User's Guide

Part Number 34401-90004
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For Safety information, Warranties, and Regulatory information,
see the pages behind the Index.

HP 34401A
Multimeter

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4

Remote Interface
Reference

Remote Interface Reference

SCPI *If you are a first-time user of the SCPI language, you may want to refer to these sections to become familiar with the language before attempting to program the multimeter.*

Command Summary

This section summarizes the SCPI (*Standard Commands for Programmable Instruments*) commands available to program the multimeter. Refer to the later sections in this chapter for more complete details on each command.

Throughout this manual, the following conventions are used for SCPI *command syntax. Square brackets* (**[ ]**) *indicate optional keywords or parameters. Braces* (**{ }**) *enclose parameters within a command string. Triangle brackets* (**< >**) *indicate that you must substitute a value for the enclosed parameter.*

SCPI

First-time SCPI users, see page 154.

The MEASure? and CONFigure Commands

(see page 117 for more information)

4

```
MEASure
  :VOLTage:DC? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :VOLTage:DC:RATio? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :VOLTage:AC? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CURRent:DC? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CURRent:AC? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :RESistance? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :FRESistance? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :FREQuency? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :PERiod? {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CONTinuity?
  :DIODe?

CONFigure
  :VOLTage:DC {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :VOLTage:DC:RATio {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :VOLTage:AC {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CURRent:DC {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CURRent:AC {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :RESistance {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :FRESistance {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :FREQuency {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :PERiod {<range>|MIN|MAX|DEF},{<resolution>|MIN|MAX|DEF}
  :CONTinuity
  :DIODe

CONFigure?
```

Measurement Configuration Commands

(see page 121 for more information)

```
[SENSe:]
  FUNCtion "VOLTage:DC"
  FUNCtion "VOLTage:DC:RATio"
  FUNCtion "VOLTage:AC"
  FUNCtion "CURRent:DC"
  FUNCtion "CURRent:AC"
  FUNCtion "RESistance"        (2-wire ohms)
  FUNCtion "FRESistance"       (4-wire ohms)
  FUNCtion "FREQuency"
  FUNCtion "PERiod"
  FUNCtion "CONTinuity"
  FUNCtion "DIODe"
  FUNCtion?

[SENSe:]
  VOLTage:DC:RANGe {<range>|MINimum|MAXimum}
  VOLTage:DC:RANGe? [MINimum|MAXimum]
  VOLTage:AC:RANGe {<range>|MINimum|MAXimum}
  VOLTage:AC:RANGe? [MINimum|MAXimum]
  CURRent:DC:RANGe {<range>|MINimum|MAXimum}
  CURRent:DC:RANGe? [MINimum|MAXimum]
  CURRent:AC:RANGe {<range>|MINimum|MAXimum}
  CURRent:AC:RANGe? [MINimum|MAXimum]
  RESistance:RANGe {<range>|MINimum|MAXimum}
  RESistance:RANGe? [MINimum|MAXimum]
  FRESistance:RANGe {<range>|MINimum|MAXimum}
  FRESistance:RANGe? [MINimum|MAXimum]
  FREQuency:VOLTage:RANGe {<range>|MINimum|MAXimum}
  FREQuency:VOLTage:RANGe? [MINimum|MAXimum]
  PERiod:VOLTage:RANGe {<range>|MINimum|MAXimum}
  PERiod:VOLTage:RANGe? [MINimum|MAXimum]

[SENSe:]
  VOLTage:DC:RANGe:AUTO {OFF|ON}
  VOLTage:DC:RANGe:AUTO?
  VOLTage:AC:RANGe:AUTO {OFF|ON}
  VOLTage:AC:RANGe:AUTO?
  CURRent:DC:RANGe:AUTO {OFF|ON}
  CURRent:DC:RANGe:AUTO?
  CURRent:AC:RANGe:AUTO {OFF|ON}
  CURRent:AC:RANGe:AUTO?
  RESistance:RANGe:AUTO {OFF|ON}
  RESistance:RANGe:AUTO?
  FRESistance:RANGe:AUTO {OFF|ON}
  FRESistance:RANGe:AUTO?
  FREQuency:VOLTage:RANGe:AUTO {OFF|ON}
  FREQuency:VOLTage:RANGe:AUTO?
  PERiod:VOLTage:RANGe:AUTO {OFF|ON}
  PERiod:VOLTage:RANGe:AUTO?
```

Default parameters are shown in **bold***.*

Measurement Configuration Commands

(continued)

```
[SENSe:]
  VOLTage:DC:RESolution {<resolution>|MINimum|MAXimum}
  VOLTage:DC:RESolution? [MINimum|MAXimum]
  VOLTage:AC:RESolution {<resolution>|MINimum|MAXimum}
  VOLTage:AC:RESolution? [MINimum|MAXimum]
  CURRent:DC:RESolution {<resolution>|MINimum|MAXimum}
  CURRent:DC:RESolution? [MINimum|MAXimum]
  CURRent:AC:RESolution {<resolution>|MINimum|MAXimum}
  CURRent:AC:RESolution? [MINimum|MAXimum]
  RESistance:RESolution {<resolution>|MINimum|MAXimum}
  RESistance:RESolution? [MINimum|MAXimum]
  FRESistance:RESolution {<resolution>|MINimum|MAXimum}
  FRESistance:RESolution? [MINimum|MAXimum]

[SENSe:]
  VOLTage:DC:NPLCycles {0.02|0.2|1|10|100|MINimum|MAXimum}
  VOLTage:DC:NPLCycles? [MINimum|MAXimum]
  CURRent:DC:NPLCycles {0.02|0.2|1|10|100|MINimum|MAXimum}
  CURRent:DC:NPLCycles? [MINimum|MAXimum]
  RESistance:NPLCycles {0.02|0.2|1|10|100|MINimum|MAXimum}
  RESistance:NPLCycles? [MINimum|MAXimum]
  FRESistance:NPLCycles {0.02|0.2|1|10|100|MINimum|MAXimum}
  FRESistance:NPLCycles? [MINimum|MAXimum]

[SENSe:]
  FREQuency:APERture {0.01|0.1|1|MINimum|MAXimum}
  FREQuency:APERture? [MINimum|MAXimum]
  PERiod:APERture {0.01|0.1|1|MINimum|MAXimum}
  PERiod:APERture? [MINimum|MAXimum]

[SENSe:]
  DETector:BANDwidth {3|20|200|MINimum|MAXimum}
  DETector:BANDwidth? [MINimum|MAXimum]

[SENSe:]
  ZERO:AUTO {OFF|ONCE|ON}
  ZERO:AUTO?

INPut
  :IMPedance:AUTO {OFF|ON}
  :IMPedance:AUTO?

ROUTe:TERMinals?
```

