTO? returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Autorange Mode**

                `RES:RANG:AUTO OFF`   *Disable autorange.*

                `RES:RANG:AUTO?`   *Query multimeter to return autorange mode.*

                `enter statement`   *Enter value into computer.*

RESistance:RANGe [:UPPer]

[SENSe:]RESistance:RANGe[:UPPer] *<expected value>* selects the range for resistance measurements. For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 Ω through 3 GΩ | MINimum|MAXimum	ohms

Example   **Changing the Range**

CONF:RES 1320,MAX	*Function: 2-wire ohms; range selected: 3 kΩ; MAX resolution: 1 Ω.*
RES:RANG 220	*Range selected: 300 Ω; MAX resolution: 100 mΩ.*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
enter statement	*Enter reading into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected resistance. The multimeter then selects the correct range.

- MIN selects the minimum range available (0 Ω). MAX selects the maximum range available (3 GΩ).

- Specifying a fixed range disables the autorange mode set by the RES:RANG:AUTO command.

- The RES:RANG command overrides the range setting from a previous CONFigure[:SCALar] command specifying the same function. With the new range, a new resolution is also selected. However, this resolution is based on the aperture time set by CONFigure[:SCALar].

- *RST Condition: RES:RANG 3.0E+04

RESistance:RANGe [:UPPer]?

[SENSe:]RESistance:RANGe[:UPPer]? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present resistance range selected if MIN or MAX is not specified.

■ The minimum resistance range available (30 Ω) if MIN is specified.

■ The maximum resistance range available (3 GΩ) if MAX is specified.

Example   Querying the Measurement Range

```
RES:RANG 220        Range selected: 300 Ω.
RES:RANG?           Query multimeter to return the present range.
enter statement     Enter value into computer.
```

RESistance:RESolution

[SENSe:]RESistance:RESolution <*resolution*> selects the resolution for resistance measurements. For a complete listing of range and resolution values available, see Table 8-4 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resolution	numeric	*resolution* (see Table 8-4| MINimum|MAXimum	ohms

Example   **Changing the Resolution**

CONF:FRES 1560,MAX   *Function: 4-wire ohms; range selected: 3 kΩ; MAX resolution: 1 Ω.*

RES:RES 1.0E-03   *Set resolution to 1 mΩ; selects 16.7 ms aperture time (60 Hz line frequency).*

READ?   *place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*

enter statement   *Enter reading into computer.*

Comments
- MIN selects the best resolution (the smallest value from Table 8-4) for the selected range. MAX selects the worst resolution (the largest value from Table 8-4) for the selected range.

- You must select a fixed range *before* specifying resolution. Also, only specify a numeric resolution (for example, not MIN or MAX) when making measurements on a fixed range. Otherwise, the resolution will change to correspond with the range selected during autoranging.

- If autoranging is required, set the resolution using the MIN or MAX parameters or select a specific aperture time using RESistance:APERture.

- If necessary to achieve the specified resolution, the multimeter will increase the integration time as needed. This command overrides the results of previously executed RESistance:APERture and RESistance:NPLCycles commands. The last command executed has priority.

- The RES:RES command overrides the resolution setting from a previous CONFigure[:SCALar] command on the same function.

- **Related Commands:** CONFigure[:SCALar], RESistance:APERture, RESistance:NPLCycles

- ***RST Condition:** Based on the *RST values for the RESistance:APERture and RESistance:NPLCycles commands.

RESistance:RESolution?

[SENSe:]RESistance:RESolution? [MINimum|MAXimum] returns one of the following
numbers to the output buffer:

■ The present resolution selected for the specified function and range if MIN or MAX are not
specified.

■ The resolution with the smallest value (for example, the best resolution) for the specified
function and range if MIN is specified.

■ The resolution with the largest value (for example, the worst resolution) for the specified
function and range if MAX is specified.

Example   **Querying the Resolution**

RES:RES 1.0E-03++   *Set resolution to 1 mΩ.*
RES:RES?   *Query multimeter to return the present resolution.*
enter statement   *Enter value into computer.*

VOLTage:AC:APERture

[SENSe:]VOLTage:AC:APERture *<time>* sets the integration time in seconds for ac voltage measurements. Values are rounded up to the nearest aperture time shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	1.67 s|2 s|167 ms|200 ms| 16.7 ms| 20 ms|1.67 ms| 2 ms|100 μs|10 μs| MINimum|MAXimum	seconds

Example   **Setting the Aperture Time in Seconds**

        VOLT:AC:APER 1.67E-01   *Aperture time is 167 ms.*

Comments   ■ MIN sets the aperture time to 10 μs. MAX sets the aperture time to 2 seconds.

■ Setting the aperture time also sets the integration time in power line cycles (PLCs) and the resolution. For example, an aperture time of 16.7 ms (60 Hz line frequency) sets an integration time of 1 PLC. The corresponding resolution depends on the function and range you select.

■ The line frequency reference set by the SYSTem:LFRequency command can be overridden by the 50 or 60 Hz aperture time set by VOLT:AC:APER. The last command executed has priority.

■ The VOLT:AC:APER command overrides the results of previously executed VOLTage:AC:NPLCycles and VOLTage:AC:RESolution command. The last command executed has priority.

■ The greater the aperture time, the greater the normal-mode rejection (and the lower the reading rate).

■ **Related Commands:** SYSTem:LFRequency

■ ***RST Condition:** VOLT:AC:APER 1.67E-02 (60 Hz) or VOLT:AC:APER 2E-02 (50 Hz)

VOLTage:AC:APERture?

[SENSe:]VOLTage:AC:APERture? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present aperture time in seconds if MIN or MAX is not specified.

■ The minimum aperture time available (10 μs) if MIN is specified.

■ The maximum aperture time available (2 seconds) if MAX is specified.

Example   **Querying the Aperture Time**

VOLT:AC:APER 1.67E-01	*Aperture time is 167 ms.*
VOLT:AC:APER?	*Query multimeter to return aperture time.*
enter statement	*Enter value into computer.*

VOLTage:AC:NPLCycles

[SENSe:]VOLTage:AC:NPLCycles <*number*> sets the integration time in power line cycles (PLCs) for voltage measurements. Values are rounded up to the nearest number of PLCs shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0.0005|0.005|0.1|1|10|100| MINimum|MAXimum	PLCs

Example   Setting the Integration Time in PLCs

> VOLT:AC:NPLC 10   *Integration time is 10 PLCs.*

Comments   ■ MIN selects 0.0005 PLCs. MAX selects 100 PLCs.

■ Setting the integration time in power line cycles (PLCs) also sets the aperture time and the resolution. For example, 10 PLCs (60 Hz line frequency) sets an aperture time of 167 ms. The corresponding resolution depends on the function and range you select.

■ The VOLT:AC:NPLC command overrides the results of previously executed VOLTage:AC:APERture and VOLTage:AC:RESolution commands. The last command executed has priority.

■ The greater the number of PLCs, the greater the normal-mode rejection (and the lower the reading rate).

■ Use the SYSTem:LFRequency command to select the line frequency reference for the multimeter's A/D converter.

■ **Related Commands:** SYSTem:LFRequency

■ ***RST Condition:** VOLT:AC:NPLC 1

VOLTage:AC:NPLCycles?

[SENSe:]VOLTage:AC:NPLCycles? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present integration time in PLCs if MIN or MAX is not specified.

■ The minimum integration time available (0.0005) if MIN is specified.

■ The maximum integration time available (100) if MAX is specified.

Example   **Querying the Integration Time**

VOLT:AC:NPLC 10	*Integration time is 10 PLCs.*
VOLT:AC:NPLC?	*Query multimeter to return integration time.*
enter statement	*Enter value into computer.*

VOLTage:AC:RANGe:AUTO

[SENSe:]VOLTage:AC:RANGe:AUTO <*mode*> enables or disables the autorange function for ac voltage measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Autoranging**

          VOLT:AC:RANG:AUTO OFF   *Disable autorange.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

           ■ When autoranging is ON, the multimeter samples the input before each measurement and selects the appropriate range.

           ■ If you explicitly select a range using VOLTage:AC:RANGe autoranging is turned OFF.

           ■ **Related Commands:** CONFigure[:SCALar], VOLTage:AC:RANGe,

           ■ ***RST Condition:** VOLT:AC:RANG:AUTO ON

VOLTage:AC:RANGe:AUTO?

[SENSe:]VOLTage:AC:RANGe:AUTO? returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Autorange Mode**

VOLT:AC:RANG:AUTO OFF	*Disable autorange.*
VOLT:AC:RANG:AUTO?	*Query multimeter to return autorange mode.*
enter statement	*Enter value into computer.*

VOLTage:AC:RANGe[:UPPer]

[SENSe:]VOLTage:AC:RANGe[:UPPer] <*expected value*> selects the range for ac voltage measurements.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | MINimum|MAXimum	volts

Example   **Changing the Range**

CONF:VOLT:AC 0.54,MAX	*Function: ac volts; range selected: 3 V; MAX resolution: 1 mV.*
VOLT:AC:RANG 25	*Range selected: 30 V; MAX resolution: 10 mV.*
READ?	*place multimeter in wait-for-trigger state and make measurement; send reading to the output buffer.*
enter statement	*Enter reading into computer.*

Comments

■ To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

■ MIN selects the minimum range available (30 mV). MAX selects the maximum range available (300 V).

■ Specifying a fixed range disables the autorange mode set by the VOLT:AC:RANG:AUTO command.

■ The VOLT:AC:RANG command overrides the range setting from a previous CONFigure[:SCALar] command specifying the same function. With the new range, a new resolution is also selected. However, this resolution is based on the aperture time set by CONFigure[:SCALar].

■ *RST Condition: VOLT:AC:RANG 30

VOLTage:AC:RANGe[:UPPer]?

[SENSe:]VOLTage:AC:RANGe[:UPPer]? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

- The present voltage range selected if MIN or MAX is not specified.

- The minimum voltage range available (30 mV) if MIN is specified.

- The maximum voltage range available (300 V) if MAX is specified.

Example   **Querying the Measurement Range**

                  VOLT:AC:RANG 0.2   *Range selected: 300 mV.*
                  VOLT:AC:RANG?   *Query multimeter to return the present range.*
                  enter statement   *Enter value into computer.*

VOLTage:AC:RESolution

[SENSe:]VOLTage:AC:RESolution <*resolution*> selects the resolution for ac voltage measurements.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resolution	numeric	*resolution* (see Table 8-2)| MINimum|MAXimum	volts

Example   **Changing the Resolution**

`CONF:VOLT:AC 8.25,MAX`	*Function: ac volts; range selected: 30 V; MAX resolution: 10 mV.*
`VOLT:AC:RES 100E-06`	*Set resolution to 100 µV; selects 1.67 ms aperture time (60 Hz line frequency).*
`READ?`	*place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*
`enter statement`	*Enter reading into computer.*

Comments
- MIN selects the best resolution (the smallest value from Table 8-2 for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

- You must select a fixed range *before* specifying resolution. Also, only specify a numeric resolution (for example, not MIN or MAX) when making measurements on a fixed range. Otherwise, the resolution will change to correspond with the range selected during autoranging.

- If autoranging is required, set the resolution using the MIN or MAX parameters or select a specific aperture time using VOLTage:AC:APERture.

- If necessary to achieve the specified resolution, the multimeter will increase the integration time as needed. This command overrides the results of previously executed VOLTage:AC:APERture and VOLTage:AC:NPLCycles commands. The last command executed has priority.

- The VOLT:AC:RES command overrides the resolution setting from a previous CONFigure[:SCALar] command on the same function.

- **Related Commands:** CONFigure[:SCALar], VOLTage:AC:APERture, VOLTage:AC:NPLCycles

- ***RST Condition:** Based on the *RST values for the VOLTage:AC:APERture and VOLTage:AC:NPLCycles commands.

VOLTage:AC:RESolution?

[SENSe:]VOLTage:AC:RESolution? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

- The present resolution selected for the specified function and range if MIN or MAX are not specified.

- The resolution with the smallest value (for example, the best resolution) for the specified function and range if MIN is specified.

- The resolution with the largest value (for example, the worst resolution) for the specified function and range if MAX is specified.

Example   **Querying the Resolution**

`VOLT:AC:RES 100E-06`	*Set resolution to 100 μV.*
`VOLT:AC:RES?`	*Query multimeter to return the present resolution.*
`enter statement`	*Enter value into computer.*

VOLTage[:DC]:APERture

[SENSe:]VOLTage[:DC]:APERture *<time>* sets the integration time in seconds for dc voltage measurements. Values are rounded up to the nearest aperture time shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	1.67 s|2 s|167 ms|200 ms| 16.7 ms| 20 ms|1.67 ms| 2 ms|100 μs|10 μs| MINimum|MAXimum	seconds

Example   **Setting the Aperture Time in Seconds**

      VOLT:DC:APER 1.67E-01   *Aperture time is 167 ms.*

Comments
- MIN sets the aperture time to 10 μs. MAX sets the aperture time to 2 seconds.

- Setting the aperture time also sets the integration time in power line cycles (PLCs) and the resolution. For example, an aperture time of 16.7 ms (60 Hz line frequency) sets an integration time of 1 PLC. The corresponding resolution depends on the function and range you select.

- The line frequency reference set by the SYSTem:LFRequency command can be overridden by the 50 or 60 Hz aperture time set by VOLT:DC:APER. The last command executed has priority.

- The VOLT:DC:APER command overrides the results of previously executed VOLTage:DC:NPLCycles and VOLTage:DC:RESolution command. The last command executed has priority.

- The greater the aperture time, the greater the normal-mode rejection (and the lower the reading rate).

- **Related Commands:** SYSTem:LFRequency

- ***RST Condition:** VOLT:DC:APER 1.67E-02 (60 Hz) or VOLT:DC:APER 2E-02 (50 Hz)

VOLTage[:DC]:APERture?

[SENSe:]VOLTage[:DC]:APERture? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present aperture time in seconds if MIN or MAX is not specified.

■ The minimum aperture time available (10 μs) if MIN is specified.

■ The maximum aperture time available (2 seconds) if MAX is specified.

Example   **Querying the Aperture Time**

VOLT:DC:APER 1.67E-01	*Aperture time is 167 ms.*
VOLT:DC:APER?	*Query multimeter to return aperture time.*
enter statement	*Enter value into computer.*

VOLTage[:DC]:NPLCycles

[SENSe:]VOLTage[:DC]:NPLCycles <*number*> sets the integration time in power line cycles (PLCs) for voltage measurements. Values are rounded up to the nearest number of PLCs shown in the following table.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0.0005|0.005|0.1|1|10|100| MINimum|MAXimum	PLCs

Example   **Setting the Integration Time in PLCs**

       VOLT:DC:NPLC 10   *Integration time is 10 PLCs.*

Comments

- MIN selects 0.0005 PLCs. MAX selects 100 PLCs.

- Setting the integration time in power line cycles (PLCs) also sets the aperture time and the resolution. For example, 10 PLCs (60 Hz line frequency) sets an aperture time of 167 ms. The corresponding resolution depends on the function and range you select.

- The VOLT:DC:NPLC command overrides the results of previously executed VOLTage:DC:APERture and VOLTage:DC:RESolution commands. The last command executed has priority.

- The greater the number of PLCs, the greater the normal-mode rejection (and the lower the reading rate).

- Use the SYSTem:LFRequency command to select the line frequency reference for the multimeter's A/D converter.

- **Related Commands:** SYSTem:LFRequency

- ***RST Condition:** VOLT:DC:NPLC 1

VOLTage[:DC]:NPLCycles?

[SENSe:]VOLTage[:DC]:NPLCycles? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present integration time in PLCs if MIN or MAX is not specified.

■ The minimum integration time available (0.0005) if MIN is specified.

■ The maximum integration time available (100) if MAX is specified.

Example   **Querying the Integration Time**

VOLT:DC:NPLC 10	*Integration time is 10 PLCs.*
VOLT:DC:NPLC?	*Query multimeter to return integration time.*
enter statement	*Enter value into computer.*

VOLTage[:DC]:RANGe:AUTO

[SENSe:]VOLTage[:DC]:RANGe:AUTO <*mode*> enables or disables the autorange function for dc voltage measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Autoranging**

    VOLT:DC:RANG:AUTO OFF   *Disable autorange.*

Comments
- You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

- When autoranging is ON, the multimeter samples the input before each measurement and selects the appropriate range.

- If you explicitly select a range using VOLTage:DC:RANGe autoranging is turned OFF.