4

Default parameters are shown in **bold**.

Math Operation Commands

(see page 124 for more information)

```
CALCulate
  :FUNCtion {NULL|DB|DBM|AVERage|LIMit}
  :FUNCtion?
  :STATe {OFF|ON}
  :STATe?

CALCulate
  :AVERage:MINimum?
  :AVERage:MAXimum?
  :AVERage:AVERage?
  :AVERage:COUNt?

CALCulate
  :NULL:OFFSet {<value>|MINimum|MAXimum}
  :NULL:OFFSet? [MINimum|MAXimum]

CALCulate
  :DB:REFerence {<value>|MINimum|MAXimum}
  :DB:REFerence? [MINimum|MAXimum]

CALCulate
  :DBM:REFerence {<value>|MINimum|MAXimum}
  :DBM:REFerence? [MINimum|MAXimum]

CALCulate
  :LIMit:LOWer {<value>|MINimum|MAXimum}
  :LIMit:LOWer? [MINimum|MAXimum]
  :LIMit:UPPer {<value>|MINimum|MAXimum}
  :LIMit:UPPer? [MINimum|MAXimum]

DATA:FEED RDG_STORE, {"CALCulate"|""}
DATA:FEED?
```

Triggering Commands

(see page 127 for more information)

```
INITiate

READ?

TRIGger
  :SOURce {BUS|IMMediate|EXTernal}
  :SOURce?

TRIGger
  :DELay {<seconds>|MINimum|MAXimum}
  :DELay? [MINimum|MAXimum]

TRIGger
  :DELay:AUTO {OFF|ON}
  :DELay:AUTO?

SAMPle
  :COUNt {<value>|MINimum|MAXimum}
  :COUNt? [MINimum|MAXimum]

TRIGger
  :COUNt {<value>|MINimum|MAXimum|INFinite}
  :COUNt? [MINimum|MAXimum]
```

System-Related Commands

(see page 132 for more information)

```
FETCh?                              SYSTem:ERRor?

READ?                               SYSTem:VERSion?

DISPlay {OFF|ON}                    DATA:POINts?
DISPlay?
                                    *RST
DISPlay
  :TEXT <quoted string>             *TST?
  :TEXT?
  :TEXT:CLEar                       *IDN?

SYSTem                              L1
  :BEEPer                           L2
  :BEEPer:STATe {OFF|ON}            L3
  :BEEPer:STATe?
```

Default parameters are shown in **bold**.

Status Reporting Commands

(see page 144 for more information)

```
SYSTem:ERRor?

STATus
  :QUEStionable:ENABle <enable value>
  :QUEStionable:ENABle?
  :QUEStionable:EVENt?

STATus:PRESet

*CLS

*ESE <enable value>
*ESE?

*ESR?

*OPC

*OPC?

*PSC {0|1}
*PSC?

*SRE <enable value>
*SRE?

*STB?
```
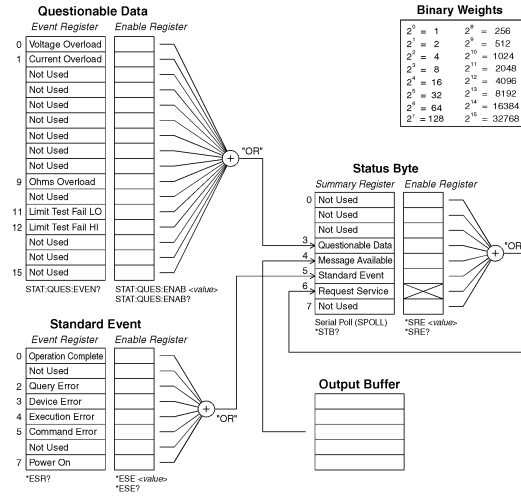
Questionable Data

Event Register	Enable Register
0 Voltage Overload	
1 Current Overload	
Not Used	
Not Used	
Not Used	
Not Used	
Not Used	
Not Used	
Not Used	
9 Ohms Overload	
Not Used	
11 Limit Test Fail LO	
12 Limit Test Fail HI	
Not Used	
Not Used	
15 Not Used	

STAT:QUES:EVEN?   STAT:QUES:ENAB <value>
STAT:QUES:ENAB?

Binary Weights

2^0	= 1	2^8	= 256
2^1	= 2	2^9	= 512
2^2	= 4	2^{10}	= 1024
2^3	= 8	2^{11}	= 2048
2^4	= 16	2^{12}	= 4096
2^5	= 32	2^{13}	= 8192
2^6	= 64	2^{14}	= 16384
2^7	= 128	2^{15}	= 32768

Status Byte

Summary Register	Enable Register
0 Not Used	
Not Used	
Not Used	
3 Questionable Data	
4 Message Available	
5 Standard Event	
6 Request Service	
7 Not Used	

Serial Poll (SPOLL)   *SRE <value>
*STB?   *SRE?