- **Related Commands:** CONFigure[:SCALar], VOLTage:DC:RANGe,

- ***RST Condition:** VOLT:DC:RANG:AUTO ON

VOLTage[:DC]:RANGe:AUTO?

[SENSe:]VOLTage[:DC]:RANGe:AUTO? returns a number to show whether the autorange mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Autorange Mode**

`VOLT:DC:RANG:AUTO OFF`	*Disable autorange.*
`VOLT:DC:RANG:AUTO?`	*Query multimeter to return autorange mode.*
`enter statement`	*Enter value into computer.*

VOLTage[:DC]:RANGe[:UPPer]

[SENSe:]VOLTage[:DC]:RANGe[:UPPer] <*expected value*> selects the range for dc voltage measurements.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
expected value	numeric	0 V through ± 300 V | MINimum|MAXimum	volts

Example   **Changing the Range**

`CONF:VOLT:DC 0.54,MAX`	*Function: dc volts; range selected: 3 V; MAX resolution: 1 mV.*
`VOLT:DC:RANG 25`	*Range selected: 30 V; MAX resolution: 10 mV.*
`READ?`	*place multimeter in wait-for-trigger state and make measurement; send reading to the output buffer.*
`enter statement`	*Enter reading into computer.*

Comments
- To select a standard measurement range, specify *expected value* as the input signal's maximum expected voltage. The multimeter then selects the correct range.

- MIN selects the minimum range available (30 mV). MAX selects the maximum range available (300 V).

- Specifying a fixed range disables the autorange mode set by the VOLT:DC:RANG:AUTO command.

- The VOLT:DC:RANG command overrides the range setting from a previous CONFigure[:SCALar] command specifying the same function. With the new range, a new resolution is also selected. However, this resolution is based on the aperture time set by CONFigure[:SCALar].

- *RST Condition: VOLT:DC:RANG 30

VOLTage[:DC]:RANGe[:UPPer]?

[SENSe:]VOLTage[:DC]:RANGe[:UPPer]? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present voltage range selected if MIN or MAX is not specified.

■ The minimum voltage range available (30 mV) if MIN is specified.

■ The maximum voltage range available (300 V) if MAX is specified.

Example   **Querying the Measurement Range**

VOLT:DC:RANG 0.2	*Range selected: 300 mV.*
VOLT:RANG?	*Query multimeter to return the present range.*
enter statement	*Enter value into computer.*

VOLTage[:DC]:RESolution

[SENSe:]VOLTage[:DC]:RESolution *<resolution>* selects the resolution for dc voltage measurements.

For a complete listing of range and resolution values available, see Table 8-2 at the beginning of this chapter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
resolution	numeric	*resolution* (see Table 8-2)| MINimum|MAXimum	volts

Example   **Changing the Resolution**

CONF:VOLT:DC 8.25,MAX   *Function: dc volts; range selected: 30 V; MAX resolution: 10 mV.*

VOLT:DC:RES 100E-06   *Set resolution to 100 μV; selects 1.67 ms aperture time (60 Hz line frequency).*

READ?   *place multimeter in wait-for-trigger state and make measurement; send reading to output buffer.*

enter statement   *Enter reading into computer.*

Comments   ■ MIN selects the best resolution (the smallest value from Table 8-2 for the selected range. MAX selects the worst resolution (the largest value from Table 8-2) for the selected range.

■ You must select a fixed range *before* specifying resolution. Also, only specify a numeric resolution (for example, not MIN or MAX) when making measurements on a fixed range. Otherwise, the resolution will change to correspond with the range selected during autoranging.

■ If autoranging is required, set the resolution using the MIN or MAX parameters or select a specific aperture time using VOLTage:DC:APERture.

■ If necessary to achieve the specified resolution, the multimeter will increase the integration time as needed. This command overrides the results of previously executed VOLTage:DC:APERture and VOLTage:DC:NPLCycles commands. The last command executed has priority.

■ The VOLT:DC:RES command overrides the resolution setting from a previous CONFigure[:SCALar] command on the same function.

■ **Related Commands:** CONFigure[:SCALar], VOLTage:DC:APERture, VOLTage:DC:NPLCycles

■ ***RST Condition:** Based on the *RST values for the VOLTage:DC:APERture and VOLTage:DC:NPLCycles commands.

VOLTage[:DC]:RESolution?

[SENSe:]VOLTage[:DC]:RESolution? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present resolution selected for the specified function and range if MIN or MAX are not specified.

■ The resolution with the smallest value (for example, the best resolution) for the specified function and range if MIN is specified.

■ The resolution with the largest value (for example, the worst resolution) for the specified function and range if MAX is specified.

Example   **Querying the Resolution**

`VOLT:DC:RES 100E-06`	*Set resolution to 100 µV.*
`VOLT:DC:RES?`	*Query multimeter to return the present resolution.*
`enter statement`	*Enter value into computer.*

STATus

The STATus subsystem enables you to examine the status of the multimeter by monitoring the Operation Status Register and Questionable Data/Signal Register groups. Figure 8-1 shows the multimeter's status registers.

QUESTIONABLE DATA/SIGNAL REGISTER

OUTPUT QUEUE

STATUS BYTE REGISTER

EVENT STATUS REGISTER

BIT NUMBER	DECIMAL WEIGHT	DESCRIPTION
0	1	OPERATION COMPLETE
1	2	RESERVED
2	4	QUERY ERROR
3	8	DEVICE DEPENDENT ERROR
4	16	EXECUTE ERROR
5	32	COMMAND ERROR
6	64	USER REQUEST
7	128	POWER-ON

STANDARD EVENT STATUS REGISTER

STANDARD OPERATION STATUS REGISTER
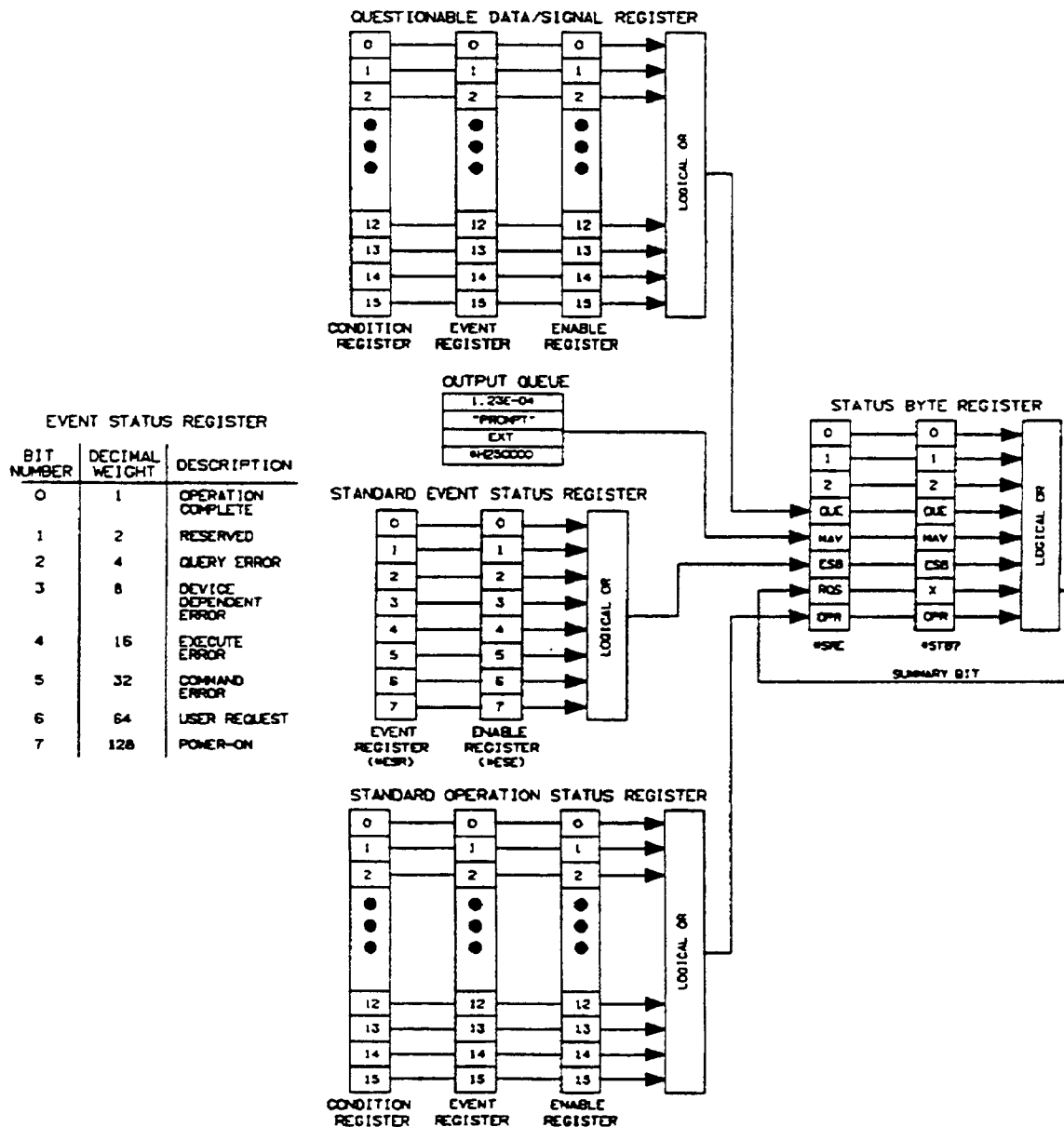
Figure 8-1. Multimeter Status Register

The various registers are set and queried using decimal weighted bit values. The decimal equivalent values for bits 15 through 0 are shown below.

Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Decimal Value	-32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Subsystem
Syntax

```
STATus
  :OPERation
    :CONDition?
    :ENABle <number>
    :ENABle?
    [:EVENt]?
    :NTRansition <mask>
    :NTRansition?
    :PTRansition <mask>
    :PTRansition?
  :PRESet
  :QUEStionable
    :CONDition?
    :ENABle <number>
    :ENABle?
    [:EVENt]?
    :NTRansition <mask>
    :NTRansition?
    :PTRansition <mask>
    :PTRansition?
```

Using the Operation Status Register

The 16-bit Operation Status Register monitors multimeter operations currently being performed. The multimeter implements bits 0, 2, and 5.

Bit Number	Decimal Weight	Description
0	1	Multimeter is Performing a Calibration.
1	-	Not used by multimeter.
2	4	Multimeter is Currently Changing Range.
3	-	Not used by multimeter.
4	-	Not used by multimeter.
5	32	Multimeter is in the Wait-for-Trigger State.
6-15	-	Not used by multimeter.

The Operation Status Register group consists of a condition register, an event register, and an enable register as shown in Figure 8-1. The commands in the STATus:OPERation subsystem control and monitor these registers.

Using the Questionable Data/Signal Register

The Questionable Data/Signal Register conveys information about the quality of the measurements taken by the multimeter. The multimeter implements bits 0, 1, 2, 4, 5, 8, 9, 12, and 14.

Bit Number	Decimal Weight	Description
0	1	Voltage Overrange.
1	2	Current Overrange.
2	4	Period Overrange.
3	-	Not used by multimeter.
4	16	Temperature Overrange.
5	32	Frequency Overrange.
6	-	Not used by multimeter.
7	-	Not used by multimeter.
8	256	Invalid Calibration.
9	512	Resistance Overrange.
10	-	Not used by multimeter.
11	-	Not used by multimeter.
12	4096	Limit test failed.
13	-	Not used by multimeter.
14	16384	Command warning.
15	-	Not used by multimeter.

The Questionable Data/Signal Register group consists of a condition register, an event register, and an enable register as shown in Figure 8-1. The commands in the STATus:QUEStionable subsystem control and monitor these registers.

:OPERation: CONDition?

STATus:OPERation:CONDition? returns a decimal-weighted number representing the bits set in the Operation Status Register's condition register. Reading the condition register does not destroy its contents.

Example   **Reading the Condition Register**

        STAT:OPER:COND?   *Read condition register.*

        enter statement   *Enter value into computer.*

Comments   ■ This command returns "0" (no bits set) or "32" (bit 5 set). Bits 0 and 2 cannot be read real-time by the STAT:OPER:COND? command.

        ■ The condition register does not implement latching or buffering. The register is updated in real-time whenever the multimeter takes a reading.

:OPERation:ENABle

STATus:OPERation:ENABle <*number*> enables bits in the Operation Status Register's enable register to be reported to the summary bit (setting Status Byte Register bit 7 true). The event register bits are not reported in the Status Bytes Register unless specifically enabled.

Note	If any bits are enabled in the enable register, the corresponding bits set in the Operation Status Register's event register are reported to the Status Byte Register.

Example   **Enabling Bits in the Enable Register**

   STAT:OPER:ENAB 33   *Enable bit 0 and bit 5.*

:OPERation:ENABle?

STATus:OPERation:ENABle? returns a decimal-weighted number representing the bits enabled in the Operation Status Register's enable register.

Example   **Reading the Enabled Bits in the Enable Register**

STAT:OPER:ENAB 33	*Enable bit 0 and bit 5.*
STAT:OPER:ENAB?	*Read condition register; clear register contents.*
enter statement	*Enter value into computer.*

:OPERation [:EVENt]?

STATus:OPERation[:EVENt]? returns a decimal-weighted number representing the bits set in the Operation Status Register's event register. This command clears all bits in the event register.

Example   **Reading the Event Register**

                        STAT:OPER:EVEN?   *Read event register; clear register contents.*

                        enter statement   *Enter value into computer.*

Comments   ■ The :EVENt parameter is optional. Both of the following command statements read the event register: STAT:OPER:EVEN? *or* STAT:OPER?

                  ■ The event register latches conditions from the condition register. Bits in the event register are latched, and once set they remain set until cleared by STAT:OPER:EVEN? or the * CLS (clear status) command.

                  ■ The *CLS command clears all status registers (Standard Event Status Register, Operation Status Register, Questionable Data/Signal Register).

:OPERation:NTRansition

STATus:OPERation:NTRansition <*mask*> sets the Operation Status Register's negative transition filter to the provided <*mask*> (bit 15 is ignored). Setting a bit in the negative transition filter will cause a 1 to 0 transition in the corresponding bit of the Operation Status Register's condition register. This will cause a 1 to be written in the corresponding bit of the Operation Status Register's event register.

Example   **Reading the Event Register**

> STAT:OPER:NTR 32   *Set the operational event bit 5 when the multi-*
> *meter exits the Wait-for-Trigger state.*

:OPERation:NTRansition?

STATus:OPERation:NTRansition? returns a decimal weighted number representing the bits set in the Operation Status Register's negative transition filter. Reading the negative transition filter does not destroy its contents.

Example   **Reading the Event Register**

> STAT:OPER:NTR?   *Read the negative transition filter.*

:OPERation:PTRansition

STATus:OPERation:PTRansition <*mask*> sets the Operation Status Register's positive transition filter to the provided <*mask*> (bit 15 is ignored). Setting a bit in the positive transition filter will cause a 0 to 1 transition in the corresponding bit of the Operation Status Register's condition register. This will cause a 1 to be written in the corresponding bit of the Operation Status Register's event register.

Example   **Reading the Event Register**

> STAT:OPER:PTR 32   *Set the operational event bit 5 when the multimeter enters the Wait-for-Trigger state.*

:OPERation:PTRansition?

STATus:OPERation:PTRansition? returns a decimal weighted number representing the bits set in the Operation Status Register's positive transition filter. Reading the positive transition filter does not destroy its contents.

Example   **Reading the Event Register**

          STAT:OPER:PTR?   *Read the positive transition filter.*

:PRESet

STATus:PRESet presets and OPERation and QUEStionable enable registers to 0, the OPERation and QUEStionable positive transition filters to 32767, and the OPERation and QUEStionable negative transition filters to 0.

Example

STAT:PRES   *preset the OPERation and QUEStionable enable registers, positive transition filters, and negative transition filters.*

Comments   ■ STATus:PRESet presets only the registers described above. No other status byte registers are affected.

:QUEStionable: CONDition?

STATus:QUEStionable:CONDition? returns a decimal-weighted number representing the bits set in the Status Register's condition register. Reading the condition register does not destroy its contents.

Example   **Reading the Condition Register**

:QUEStionable:COND?	*Read condition register.*
enter statement	*Enter value into computer.*

Comments   ■ This command returns "0" (no bits set) or "32" (bit 5 set).

■ The condition register does not implement latching or buffering. The register is updated in real-time whenever the multimeter takes a reading.

:QUEStionable:ENABle

STATus:QUEStionable:ENABle <*number*> enables bits in the Questionable Data/Signal Register's enable register to be reported to the summary bit (setting Status Byte Register bit 3 true). The event register bits are not reported in the Status Bytes Register unless specifically enabled.