Standard Event

Event Register	Enable Register
0 Operation Complete	
Not Used	
2 Query Error	
3 Device Error	
4 Execution Error	
5 Command Error	
Not Used	
7 Power On	

*ESR?   *ESE <value>
        *ESE?

Output Buffer

Calibration Commands

(see page 146 for more information)

```
CALibration?

CALibration:COUNt?

CALibration
  :SECure:CODE <new code>
  :SECure:STATe {OFF|ON},<code>
  :SECure:STATe?

CALibration
  :STRing <quoted string>
  :STRing?

CALibration
  :VALue <value>
  :VALue?
```

Default parameters are shown in **bold**.

RS-232 Interface Commands

(see page 148 for more information)

```
SYSTem:LOCal

SYSTem:REMote

SYSTem:RWLock
```

IEEE-488.2 Common Commands

(see page 169 for more information)

```
*CLS

*ESE <enable value>
*ESE?

*ESR?

*IDN?

*OPC

*OPC?

*PSC {0|1}
*PSC?

*RST

*SRE <enable value>
*SRE?

*STB?

*TRG

*TST?
```

4

Default parameters are shown in `bold`.

SCPI

*First-time
SCPI users,
see page 154.*

Simplified Programming Overview

You can program the multimeter to take measurements from the remote
interface using the following simple seven-step sequence.

1. Place the multimeter in a known state (often the *reset* state).
2. Change the multimeter's settings to achieve the desired configuration.
3. Set-up the triggering conditions.
4. Initiate or arm the multimeter for a measurement.
5. Trigger the multimeter to make a measurement.
6. Retrieve the readings from the output buffer or internal memory.
7. Read the measured data into your bus controller.

The MEASure? and CONFigure commands provide the most straight-
forward method to program the multimeter for measurements. You can
select the measurement function, range, and resolution all in one
command. The multimeter automatically *presets* other measurement
parameters (ac filter, autozero, trigger count, etc.) to default values as
shown below.

MEASure? and CONFigure Preset States

Command	MEASure? and CONFigure Setting
AC Filter (DET:BAND)	20 Hz (medium filter)
Autozero (ZERO:AUTO)	OFF if resolution setting results in NPLC < 1; ON if resolution setting results in NPLC ≥ 1
Input Resistance (INP:IMP:AUTO)	OFF (fixed at 10 MΩ for all dc voltage ranges)
Samples per Trigger (SAMP:COUN)	1 sample
Trigger Count (TRIG:COUN)	1 trigger
Trigger Delay (TRIG:DEL)	Automatic delay
Trigger Source (TRIG:SOUR)	Immediate
Math Function (CALCulate subsystem)	OFF

Using the MEASure? Command

The easiest way to program the multimeter for measurements is by using the MEASure? command. However, this command does not offer much flexibility. When you execute the command, the multimeter *presets* the best settings for the requested configuration and immediately performs the measurement. You cannot change any settings (other than function, range, and resolution) before the measurement is taken. The results are sent to the output buffer.

Sending the MEASure? command is the same as sending a CONFigure command followed immediately by a READ? command.

Using the CONFigure Command

For a little more programming flexibility, use the CONFigure command. When you execute the command, the multimeter *presets* the best settings for the requested configuration (like the MEASure? command). However, the measurement *is not* automatically started and you can change measurement parameters before making measurements. This allows you to "incrementally" change the multimeter's configuration from the *preset* conditions. The multimeter offers a variety of low-level commands in the INPut, SENSe, CALCulate, and TRIGger subsystems. (You can use the SENSe:FUNCtion command to change the measurement function without using MEASure? or CONFigure.)

Use the INITiate or READ? command to initiate the measurement.

4

Using the *range* and *resolution* **Parameters**

With the `MEASure?` and `CONFigure` commands, you can select the measurement function, range, and resolution all in one command. Use the *range* parameter to specify the expected value of the input signal. The multimeter then selects the correct measurement range.

For frequency and period measurements, the multimeter uses one "range" for all inputs between 3 Hz and 300 kHz. The range parameter is required only to specify the resolution. Therefore, it is not necessary to send a new command for each new frequency to be measured.

Use the *resolution* parameter to specify the desired resolution for the measurement. Specify the resolution in the same units as the measurement function, *not in number of digits*. For example, for dc volts, specify the resolution in volts. For frequency, specify the resolution in hertz.

You must specify a range to use the resolution parameter.

Using the READ? Command

The `READ?` command changes the state of the trigger system from the "idle" state to the "wait-for-trigger" state. Measurements will begin when the specified trigger conditions are satisfied following the receipt of the `READ?` command. Readings are sent *immediately* to the output buffer. You *must* enter the reading data into your bus controller or the multimeter will stop making measurements when the output buffer fills. Readings *are not* stored in the multimeter's internal memory when using the `READ?` command.

Sending the READ? command is like sending the INITiate command followed immediately by the FETCh? command, except readings are not buffered internally.

Caution   *If you send two query commands without reading the response from the first, and then attempt to read the second response, you may receive some data from the first response followed by the complete second response. To avoid this, do not send a query command without reading the response. When you cannot avoid this situation, send a device clear before sending the second query command.*

Using the INITiate and FETCh? Commands

The INITiate and FETCh? commands provide the lowest level of control (with the most flexibility) of measurement triggering and reading retrieval. Use the INITiate command after you have configured the multimeter for the measurement. This changes the state of the triggering system from the "idle" state to the "wait-for-trigger" state. Measurements will begin when the specified trigger conditions are satisfied after the INITiate command is received. The readings *are* placed in the multimeter's internal memory (up to 512 readings can be stored). Readings *are stored* in memory until you are able to retrieve them.

Use the FETCh? command to transfer the readings from the multimeter's internal memory to the multimeter's output buffer where you can read them into your bus controller.

4

MEASure? Example   The following program segment shows how to use the MEASure? command to make a measurement. This example configures the multimeter for dc voltage measurements, automatically places the multimeter in the "wait-for-trigger" state, internally triggers the multimeter to take one reading, and then sends the reading to the output buffer.

```
MEAS:VOLT:DC? 10,0.003
bus enter statement
```

This is the simplest way to take a reading. However, you do not have any flexibility with MEASure? to set the trigger count, sample count, trigger delay, etc. All measurement parameters except function, range, and resolution are preset for you automatically (*see the table on page 112*).

CONFigure Example

The following program segment shows how to use the READ? command with CONFigure to make an externally-triggered measurement. The program configures the multimeter for dc voltage measurements. CONFigure does not place the multimeter in the "wait-for-trigger" state. The READ? command places the multimeter in the "wait-for-trigger" state, takes a reading when the *Ext Trig* terminal is pulsed, and sends the reading to the output buffer.

```
CONF:VOLT:DC 10, 0.003
TRIG:SOUR EXT
READ?
bus enter statement
```

CONFigure Example

The following program segment is similar to the program above but it uses INITiate to place the multimeter in the "wait-for-trigger" state. The INITiate command places the multimeter in the "wait-for-trigger" state, takes a reading when the *Ext Trig* terminal is pulsed, and sends the reading to the multimeter's internal memory. The FETCh? command transfers the reading from internal memory to the output buffer.

```
CONF:VOLT:DC 10, 0.003
TRIG:SOUR EXT
INIT
FETC?
bus enter statement
```

Storing readings in memory using the INITiate command is faster than sending readings to the output buffer using the READ? command. The multimeter can store up to 512 readings in internal memory. If you configure the multimeter to take more than 512 readings (using the sample count and trigger count), and then send INITiate, a memory error is generated.

After you execute an INITiate command, no further commands are accepted until the measurement sequence is completed. However, if you select TRIGger:SOURce BUS, the multimeter will accept the *TRG command (bus trigger) or an IEEE-488 *Group Execute Trigger* message.

The MEASure? and CONFigure Commands

See also "Measurement Configuration," starting on page 51 in chapter 3.

- For the *range* parameter, MIN selects the lowest range for the selected function; MAX selects the highest range; DEF selects autoranging.

- For the *resolution* parameter, specify the resolution in the same units as the measurement function, *not in number of digits*. MIN selects the smallest value accepted, which gives the best resolution; MAX selects the largest value accepted, which gives the least resolution; DEF selects the default resolution which is 5½ digits slow (10 PLC).

Note: *You must specify a **range** to use the **resolution** parameter.*

4

MEASure:VOLTage:DC? {*<range>*/**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and make a dc voltage measurement with the specified range and resolution. The reading is sent to the output buffer.

MEASure:VOLTage:DC:RATio? {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and make a dc:dc ratio measurement with the specified range and resolution. The reading is sent to the output buffer. For ratio measurements, the specified range applies to the signal connected to the **Input** terminals. Autoranging is automatically selected for reference voltage measurements on the **Sense** terminals.

MEASure:VOLTage:AC? {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and make an ac voltage measurement with the specified range and resolution. The reading is sent to the output buffer. For ac measurements, resolution is actually fixed at 6½ digits. The *resolution* parameter only affects the front-panel display.

MEASure:CURRent:DC? {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and make a dc current measurement with the specified range and resolution. The reading is sent to the output buffer.

MEASure:CURRent:AC? {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and make an ac current measurement with the specified range
and resolution. The reading is sent to the output buffer. For ac
measurements, resolution is actually fixed at 6½ digits. The *resolution*
parameter only affects the front-panel display.

MEASure:RESistance? {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and make a 2-wire ohms measurement with the specified range
and resolution. The reading is sent to the output buffer.

MEASure:FRESistance? {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and make a 4-wire ohms measurement with the specified range
and resolution. The reading is sent to the output buffer.

MEASure:FREQuency? {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and make a frequency measurement with the specified range and
resolution. The reading is sent to the output buffer. For frequency
measurements, the multimeter uses one "range" for all inputs between
3 Hz and 300 kHz. With no input signal applied, frequency measurements
return "0".

MEASure:PERiod? {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and make a period measurement with the specified range and
resolution. The reading is sent to the output buffer. For period
measurements, the multimeter uses one "range" for all inputs between
0.33 seconds and 3.3 μsec. With no input signal applied, period
measurements return "0".

MEASure:CONTinuity?
Preset and make a continuity measurement. The reading is sent to the
output buffer. The range and resolution are fixed for continuity tests
(1 kΩ range and 5½ digits).

MEASure:DIODe?
Preset and make a diode measurement. The reading is sent to the
output buffer. The range and resolution are fixed for diode tests
(1 Vdc range with 1 mA current source output and 5½ digits).

CONFigure:VOLTage:DC {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for dc voltage measurements with
the specified range and resolution. This command *does not* initiate the
measurement.

CONFigure:VOLTage:DC:RATio {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for dc:dc ratio measurements with
the specified range and resolution. This command *does not* initiate the
measurement. For ratio measurements, the specified range applies to
the signal connected to the **Input** terminals. Autoranging is automatically
selected for reference voltage measurements on the **Sense** terminals.