Note	If any bits are enabled in the enable register, the corresponding bits set in the Questionable Data/Signal Register's event register are reported to the Status Byte Register.

Example   **Enabling Bits in the Enable Register**

STAT:QUES:ENAB 513   *Enable bit 0 (voltage overrange) and bit 9 (resistance overrange).*

:QUEStionable: ENABle?

STATus:QUEStionable:ENABle? returns a decimal-weighted number representing the bits enabled in the Questionable Data/Signal Register's enable register.

Example   **Reading the Enabled Bits in the Enable Register**

STAT:QUES:ENAB 513	*Enable bit 0 (voltage overrange) and bit 9 (resistance overrange).*
STAT:QUES:ENAB?	*Read condition register; clear register contents.*
enter statement	*Enter value into computer.*

:QUEStionable [:EVENt]?

STATus:QUEStionable[:EVENt]? returns a decimal-weighted number representing the bits set in the Questionable Data/Signal Register's event register. This command clears all bits in the event register.

Example   **Reading the Event Register**

                  STAT:QUES:EVEN?   *Read event register; clear register contents.*

                  enter statement   *Enter value into computer.*

Comments   ■ The :EVENt parameter is optional. Both of the following command statements read the event register: STAT:QUES:EVEN? *or* STAT:QUES?

■ The event register latches conditions from the condition register. Bits in the event register are latched, and once set they remain set until cleared by STAT:QUES:EVEN? or the * CLS (clear status) command.

■ The *CLS command clears all status registers (Standard Event Status Register, Operation Status Register, Questionable Data/Signal Register).

:QUEStionable:NTRansition

STATus:QUEStionable:NTRansition <*mask*> sets the Questionable Status Register's negative transition filter to the provided <*mask*> (bit 15 is ignored). Setting a bit in the negative transition filter will cause a 1 to 0 transition in the corresponding bit of the Questionable Status Register's condition register. This will cause a 1 to be written in the corresponding bit of the Questionable Status Register's event register.

Comments   ■ There are no conditions in the questionable status register of this multimeter. Therefore, this command has no effect and is provided for Standard Commands for Programmable Instruments (SCPI) compatibility only.

:QUEStionable:NTRansition?

STATus:QUEStionable:NTRansition? returns a decimal weighted number representing the bits set in the Questionable Status Register's negative transition filter. Reading the negative transition filter does not destroy its contents.

Example   **Reading the Event Register**

STAT:QUES:NTR?   *Read the negative transition filter.*

:QUEStionable:PTRansition

STATus:QUEStionable:PTRansition <*mask*> sets the Questionable Status Register's positive transition filter to the provided <*mask*> (bit 15 is ignored). Setting a bit in the positive transition filter will cause a 0 to 1 transition in the corresponding bit of the Questionable Status Register's condition register. This will cause a 1 to be written in the corresponding bit of the Questionable Status Register's event register.

Comments   ■ There are no conditions in the questionable status register of this multimeter. Therefore, this command has no effect and is provided for Standard Commands for Programmable Instruments (SCPI) compatibility only.

:QUEStionable:PTRansition?

STATus:QUEStionable:PTRansition? returns a decimal weighted number representing the bits set in the QUEStionable Status Register's positive transition filter. Reading the positive transition filter does not destroy its contents.

Example   **Reading the Event Register**

    STAT:QUES:PTR?   *Read the positive transition filter.*

SYSTem

The SYSTem command subsystem returns error numbers and messages stored in the error queue.

■ Selects the multimeter's line frequency reference (SYSTem:LFRequency).

Subsystem   SYSTem
Syntax   :ERRor?
                         :LFRequency <*frequency*>
                         :LFRequency? [MINimum|MAXimum]
                         :SERial
                         :SERial?
                         :VERSion?

:ERRor?

SYSTem:ERRor? returns the error numbers and error messages stored in the error queue. Refer to Chapter 6 for a listing of the error numbers and messages.

Example   **Reading the Error Queue**

        SYST:ERR?   *Query the error queue.*

Comments
- As multimeter errors are detected, they are placed in its error queue. The error queue is first-in, first-out. This means that if several error messages are waiting in the queue, each SYST:ERR? command returns the oldest error message, and that message is deleted from the queue.

- If the error queues fills to 12 entries, the last error is replaced with -350, "Too many errors". No additional errors are accepted until space becomes available using SYST:ERR?, or the queue is cleared using the * CLS (clear status) command.

- When SYST:ERR? is sent while the error queue is empty, the multimeter responds with 0, "No error".

- ***RST Condition:** *RST does not clear the error queue.

:LFRequency

SYSTem:LFRequency <*frequency*> selects the line frequency reference used by the multimeter's analog-to-digital (A/D) converter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
frequency	numeric	50|60|400|	hertz
		MINimum|MAXimum	hertz

Example   **Selecting the Line Frequency Reference**

SYST:LFR 50   *Frequency is 50 Hz.*

Comments   ■ MIN selects the minimum line frequency reference available (50 Hz). MAX selects the maximum line frequency reference available (60 Hz).

■ The line frequency reference is set to 60 Hz at the factory. The setting is stored in non-volatile multimeter memory and is changed only when SYSTem:LFRequency is executed.

■ If 400 Hz is specified as the A/D converter's reference, the multimeter actually uses a 50 Hz reference frequency. However, since 50 Hz is a subharmonic of 400 Hz, it provides normal-mode rejection of power line related noise.

■ The line frequency reference set by SYSTem:LFRequency can be overridden by the 50 or 60 Hz aperture time set by the SENSe:RESistance:APERture, SENSe:CURRent:APERture, or SENSe:VOLTage:APERture commands. The last command executed has priority.

■ **Related Commands:** SENSe:RESistance:APERture, SENSe:CURRent:APERture, SENSe:VOLTage:APERture

■ ***RST Condition:** The selected line frequency reference remains unchanged since it is stored in non-volatile multimeter memory.

:LFRequency?

SYSTem:LFRequency? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present line frequency reference (50 or 60) if MIN or MAX is not specified.

■ The minimum line frequency reference available (50) if MIN is specified.

■ The maximum line frequency reference available (60) if MAX is specified.

Example   **Querying the Line Frequency Reference**

SYST:LFR 50	*Frequency is 50 Hz.*
SYST:LFR?	*Query multimeter to return frequency value.*
enter statement	*Enter value into computer.*

:SERial

SYSTem:SERial <*serial#*> sets the products serial number.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
serial#	alphanumeric	1 to 15 characters	none

Example   **Setting the Serial Number**

        `CAL:SEC OFF,12345`   *Allow setting of serial number by turning security off.*

        `SYST:SER"A101292"`   *Setting the serial number.*

        `CAL:SEC ON,12345`   *Turn security on.*

Comments

- CALibration:SECure must be OFF to set the serial number.

- The <*serial#*> must be quoted.

- The serial number gets written to non-volatile memory, so it only needs to be entered once.

- The default value prior to being set by the user is "0000U00000".

- **Related Commands:** CALibration:SECure[:STATe]; *IDN?

- ***RST Condition:** *RST sets cal security on; therefore it does not allow setting of the serial number.

:SERial?

SYSTem:SERial? returns the products serial number in a quoted string of (at most 15) alphanumeric characters.

Comments　　　■ **Related Commands:** *IDN?,SYST:SER

　　　　　　　■ ***RST Condition:** Whatever has been entered by the user. If no value has been entered, the default value is "0000U00000".

:VERsion?

SYSTem:VERsion? returns the numeric value corresponding to the Standard Commands for Programmable Instruments (SCPI) version for which this instrument is compliant.

This instrument complies with SCPI version 1991.0.

Example   **Reading the SCPI Version**

              SYST:VER?   *Returns 1991.0.*

TEST

The TEST command subsystem performs a series of internal self-tests on the multimeter.

Subsystem   TEST

Syntax   [:ALL]?
                     :INGuard
                     :AMP?
                     :FLATness?
                     :GAIN?
                     :INTegrator?
                     :LINK?
                     :OFFSet?
                     :PRECharge?
                     :ZERO?
                 :OUTGuard
                     :MEMory?

[:ALL]?

TEST[:ALL]? performs a series of internal self-tests on the multimeter. If any test fails, the multimeter returns a decimal-weighted number representing the failed condition (see below). The number is sent to the output buffer.