CONFigure:VOLTage:AC {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for ac voltage measurements with
the specified range and resolution. This command *does not* initiate the
measurement. For ac measurements, resolution is actually fixed at
$6\frac{1}{2}$ digits. The *resolution* parameter only affects the front-panel display.

CONFigure:CURRent:DC {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for dc current measurements with
the specified range and resolution. This command *does not* initiate the
measurement.

CONFigure:CURRent:AC {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for ac current measurements with
the specified range and resolution. This command *does not* initiate the
measurement. For ac measurements, resolution is actually fixed at
$6\frac{1}{2}$ digits. The *resolution* parameter only affects the front-panel display.

CONFigure:RESistance {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for 2-wire ohms measurements
with the specified range and resolution. This command *does not* initiate
the measurement.

CONFigure:FRESistance {*<range>*|**MIN**|**MAX**|**DEF**},{*<resolution>*|**MIN**|**MAX**|**DEF**}
Preset and configure the multimeter for 4-wire ohms measurements
with the specified range and resolution. This command *does not* initiate
the measurement.

4

CONFigure:FREQuency {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and configure a frequency measurement with the specified range
and resolution. This command *does not* initiate the measurement.
For frequency measurements, the multimeter uses one "range" for all
inputs between 3 Hz and 300 kHz. With no input signal applied,
frequency measurements return "0".

CONFigure:PERiod {<*range*>|**MIN**|**MAX**|**DEF**},{<*resolution*>|**MIN**|**MAX**|**DEF**}
Preset and configure a period measurement with the specified range
and resolution. This command *does not* initiate the measurement.
For period measurements, the multimeter uses one "range" for all
inputs between 0.33 seconds and 3.3 μsec. With no input signal applied,
period measurements return "0".

CONFigure:CONTinuity
Preset and configure the multimeter for continuity measurements.
This command *does not* initiate the measurement. The range and
resolution are fixed for continuity tests (1 kΩ range and 5½ digits).

CONFigure:DIODe
Preset and configure the multimeter for diode measurements.
This command *does not* initiate the measurement. The range and
resolution are fixed for diode tests (1 Vdc range with 1 mA current
source output and 5½ digits).

CONFigure?
Query the multimeter's present configuration and return a quoted string.

Measurement Configuration Commands

See also "Measurement Configuration," starting on page 51 in chapter 3.

FUNCtion "<*function***>"**
Select a measurement function. The function must be enclosed in quotes in the command string (FUNC "VOLT:DC"). Specify one of the following strings.

VOLTage:DC	FRESistance (*4-wire ohms*)
VOLTage:DC:RATio	FREQuency
VOLTage:AC	PERiod
CURRent:DC	CONTinuity
CURRent:AC	DIODe
RESistance (*2-wire ohms*)	

FUNCtion?
Query the measurement function and return a quoted string.

<*function***>:RANGe {<***range***>|MINimum|MAXimum}**
Select the range for the selected function. For frequency and period measurements, ranging applies to the signal's input voltage, *not* its frequency (use FREQuency:VOLTage or PERiod:VOLTage). MIN selects the lowest range for the selected function. MAX selects the highest range. *[Stored in volatile memory]*

<*function***>:RANGe? [MINimum|MAXimum]**
Query the range for the selected function.

<*function***>:RANGe:AUTO {OFF|ON}**
Disable or enable autoranging for the selected function. For frequency and period, use FREQuency:VOLTage or PERiod:VOLTage. Autorange thresholds: Down range at <10% of range; Up range at >120% of range. *[Stored in volatile memory]*

<*function***>:RANGe:AUTO?**
Query the autorange setting. Returns "0" (OFF) or "1" (ON).

4

<*function*>:RESolution {<*resolution*>|MINimum|MAXimum}
Select the resolution for the specified function (not valid for frequency, period, or ratio). Specify the resolution in the same units as the measurement function, *not in number of digits*. MIN selects the smallest value accepted, which gives the most resolution. MAX selects the largest value accepted which gives the least resolution. *[Stored in volatile memory]*

<*function*>:RESolution? [MINimum|MAXimum]
Query the resolution for the selected function. For frequency or period measurements, the multimeter returns a resolution setting based upon a 3 Hz input frequency.

<*function*>:NPLCycles {0.02|0.2|1|10|100|MINimum|MAXimum}
Select the integration time in number of power line cycles for the present function (the default is 10 PLC). This command is valid only for dc volts, ratio, dc current, 2-wire ohms, and 4-wire ohms. MIN = 0.02. MAX = 100. *[Stored in volatile memory]*

<*function*>:NPLCycles? [MINimum|MAXimum]
Query the integration time for the selected function.

FREQuency:APERture {0.01|0.1|1|MINimum|MAXimum}
Select the aperture time (or gate time) for frequency measurements (the default is 0.1 seconds). Specify 10 ms (4½ digits), **100 ms** (default; 5½ digits), or 1 second (6½ digits). MIN = 0.01 seconds. MAX = 1 second.
[Stored in volatile memory]

FREQuency:APERture? [MINimum|MAXimum]
Query the aperture time for frequency measurements.

PERiod:APERture {0.01|0.1|1|MINimum|MAXimum}
Select the aperture time (or gate time) for period measurements (the default is 0.1 seconds). Specify 10 ms (4½ digits), **100 ms** (default; 5½ digits), or 1 second (6½ digits). MIN = 0.01 seconds. MAX = 1 second.
[Stored in volatile memory]

PERiod:APERture? [MINimum|MAXimum]
Query the aperture time for period measurements.

`[SENSe:]DETector:BANDwidth {3|20|200|MINimum|MAXimum}`
Specify the lowest frequency expected in the input signal. The multimeter
selects the slow, medium (default), or fast ac filter based on the frequency
you specify. MIN = 3 Hz. MAX = 200 Hz. *[Stored in volatile memory]*

`[SENSe:]DETector:BANDwidth? [MINimum|MAXimum]`
Query the ac filter. Returns "3", "20", or "200".

`[SENSe:]ZERO:AUTO {OFF|ONCE|ON}`
Disable or enable (default) the autozero mode. The OFF and ONCE
parameters have a similar effect. Autozero OFF *does not* issue a new
zero measurement until the next time the multimeter goes to the
"wait-for-trigger" state. Autozero ONCE issues an immediate zero
measurement. *[Stored in volatile memory]*

`[SENSe:]ZERO:AUTO?`
Query the autozero mode. Returns "0" (OFF or ONCE) or "1" (ON).

`INPut:IMPedance:AUTO {OFF|ON}`
Disable or enable the automatic input resistance mode for dc voltage
measurements. With AUTO OFF (default), the input resistance is fixed
at 10 MΩ for all ranges. With AUTO ON, the resistance is set to >10 GΩ
for the 100 mV, 1 V, and 10 V ranges. *[Stored in volatile memory]*

`INPut:IMPedance:AUTO?`
Query the input resistance mode. Returns "0" (OFF) or "1" (ON).

`ROUTe:TERMinals?`
Query the multimeter to determine if the front or rear input terminals
are selected. Returns "FRON" or "REAR".

4

Math Operation Commands

See also "Math Operations," starting on page 63 in chapter 3.

There are five math operations available, only one of which can be enabled at a time. Each math operation performs a mathematical operation on each reading or stores data on a series of readings. The selected math operation remains in effect until you disable it, change functions, turn off the power, or perform a remote interface reset. The math operations use one or more internal registers. You can preset the values in some of the registers, while others hold the results of the math operation.

The following table shows the math/measurement function combinations allowed. Each "X" indicates an allowable combination. If you choose a math operation that is not allowed with the present measurement function, math is turned off. If you select a valid math operation and then change to one that is invalid, a "Settings conflict" error is generated over the remote interface. *For null and dB measurements, you must turn on the math operation before writing to their math registers.*

	DC V	AC V	DC I	AC I	Ω 2W	Ω 4W	Freq	Per	Cont	Diode	Ratio
Null	X	X	X	X	X	X	X	X			
Min-Max	X	X	X	X	X	X	X	X			X
dB	X	X									
dBm	X	X									
Limit	X	X	X	X	X	X	X	X			X

CALCulate:FUNCtion {NULL|DB|DBM|AVERage|LIMit}
Select the math function. Only one function can be enabled at a time. The default function is null. *[Stored in volatile memory]*

CALCulate:FUNCtion?
Query the present math function. Returns NULL, DB, DBM, AVER, or LIM.

CALCulate:STATe {OFF|ON}
Disable or enable the selected math function. *[Stored in volatile memory]*

CALCulate:STATe?
Query the state of the math function. Returns "0" (OFF) or "1" (ON).

CALCulate:AVERage:MINimum?
Read the minimum value found during a min-max operation. The
multimeter clears the value when min-max is turned on, when power
has been off, or after a remote interface reset. *[Stored in volatile memory]*

CALCulate:AVERage:MAXimum?
Read the maximum value found during a min-max operation. The
multimeter clears the value when min-max is turned on, when power
has been off, or after a remote interface reset. *[Stored in volatile memory]*

CALCulate:AVERage:AVERage?
Read the average of all readings taken since min-max was enabled.
The multimeter clears the value when min-max is turned on, when
power has been off, or after a remote interface reset. *[Stored in volatile
memory]*

CALCulate:AVERage:COUNt?
Read the number of readings taken since min-max was enabled. The
multimeter clears the value when min-max is turned on, when power
has been off, or after a remote interface reset. *[Stored in volatile
memory]*

4

CALCulate:NULL:OFFSet {**<***value***>|MINimum|MAXimum**}
Store a null value in the multimeter's Null Register. *You must turn on the math
operation before writing to the math register*. You can set the null value to any
number between 0 and ±120% of the highest range, for the present
function. MIN = −120% of the highest range. MAX = 120% of the highest
range. *[Stored in volatile memory]*

CALCulate:NULL:OFFSet? [MINimum|MAXimum]
Query the null value.

CALCulate:DB:REFerence {**<***value***>|*MINimum|MAXimum*}**
Store a relative value in the dB Relative Register. *You must turn on the math
operation before writing to the math register*. You can set the relative value to
any number between 0 dBm and ±200 dBm.
MIN = −200.00 dBm. MAX = 200.00 dBm. *[Stored in volatile memory]*

CALCulate:DB:REFerence? [MINimum|MAXimum]
Query the dB relative value.

CALCulate:DBM:REFerence {<*value*>|**MINimum**|**MAXimum**}
Select the dBm reference value. Choose from: *50, 75, 93, 110, 124, 125, 135, 150, 250, 300, 500, **600**, 800, 900, 1000, 1200, or 8000 ohms.*
MIN = 50 Ω. MAX = 8000 Ω. *[Stored in non-volatile memory]*

CALCulate:DBM:REFerence? [MINimum|MAXimum]
Query the dBm reference resistance.

CALCulate:LIMit:LOWer {<*value*>|*MINimum*|*MAXimum*}
Set the lower limit for limit testing. You can set the value to any number between 0 and ±120% of the highest range, for the present function.
MIN = –120% of the highest range. MAX = 120% of the highest range.
[Stored in volatile memory]

CALCulate:LIMit:LOWer? [MINimum|MAXimum]
Query the lower limit.