Weighted Value	Description
0	All tests passed.
1	Inguard UART failure.
2	Inguard CPU failure.
4	Inguard link failure.
8	Integrator convergence error.
16	Front end zero measurement error.
32	Gain test error.
64	Amps Function gain.
128	AC amplifier's dc offset test failure.
256	AC flatness check failure.
512	Ohms precharge failure.
2048	System RAM checksum failure.
4096	Calibration memory checksum failure.
8192	Autocalibration memory checksum failure.
16384	ROM checksum failure.

Example   **Performing a Self-Test**

TEST?   *perform self-test routines and place result in output buffer.*

enter statement   *Enter value into computer.*

Comments   ■ The :ALL parameter is optional. Both of the following command statements perform the multimeter self-test: TEST:ALL? *or* TEST?

■ The TEST? command performs the same action as the *TST? common command.

■ Always disconnect all input signals before you run self-test. If you leave an input signal connected to the multimeter, it may cause a self-test failure.

:INGuard:AMP?

TEST:INGuard:AMP? performs a self-test on the amp function gain. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.

- "64" if the amp function gain test fails.

Example   **Performing the AMP gain Self-Test**

TEST:ING:AMP?	*perform self-test on the amp function gain and place result in output buffer.*
enter statement	*Enter value into computer.*

:INGuard:FLATness?

TEST:INGuard:FLATness? performs the ac flatness self-test. The command returns one of the following numbers to the output buffer:

■ "0" if all tests pass.

■ "256" if the ac flatness check fails.

Example   **Performing the AC Flatness Self-Test**

TEST:ING:FLAT?	*perform ac flatness self-test routine and place result in output buffer.*
enter statement	*Enter value into computer.*

:INGuard:GAIN?

TEST:INGuard:GAIN? performs the gain self-test. The command returns one of the following numbers to the output buffer:

■ "0" if all tests pass.

■ "32" if the gain test fails.

Example   **Performing the Gain Self-Test**

TEST:ING:GAIN?	*perform gain self-test routine and place result in output buffer.*
enter statement	*Enter value into computer.*

:INGuard:INTegrator?

TEST:INGuard:INTegrator? performs the integrator convergence self-test. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.

- "8" if the integrator convergence test fails.

Example   **Performing the Integrator Convergence Self-Test**

                        `TEST:ING:INT?`   *perform integrator convergence self-test routine and place result in output buffer.*

                        `enter statement`   *Enter value into computer.*

:INGuard:LINK?

TEST:INGuard:LINK? performs a self-test on the Inguard CPU and link. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.
- "1" if the Inguard UART test fails.
- "2" if the Inguard CPU test fails.
- "4" if the Inguard link test fails.

Example   **Performing the Inguard CPU and Link Self-Test**

               `TEST:ING:LINK?`   *perform CPU and link self-test routines and place result in output buffer.*

               `enter statement`   *Enter value into computer.*

:INGuard:OFFSet?

TEST:INGuard:OFFSet? performs the ac amplifier's dc offset self-test. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.

- "128" if the offset test fails.

Example   **Performing the Offset Self-Test**

TEST:ING:OFFS?   *perform offset self-test routine and place result in output buffer.*

enter statement   *Enter value into computer.*

:INGuard:PRECharge?

TEST:INGuard:PRECharge? performs the ohms precharge self-test. The command returns one of the following numbers to the output buffer:

■ "0" if all tests pass.

■ "512" if the ohms precharge test fails.

Example   **Performing the Ohms Precharge Self-Test**

        `TEST:ING:PREC?`   *perform ohms precharge self-test routine and place result in output buffer.*

        `enter statement`   *Enter value into computer.*

:INGuard:ZERO?

TEST:INGuard:ZERO? performs the front end zero measurement self-test. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.

- "16" if the zero measurement test fails.

Example   **Performing the Zero Measurement Self-Test**

                `TEST:ING:ZERO?`   *perform zero measurement self-test routine and place result in output buffer.*

                       `enter statement`   *Enter value into computer.*

:OUTGuard:MEMory?

TEST:OUTGuard:MEMory? performs a self-test on RAM, calibration memory, and ROM. The command returns one of the following numbers to the output buffer:

- "0" if all tests pass.

- "2048" if the system RAM checksum fails.

- "4096" if the calibration memory checksum fails.

- "8192" if the autocalibration memory checksum fails.

- "16384" if the ROM checksum fails.

Example   **Performing the OUTGuard MEMory Self-Test**

TEST:OUTG:MEM?	*perform outguard memory self-test routines and place result in output buffer.*
enter statement	*Enter value into computer.*

TRIGger

The TRIGger command subsystem controls the behavior of the trigger system. The subsystem can control:

- Trigger buffering (TRIGger:BUFFered).

- The number of triggers to occur before the multimeter returns to the idle state (TRIGger:COUNt).

- The delay between trigger and measurement (TRIGger:DELay).

- An immediate internal trigger (TRIGger:IMMediate).

- The trigger slope of the multimeter's rear panel "EXT TRIG" connector (TRIGger:SLOPe).

- The source of the trigger (TRIGger:SOURce).

Subsystem   TRIGger
Syntax   [:SEQuence|:SEQuence1|STARt]
                          :BUFFered <*mode*>
                          :BUFFered?
                          :COUNt <*number*>
                          :COUNt? [MINimum|MAXimum]
                          :DELay:AUTO <*mode*>
                          :DELay:AUTO?
                          :DELay <*period*>
                          :DELay? [MINimum|MAXimum]
                          [:IMMediate]
                          :SLOPe <*edge*>
                          :SLOPe?
                          :SOURce <*source*>
                          :SOURce?

:BUFFered

TRIGger:BUFFered <*mode*> enables or disables the multimeter's trigger buffer and corrects for a "Trigger too fast" error. The trigger source must be the multimeter's rear panel "EXT TRIG" connector.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Enabling the Trigger Buffer**

TRIG:SOUR EXT   *Trigger source is external BNC on multimeter rear panel.*

TRIG:BUFF ON   *Enable trigger buffer.*

Comments
- You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

- With TRIG:BUFF OFF, any external trigger occurring during a reading generates a "Trigger too fast" error and the triggers are ignored.

- With TRIG:BUFF ON, the first external trigger occurring during a reading is stored and no error is generated. After the reading is complete, the stored trigger satisfies the EXT event if the multimeter is so programmed. However, a second trigger occurring during a reading does generate the "Trigger too fast" error.

- *RST Condition: TRIG:BUFF OFF

:BUFFered?

TRIGger:BUFFered? returns a number to show whether trigger buffering is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Trigger Buffer Mode**

TRIG:BUFF ON	*Enable trigger buffer.*
TRIG:BUFF?	*Query multimeter to return trigger buffer mode.*
enter statement	*Enter value into computer.*

:COUNt

TRIGger:COUNt *<number>* sets the number of triggers issued.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	1 through 16,777,215| MINimum|MAXimum	none

Example   **Setting the Trigger Count**

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter rear panel.*
TRIG:COUN 10	*Multimeter will accept 10 external triggers (one measurement is taken per trigger).*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments   ■ MIN selects 1 trigger. MAX selects 16,777,215 triggers.

■ The multimeter has enough memory to store 4,096 readings. The trigger count (TRIG:COUN) multiplied by the sample count (SAMP:COUN) must be less than or equal to 4,096.

■ CONFigure[:SCALar] and MEASure[:SCALar] set the trigger count to 1.

■ ***RST Condition:** TRIG:COUN 1

:COUNt?

TRIGger:COUNt? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present trigger count (1 through 16,777,215) if MIN or MAX are not specified.

■ The minimum trigger count available (1) if MIN is specified.

■ The maximum trigger count available (16,777,215) if MAX is specified.

Example   **Querying the Trigger Count**

TRIG:COUN 10	*Multimeter will accept 10 triggers from current trigger source.*
TRIG:COUN?	*Query multimeter to return trigger count.*
enter statement	*Enter value into computer.*

:DELay:AUTO

TRIGger:DELay:AUTO <*mode*> enables or disables a trigger delay based on the present function, range, and integration time. The trigger delay specifies the period between the trigger signal and the start of the measurement.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	boolean	OFF|0|ON|1	none

Example   **Disabling Automatic Trigger Delay**

> TRIG:DEL:AUTO OFF   *Disable automatic trigger delay.*

Comments   ■ You can substitute decimal values for the OFF ("0") and ON ("1") parameters.