CALCulate:LIMit:UPPer {<*value*>|*MINimum*|*MAXimum*}
Set the lower limit for limit testing. You can set the value to any number between 0 and ±120% of the highest range, for the present function.
MIN = –120% of the highest range. MAX = 120% of the highest range.
[Stored in volatile memory]

CALCulate:LIMit:UPPer? [MINimum|MAXimum]
Query the upper limit.

DATA:FEED RDG_STORE, {"CALCulate"|""}
Selects whether readings taken using the INITiate command are stored in the multimeter's internal memory (default) or not stored at all. In the default state (DATA:FEED RDG_STORE, "CALC"), up to 512 readings are stored in memory when INITiate is executed. The MEASure? and CONFigure commands automatically select "CALC". With memory disabled (DATA:FEED RDG_STORE, ""), readings taken using INITiate are not stored. This may be useful with the min-max operation since it allows you to determine an average of the readings without storing the individual values. An error will be generated if you attempt to transfer readings to the output buffer using the FETCh? command.

DATA:FEED?
Query the reading memory state. Returns **"CALC"** or **""**.

SCPI

Triggering

See also "Triggering," starting on page 71 in chapter 3.

The multimeter's triggering system allows you to generate triggers
either manually or automatically, take multiple readings per trigger,
and insert a delay before each reading. Normally, the multimeter will
take one reading each time it receives a trigger, but you can specify
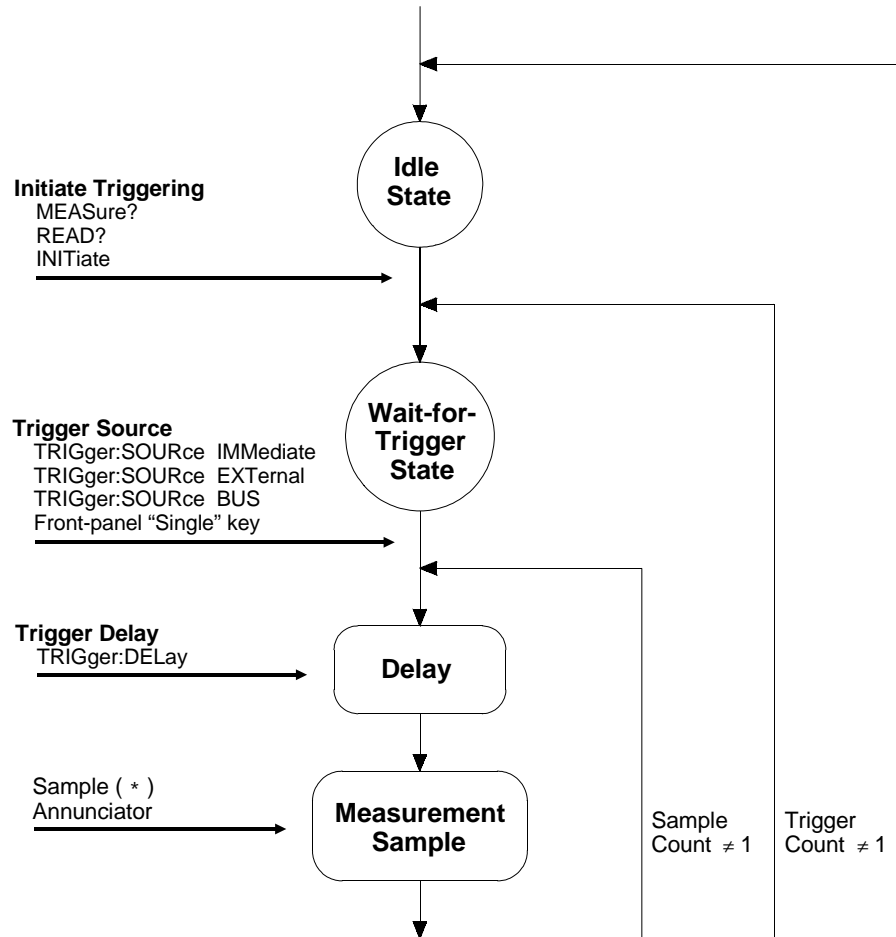multiple readings (up to 50,000) per trigger.

Triggering the multimeter from the remote interface is a multi-step
process that offers triggering flexibility.

- First, you must configure the multimeter for the measurement by
  selecting the function, range, resolution, etc.

- Then, you must specify the source from which the multimeter will
  accept the trigger. The multimeter will accept a software (bus) trigger
  from the remote interface, a hardware trigger from the rear-panel
  Ext Trig (external trigger) terminal, or an immediate internal trigger.

- Then, you must make sure that the multimeter is ready to accept
  a trigger from the specified trigger source (this is called the *wait-for-
  trigger* state).

The diagram on the next page shows the multimeter's triggering system.

4

HP 34401A Triggering System

Idle State

Initiate Triggering
  MEASure?
  READ?
  INITiate

Wait-for-Trigger State

Trigger Source
  TRIGger:SOURce IMMediate
  TRIGger:SOURce EXTernal
  TRIGger:SOURce BUS
  Front-panel "Single" key

Trigger Delay
  TRIGger:DELay

Delay

Sample (*)
Annunciator

Measurement Sample

Sample
Count $\neq$ 1

Trigger
Count $\neq$ 1

The Wait-for-Trigger State

After you have configured the multimeter and selected a trigger source, you must place the multimeter in the *wait-for-trigger* state. A trigger will not be accepted until the multimeter is in this state. If a trigger signal is present, and if multimeter is in the "wait-for-trigger" state, the measurement sequence begins and readings are taken.

The "wait-for-trigger" state is a term used primarily for remote interface operation. From the front panel, the multimeter is always in the "wait-for-trigger" state and will accept triggers at any time, unless a measurement is already in progress.