■ If you do not specify a trigger delay (TRIGger:DELay command), the multimeter automatically determines a delay time (default delay) based on the present measurement function, range, resolution, and ac bandwidth setting. The delay time is actually the settling time allowed before measurements which ensures accurate readings. The default delay time is automatically updated whenever you change the function or range. Once you specify a delay time value, however, the value does not change until you specify another value or reset the multimeter. Table 3-12 shows the default delay times for all functions.

■ The values shown in Table 3-12 (for ac measurement functions) assume the range and function have been selected for at least one reading. Whenever the range changes on an ac measurement function, the first reading after the change has an additional delay added to the default delay. This is shown in Table 3-13. Whenever you select an ac measurement function, an additional delay is added to the default delay before the first reading. This delay is shown in Table 3-14.

■ If you specify a trigger delay using the TRIGger:DELay command, TRIG:DEL:AUTO is automatically turned OFF.

■ ***RST Condition:** TRIG:DEL:AUTO ON

:DELay:AUTO?

TRIGger:DELay:AUTO? returns a number to show whether the automatic trigger delay mode is enabled or disabled: "1" = ON, "0" = OFF. The number is sent to the output buffer.

Example   **Querying the Trigger Delay Mode**

TRIG:DEL:AUTO OFF	*Disable automatic trigger delay.*
TRIG:DEL:AUTO?	*Query multimeter to return trigger delay mode.*
enter statement	*Enter value into computer.*

:DELay

TRIGger:DELay <*period*> sets the delay period between receipt of the trigger and the start of the measurement.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
period	numeric	1 μs through 2100 s| MINimum|MAXimum	seconds

Example   **Setting the Trigger Delay**

TRIG:DEL 2   *Wait 2 seconds between trigger and start of measurement.*

Comments   ■ MIN selects the minimum delay of 1 μs. MAX selects the maximum delay of 2100 seconds.

■ The *period* values are accurate down to 150 μs. If you specify a value below 150 μs, the actual delay is approximately: 67 μs for the MINimum aperture time.
82 μs for all other aperture times.

■ If you specify a trigger delay using TRIG:DEL, TRIGger:DELay:AUTO is automatically turned OFF.

■ You can set a delay between measurements in a burst using the SAMPle:TIMer command.

■ ***RST Condition:** The multimeter automatically determines a delay time (default delay) based on the present measurement function, range, resolution, and ac bandwidth setting (see TRIG:DEL:AUTO).

:DELay?

TRIGger:DELay? [MINimum|MAXimum] returns one of the following numbers to the output buffer:

■ The present trigger delay (1 μs through 2100 seconds) if MIN or MAX is not specified.

■ The minimum trigger delay available (1 μs) if MIN is specified.

■ The maximum trigger delay available (2100 seconds) if MAX is specified.

Example   **Querying the Trigger Delay**

TRIG:DEL 2	*Wait 2 seconds between trigger and start of measurement.*
TRIG:DEL?	*Query multimeter to return trigger count.*
enter statement	*Enter value into computer.*

[:IMMediate]

TRIGger[:IMMediate] causes a trigger to occur immediately if the multimeter is in the wait-for-trigger state (see the INITiate subsystem). The trigger source must be TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

Example   **Sending an Immediate Trigger**

CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR HOLD	*Suspend triggering.*
INIT	*place multimeter in wait-for-trigger state; store reading in memory when trigger is received.*
TRIG	*Trigger the multimeter.*
FETC?	*place reading in output buffer.*
enter statement	*Enter reading into computer.*

Comments   ■ The :IMMediate parameter is optional. Both of the following command statements are valid: TRIG:IMM *or* TRIG

■ The TRIG:IMM command must be executed after the multimeter is placed in the wait-for-trigger state by the INITiate command. When the TRIG:IMM command is executed, the readings are stored in multimeter memory. Use FETCh? to place the readings in the output buffer.

■ The TRIGger:SOURce BUS or TRIGger:SOURce HOLD commands remain in effect after TRIG:IMM is executed.

■ Do not confuse the levels of triggering commands containing the IMMediate parameter. The TRIGger:SOURce IMMediate command (later in this chapter) bypasses the trigger system so that the multimeter is triggered immediately if it is in the wait-for-trigger state. The TRIG:IMM command initiates a single trigger cycle after the trigger system has been disabled.

■ **Related Commands:** FETCh?, INITiate, TRIGger:SOURce

:SLOPe

TRIGger:SLOPe <edge> determines which edge (rising or falling) of a signal input to the rear panel "EXT TRIG" connector will trigger the multimeter.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
edge	discrete	POSitive|NEGative	none

Example   Selecting the Trigger Slope

          TRIG:SLOP POS   *Select positive (rising) edge.*

Comments   ■ The minimum pulse width recognized on the "EXT TRIG" connector is 10 ns.

          ■ *RST Condition: TRIG:SLOP NEG

:SLOPe?

TRIGger:SLOPe? returns "NEG" or "POS" to show the present trigger slope. The string is sent to the output buffer.

Example　　　**Querying the Trigger Slope**

　　　　　　　　TRIG:SLOP POS　　　*Select positive (rising) edge.*
　　　　　　　　TRIG:SLOP?　　　　*Query multimeter to return trigger slope.*
　　　　　　　　enter statement　　*Enter value into computer.*

:SOURce

TRIGger:SOURce <*source*> configures the trigger system to respond to the specified source. The following sources are available:

- **BUS**: Group Execute Trigger (GET) bus command or * TRG common command.

- **EXTernal**: The multimeter's rear panel "EXT TRIG" connector.

- **HOLD**: Suspend triggering. Only the TRIGger:IMMediate command will trigger the multimeter.

- **IMMediate**: The trigger system is always true (continuous triggering).

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	BUS|EXTernal|HOLD|IMMediate	none

Example   **Setting the Trigger Source**

dimension array	*Dimension computer array.*
CONF:VOLT:DC	*Function: dc voltage.*
TRIG:SOUR EXT	*Trigger source is external BNC on multimeter front panel.*
TRIG:COUN 10	*Multimeter will accept 10 external triggers.*
READ?	*place multimeter in wait-for-trigger state; make measurements when external trigger is received; send readings to output buffer.*
enter statement	*Enter readings into computer.*

Comments

- The TRIGger:SOURce command only selects the trigger source. You must use the INITiate command to place the multimeter in the wait-for-trigger state.

- You can change the trigger source only when the multimeter is in the idle state. Attempting to change the trigger source while the multimeter is in the wait-for-trigger state will generate the "Settings conflict" error.

- TRIGger:SOURce EXTernal uses the multimeter's rear panel "EXT TRIG" connector as the trigger source. The trigger slope for this BNC connector is controlled by the TRIGger:SLOPe command.

- TRIGger:SOURce IMMediate causes a trigger to occur immediately if the multimeter is placed in the wait-for-trigger state using INITiate.

- When TRIGger:SOURce BUS is selected, ABORt returns the multimeter to the idle state. When a Group Execute Trigger (GET) bus command or * TRG common command is executed, the "Trigger ignored" error is generated.

- When TRIGger:SOURce HOLD is selected, ABORt returns the multimeter to the idle state. All subsequent single triggers sent using

TRIGger:IMMediate are ignored and the "Trigger ignored" error is
generated.

■ The CONFigure[:SCALar] and MEASure[:SCALar] command subsystems
automatically set the trigger source to TRIG:SOUR IMM.

■ The READ? command cannot be used if the trigger source is TRIG:SOUR
BUS or TRIG:SOUR HOLD.

■ Do not confuse the levels of triggering commands containing the IMMediate
parameter. The TRIGger:SOURce IMMediate command bypasses the
trigger system so that the multimeter is triggered immediately if it is in
the wait-for-trigger state. The TRIGger[:IMMediate] command (earlier
in this chapter) initiates a single trigger cycle after the trigger system
has been disabled (the trigger source must be TRIGger:SOURce BUS or
TRIGger:SOURce HOLD).

■ **Related Commands:** ABORt, INITiate, TRIGger:IMMediate

■ ***RST Condition:** TRIG:SOUR IMM

:SOURce?

TRIGger:SOURce? returns "BUS", "EXT", "HOLD", or "IMM" to show the present trigger source. The string is sent to the output buffer.

Example   **Querying the Trigger Source**

<table>
<tr><td>TRIG:SOUR EXT</td><td>Trigger source is external BNC on multimeter rear panel.</td></tr>
<tr><td>TRIG:SOUR?</td><td>Query multimeter to return trigger source setting.</td></tr>
<tr><td>enter statement</td><td>Enter quoted string into computer.</td></tr>
</table>

```
1!     LOADER
3      !
4      !  $Header: load_brains,v 1.1 92/08/28 13:27:10 hmgr Exp $
5      !
6      ! This program loads an instrument firmware image
7      ! from a disk file contained on the same disk as
8      ! this program.  Its use it for upgrading the firmware
9      ! of the target instrument.
10     !
11     ! Instruments which support this process are:
12     !     70110A Digital Multimeter
13     !     70120A Universal Counter
14     !     70330A Pulse Generator
15     !     70332A Multiple Clock Generator
16     !
17     ! Requirements:
18     !     HP Rocky Mountain BASIC 3.0 or higher with at least
19     !     these binaries:
20     !                     IO
21     !                     ERR
22     !                     HPIB
23     !                     TRANS
24     !                     CS80
25     !     An HP Series 300 computer running BASIC/WS or a PC
26     !     with an HP Viper card.
27     !
28     !     BASIC/UX is supported but the firmware file must first
29     !     be copied to an HFS file system.  The BASIC TRANSFER
30     !     command does not support floppy discs in HP-UX.
31     !
32     ! Getting Started:
33     !     Before running this program, be sure that the FLASH
34     !     EPROM write switch is enabled.  Refer to the Service
35     !     Guide for instructions for enabling this switch.  This
36     !     program assumes that the LOADER will be enabled via
37     !     software.  If you plan to write new firmware using the
38     !     hardware enable, refer to the Service Guide for
39     !     instructions on this procedure.  Following an upgrade,
40     !     the EPROM write switch may be left in the enabled
41     !     position, but this will not protect the EPROM from
42     !     accidental erasure.
43     !
44     ! Description:
45     !     The program first asks the operator to enter the HP-IB
46     !     address of the target instrument and the filename
47     !     of the firmware disk image, or confirm the defaults.
48     !     The instrument is sent the boot commands.  At this point
49     !     the operator is asked to cycle the power on the target
50     !     instrument.  This will place the instrument in the mode
51     !     to accept a new firmware image.
52     !     The program then reads the firmware disk image and counts
53     !     size of the file.  A buffer is allocated to receive the
54     !     disk image.  The file is read into the buffer and then the
55     !     buffer is written to the instrument.  After the firmware
56     !     is written, the instrument is placed back into its normal
57     !     operating mode and again the power is cycled.  Lastly,
58     !     the program checks the instrument for errors.
59     !
60     ! Written by:  Santa Rosa Systems Division
61     !                 Copyright (c) 1992 by Hewlett-Packard Company
62     !-------------------------------------------------------------------
```

10

Program Loader

The HP 70110A digital multimeter has an internal microprocessor that executes a program from erasable programmable read only memory (EPROM). A program loader is included that allows the memory to be programmed. In the event that future options or upgrades are available, the program loader may be used to load the multimeter's program memory.

Setting the program loader configuration switch or sending the DIAGnostic:BOOT command to the multimeter will indicate that the program loader is to be run on the next power up. The program loader is separate from the normal multimeter operation. When the program loader is running no multimeter commands will be operational.

Program Loader Command Reference

This section describes the SCPI commands applicable to the program loader of the HP 70110A digital multimeter. The same command and parameter formats described in the multimeter command section apply to the program loader. In addition the program data parameter is sent using the *IEEE Std 488.2-1987* arbitrary block program data format.

IEEE Std 488.2-1987 Common Commands

The following *IEEE Std 488.2-1987* commands are implemented. Refer to *IEEE Std 488.2-1987* Command Reference for description.

    *CLS
    *ESE
    *ESE?
    *ESR?
    *IDN?
    *OPC?
    *RST
    *SRE
    *SRE?
    *STB?
    *TST?
    *WAI

Common Multimeter Commands

The following commands are implemented in the program loader as well as the multimeter. Refer to Chapter 8 for the command descriptions. The Operation Status Register and Questionable Data Register commands are provided for SCPI consistency, but have no operational bits.

```
:SYSTem
    :ERRor?
:STATus
    :OPERation
        :[EVENt]
        :CONDition?
        :ENABle
        :ENABle?
    :PRESet
    :QUEStionable
        :[EVENt]?
        :CONDition?
        :ENABle
        :ENABle?
```

Specific Program Loader Commands

The following commands are specific to the program loader. Command descriptions are provided on the pages that follow.

```
DIAGnostic
    :BOOT[:SOURce]
    :PMEMory
        :ERASe
        :LOAD
```

DIAGnostic

The DIAGnostic command subsystem:

■ Loads new program memory images.

■ Specifies multimeter or program loader boot source.

■ Can erase program memory.

Subsystem Syntax

```
DIAGnostic
    :BOOT[:SOURce]
    :PMEMory
        :ERASe
        :LOAD
```

:BOOT[:SOURce]

DIAGnostic:BOOT[:SOURce] <*source*> instructs the instrument to run the multimeter or the program loader on the next power up.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	LOADer|INSTrument	none

Example   Select the program loader to be run on the next power up.

Comments
- LOAD instructs the module to run the program loader on the next power up.

- INST instructs the module to run the multimeter instrument on the next power up.

- The DIAGnostic:BOOT[:SOURce] <*source*> is stored in non- volatile electrically erasable memory. It is recommended to only use this command when necessary because this memory is limited to 10,000 write cycles.

- If the Program Loader configuration switch is set then the Program Loader will be run regardless of the state of the DIAGnostic:BOOT <*source*> command.

- During power up of the program loader DIAGnotic:BOOT[:SOURce] is set to INST. This setting will be used in the next power-up.

- ***RST Condition:** INST

:BOOT[:SOURce]?

DIAGnostic:BOOT[:SOURce]? returns the current boot source, either LOAD or INST.

:PMEMory:ERASe

DIAGnostic:PMEMory:ERASe instructs the program loader to erase the multimeter program memory. The program memory must be first erased before loading a new program image.

Example   **Erasing program memory**

                `DIAG:PMEM:ERAS`   *Erase program memory.*

Comments   ■ The program loader may be protected from accidental erasure with the "secure program" configuration switch. The default position for this switch is in the secured position.

                  ■ If the "secure program" configuration switch is set a −258 Media Protected error is generated.

:PMEMory:LOAD

DIAGnostic:PMEMory:LOAD <*program data*> instructs the program loader to load the *program data* into program memory.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
program data	arbitrary block	8 bit binary	none

Comments
- If a program record calls for a memory location outside the available memory range a −223 Too much data error is generated.

- If the program storage memory can not be programmed, a −253 Corrupt Media error is generated.

- A successful load command will set the DIAGnostic:BOOT <*source*> to INST.

Program Loader Error Messages

The following error messages are specific to the Program Loader.

Code	Message	Cause
−161	Invalid Block data	A block data element was expected, but was invalid for some reason.
−223	Too much data	A legal program data element of block expression or string was received that contained more data than the device could handle.
−253	Corrupt Media	Program storage memory can not be programmed.
−258	Media protected	Program memory is secured and an erase command was attempted
3501	Unknown file format	The Program Loader did not recognize the format of the load data.
3502	Instrument program invalid	The Program Loader has determined that the Instrument Firmware Image is corrupted.
3503	Instrument program protected	The Program Loader can not modify the Instrument Firmware Image since the protect switch is set to PROTECTED.
3504	Nonvolatile memory invalid	The Program Loader has determined that the nonvolatile memory is corrupt.
3505	Nonvolatile memory write failure	The Program Loader is not able to write to the nonvolatile memory.
3506	Nonvolatile memory read failure	The Program Loader is not able to successfully read the nonvolatile memory
3507	Program enable failure	The Program Loader is not able to enable the Instrument Memory Image to be programmed.
3508	Program disable failure	The Program Loader is not able to disable the Instrument Memory Image from being programmed.
3509	Program load failure	The Program Loader was not able to successfully complete the Instrument Firmware Image load.
3510	Program erase failure	The Program Loader was not able to erase the Instrument Firmware Image.
3511	Program memory not erased	The instruction DIAG:PMEM:LOAD was sent before DIAG:PMEM:ERAS, so the Instrument Firmware Image has not been erased, and the load cannot proceed.

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