You can place the multimeter in "wait-for-trigger" state by executing any of the following commands from the remote interface.

```
MEASure?
READ?
INITiate
```

4

The multimeter requires approximately 20 ms of set-up time after you send a command to change to the "wait-for-trigger" state. Any external triggers that occur during this set-up time are ignored.

Triggering Commands

See also "Triggering," starting on page 71 in chapter 3.

INITiate
Change the state of the triggering system from the "idle" state to the "wait-for-trigger" state. Measurements will begin when the specified trigger conditions are satisfied after the INITiate command is received. The readings are placed in the multimeter's internal memory (up to 512 readings can be stored). Readings *are stored* in memory until you are able to retrieve them. Use the FETCh? command to retrieve reading results.

A new command is available starting with firmware Revision 2 which allows you to take readings using INITiate *without storing them in internal memory. This command may be useful with the min-max operation since it allows you to determine the average of a series of readings without storing the individual values.*

```
DATA:FEED RDG_STORE, ""            do not store readings
DATA:FEED RDG_STORE, "CALCulate"   store readings (default)
```

See page 126 for more information on using the DATA:FEED *command.*

READ?
Change the state of the trigger system from the "idle" state to the "wait-for-trigger" state. Measurements will begin when the specified trigger conditions are satisfied following the receipt of the READ? command. Readings are sent immediately to the output buffer.

TRIGger:SOURce {BUS|IMMediate|EXTernal}
Select the source from which the multimeter will accept a trigger. The multimeter will accept a software (bus) trigger, an immediate internal trigger (this is the default source), or a hardware trigger from the rear-panel *Ext Trig* (external trigger) terminal. *[Stored in volatile memory]*

TRIGger:SOURce?
Query the present trigger source. Returns "BUS", "IMM", or "EXT".

TRIGger:DELay {<*seconds*>|**MINimum**|**MAXimum**}
Insert a trigger delay between the trigger signal and each sample that follows. If you do not specify a trigger delay, the multimeter automatically selects a delay for you. Select from 0 to 3600 seconds. MIN = 0 seconds. MAX = 3600 seconds. *[Stored in volatile memory]*

TRIGger:DELay? [MINimum|MAXimum]
Query the trigger delay.

TRIGger:DELay:AUTO {**OFF**|**ON**}
Disable or enable an automatic trigger delay. The delay is determined by function, range, integration time, and ac filter setting. Selecting a specific trigger delay value automatically turns off the automatic trigger delay. *[Stored in volatile memory]*

TRIGger:DELay:AUTO?
Query the automatic trigger delay setting. Returns "0" (OFF) or "1" (ON).

4

SAMPle:COUNt {<*value*>|**MINimum**|**MAXimum**}
Set the number of readings (samples) the multimeter takes per trigger. Select from 1 to 50,000 readings per trigger. MIN = 1. MAX = 50,000. *[Stored in volatile memory]*

SAMPle:COUNt? [MINimum|MAXimum]
Query the sample count.

TRIGger:COUNt {<*value*>|**MINimum**|**MAXimum**|**INFinite**}
Set the number of triggers the multimeter will accept before returning to the "idle" state. Select from 1 to 50,000 triggers. The INFinite parameter instructs the multimeter to continuously accept triggers (you must send a device clear to return to the "idle" state). Trigger count is ignored while in local operation. MIN = 1. MAX = 50,000. *[Stored in volatile memory]*

TRIGger:COUNt? [MINimum|MAXimum]
Query the trigger count. If you specify an infinite trigger count, the query command returns "9.90000000E+37".

System-Related Commands

See also "System-Related Operations," starting on page 84 in chapter 3.

FETCh?
Transfer readings stored in the multimeter's internal memory by the
INITiate command to the multimeter's output buffer where you can
read them into your bus controller.

READ?
Change the state of the trigger system from the "idle" state to the
"wait-for-trigger" state. Measurements will begin when the specified
trigger conditions are satisfied following the receipt of the READ?
command. Readings are sent immediately to the output buffer.

DISPlay {OFF|ON}
Turn the front-panel display off or on. *[Stored in volatile memory]*

DISPlay?
Query the front-panel display setting. Returns "0" (OFF) or "1" (ON).

DISPlay:TEXT <*quoted string***>**
Display a message on the front panel. The multimeter will display up to 12
characters in a message; any additional characters are truncated.
[Stored in volatile memory]

DISPlay:TEXT?
Query the message sent to the front panel and return a quoted string.

DISPlay:TEXT:CLEar
Clear the message displayed on the front panel.

`SYSTem:BEEPer`
Issue a single beep immediately.

`SYSTem:BEEPer:STATe {OFF|ON}`
Disable or enable the front-panel beeper. *[Stored in non-volatile memory]*

When you disable the beeper, the multimeter *will not* emit a tone when:
1) a new minimum or maximum is found in a min–max test.
2) a stable reading is captured in reading hold.
3) a limit is exceeded in a limit test.
4) a forward-biased diode is measured in the diode test function.

`SYSTem:BEEPer:STATe?`
Query the state of the front-panel beeper. Returns "0" (OFF) or "1" (ON).

`SYSTem:ERRor?`
Query the multimeter's error queue. Up to 20 errors can be stored in the queue. Errors are retrieved in first-in-first out (FIFO) order. Each error string may contain up to 80 characters.

4

`SYSTem:VERSion?`
Query the multimeter to determine the present SCPI version.

`DATA:POINts?`
Query the number of readings stored in the multimeter's internal memory.

`*RST`
Reset the multimeter to its power-on configuration.

`*TST?`
Perform a complete self-test of the multimeter. Returns "0" if the self-test is successful, or "1" if it test fails.

`*IDN?`
Read the multimeter's identification string (be sure to dimension a string variable with at least 35 characters).